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Proceedings of the Twentieth Convocation of the
Royal Australasian College of Dental Surgeons
11 to 14 March, 2010

Published by
ROYAL AUSTRALASIAN COLLEGE OF DENTAL SURGEONS
Incorporated
Level 13/37 York Street, Sydney, New South Wales 2000
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ISSN 0158-1570
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ANNALS OF THE
ROYAL AUSTRALASIAN COLLEGE OF DENTAL SURGEONS
VOLUME 20 MARCH 2010

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ROYAL AUSTRALASIAN COLLEGE OF DENTAL SURGEONS
(Incorporated in ACT)
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Chief Executive Officer
Stephen Robbins
FOUNDERS OF THE COLLEGE

Committee appointed by the Australian Dental Association to investigate ways and means of establishing an Australian College of Dental Surgeons

Alfred Gordon Rowell, Chairman
Kenneth Thomas Adamson
Alwyn James Arnott
H Roy Cash

William Alan Grainger
Robert Harris
William Keith Ross Mackenzie
K Robertson

1. Subscribers to the Initial Constitution
Kenneth Thomas Adamson
Alwyn James Arnott
William Alan Grainger
Robert Harris
William Keith Ross Mackenzie
Alfred Gordon Rowell

2. Interim Council, elected 14 March, 1965
President A G Rowell
Vice-President K T Adamson
Censor-in-Chief W A Grainger
Honorary Secretary R Harris
Honorary Treasurer W R K Mackenzie
Councillors H R Cash* J F Lavis

3. First Council, elected 5 November, 1966
President A G Rowell
Vice-President K T Adamson
Censor-in-Chief W A Grainger
Honorary Secretary R Harris
Honorary Treasurer J S Lyell
Councillors G Christensen J F Lavis R L Taylor

*Did not serve.

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1965    John Hall Best*
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1966    T Draper Campbell*
1966    Sidney Firth Lumb*
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1968    Terence Ward*
1968    Frank Clare Wilkinson*
1970    Gerald Leatherman*
1971    Neil William George Macintosh*
1973    Alan Docking*
1974    William Alan Grainger*
1976    Kenneth Adamson*

1966-1969 F G Christensen*
1966-1971 R L Taylor
1966-1973 W A Grainger*
1966-1975 J S Lyell*
1966-1976 K T Adamson*
1966-1978 R Harris*
1966-1978 J F Lavis
1966-1978 A G Rowell
1969-1973 G B Ferguson*
1970-1982 T B Lindsay
1971-1982 H G Lamplough
1971-1982 W O Read*
1974-1986 S G Kings
1974-1986 J A Sagar*
1975-1988 R Y Norton*

1976    Kenneth Wollaston Cleland*
1977    Percy Raymond Begg*
1977    George Neville Davies
1978    Ivor Robert Horton Kramer
1979    Robert Harris*
1979    John Frederic Lavis
1979    Alfred Gordon Rowell*
1982    Paul Anthony Bramley
1983    Kenneth Joseph George Sutherland
1985    Henry Gordon Lamplough
1985    Warwick Olver Read*
1987    Earle Harold Bastian*
1987    Stanley George Kings
1987    John Alfred Sagar*

1976-1988 R M King
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1978-1990 G Wing
1978-1979 D E Poswillo
1979-1992 J H Muller
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1982-1994 R W Hession
1982-1996 P W McMerracher
1986-1996 G H Hewitt
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1988-2000 J H Sinclair
1988-1996 B Feiglin
1990-2002 K H Wendon
1990-2004 R J Bastiaan
1990-2004 J P H Rogers
1990-2002 G A Thomas
1992-2006 D H Thomson
1994-2004 A N Goss
1996-2005 R G Cook
1996- S C Daymond
1996-2002 E D Kingsford-Smith
1996- N J J Peppitt
1998-2000 B K Drummond
1998-2002 M J Tyas
2002- S M Hanlin
2002- R D Story
2002- M J Suthers
2002- M J Tyas
2002- M J Suthers
2002- R T Drummond
2002-2006 B M Woodhouse
2004- D D Bamberry†
2004- W H Bischof
2004- F S W Chau
2006 J P. Fricker
2006 D G. Sykes‡
2008- B. Pearlman
2008- P. Russo

1989    Richard Manning King
1989    Robert York Norton*
1991    George Wing
1993    John Henry Muller
1993    Diana, Princess of Wales*
1995    Reginald William Hession
1998    John Kenneth Harcourt
1998    George Henry Hewitt
2000    Sydney Charles Warneke
2001    John Hugh Sinclair
2003    Kenneth Howard Wendon
2005    Ross Jan Bastiaan
2007    David Henry Thomson
2009    Neil John Joseph Peppitt

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1964-1969 F G Christensen*
1966-1971 R L Taylor
1966-1973 W A Grainger*
1966-1975 J S Lyell*
1966-1976 K T Adamson*
1966-1978 R Harris*
1966-1978 J F Lavis
1966-1978 A G Rowell
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2004- D D Bamberry†
2004- W H Bischof
2004- F S W Chau
2006 J P. Fricker
2006 D G. Sykes‡
2008- B. Pearlman
2008- P. Russo

*Deceased
†Representing the New Zealand Region
‡Representing the Asian Region
## OFFICE BEARERS

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<th>President</th>
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<th>Honorary Treasurer</th>
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<td>W O Read</td>
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<td>M J Tyas</td>
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## CONVOCATION COMMITTEE

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  - Philip Cockerill
- **Members**
  - Andrew Bochenek
  - Fleur Creeper
  - Dina Papas
  - Andrew Savundra
  - Richard Cook
  - Chris Wholley

### YOUNG LECTURER AWARD
- **CO-ORDINATOR**
  - F Creeper

## COLLEGE REGIONAL COMMITTEES, DIVISIONS, STANDING COMMITTEES AND BOARDS OF STUDIES

(see the RACDS Handbook 2010)

## CONVOCATIONS

<table>
<thead>
<tr>
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<td>Canberra, Australia</td>
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<td>20-23 February 1977:</td>
<td>Melbourne, Australia</td>
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<td>13-16 May 1979:</td>
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<td>Sydney, Australia</td>
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<td>2-5 April 1984:</td>
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<td>19</td>
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<td>Hong Kong, SAR China</td>
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<td>20</td>
<td>11 - 14 March 2010:</td>
<td>Perth, Western Australia</td>
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EDITORIAL

Interdisciplinary Dentistry for the New Decade: Something for Everyone. The Twentieth Convocation in Perth was, as expected, a great success. It was held in a compact venue at the Burswood Convention Centre with excellent accommodation within less than a minute walking. Perth also turned on excellent sunny weather for the occasion. The lecture presentations were up to the usual high standard we have come to expect on our Convocations. These were backed by an extensive trade display and a great social programme.

The organizing committee put together a well balanced lecture programme highlighting the advances of the last decade and how they will influence the practice of dentistry in the coming decade.

We will continue the practice of providing the Annals largely in an electronic format with a limited number of print versions including College details, the Opening Ceremony, Keynote Speaker and Young Lecturer presentations being prepared and made available on request.

Thank you to all those authors who sent their contributions in on time – modern communication techniques have made the editor’s task much easier in preparing page proofs and having them approved by the presenters. However, as usual, there may be some omissions as abstracts, short papers or papers were not available at the time of preparation of the CD-ROM.

Thank you to all concerned in the organization of the Convocation – the College Office staff, the Convocation organizing committee and the Convention Managers.

John K. Harcourt, OAM, DDSc, FRACDS, FDSRCS(Hon)
Honorary Editor, Annals RACDS
I would like to respectfully acknowledge the Nyungah people, the traditional owners of the land on which this Convocation is being held.

Distinguished guests, Members and Fellows of the Royal Australasian College of Dental Surgeons, Partners and Guests: On behalf of our College Council and Convocation Organizing Committee, it is my very great pleasure to welcome you to Perth and the Twentieth Convocation of the Royal Australasian College of Dental Surgeons.

I would like to acknowledge and welcome our official guests this evening:

His Excellency, Dr Ken Michael, Governor of Western Australia and Mrs Michael.

Retired Brigadier General Michael Wholley - Consul General National Aeronautics and Space Administration. Dr Michael McGuinness representing the President of the Australian Dental Council. Dr Brian Koch – President of the Western Australian Branch of the Australian Dental Association. Dr Gervase Chaney – President of the Royal Australasian College of Physicians. Dr Jocelyn Shand – President of the Australian and New Zealand Association of Oral and Maxillofacial Surgeons. Professor Andrew Smith – Head of School of Dentistry, University of Western Australia and Director of the Oral Health Care Centre of Western Australia.

It is the 45th year of the College’s history, and I would firstly like to acknowledge and honour the 20 Presidents and 21 Councils who have contributed their time, particular expertise and enthusiasm to bring us to a vibrant and forward moving organization in 2010. I am extremely privileged that our Members and Fellows have allowed me to be part of the ongoing history of this College. The Royal Australasian College of Dental Surgeons was founded in 1965 by a visionary group of dentists to provide an avenue for dentists to improve their scientific knowledge, clinical skills and professional standing. This vision provided an important lead in continuing professional development, which has become an essential part of dental practice. In this respect the motto of our College: ‘Vincat Scientia Morbis’ – Let knowledge conquer disease underpins the College’s work and developments to adapt to the requirements of supporting the life long learning and assessment which is an integral part of the delivery of oral health care in the 21st century.

If we take time to review the history and changes that our College has experienced in the past 45 years, it is clear that the College has responded to the requests and needs of the dental profession during that time. Following the initial
development of the general stream Fellowship, we now have a suite of programmes and examinations that support dental practitioners in general practice and specialist practice. These developments have not occurred without careful thought and discussion. There is clear evidence of several Councils in succession carefully deliberating and planning the introduction of new initiatives. New developments bring with them needs for financial and personnel support and the last four Councils in particular have boldly planned for a significant infrastructure development in terms of personnel. We have an excellent Chief Executive Officer leading 10 full-time and part-time staff all of whom who have the qualifications, knowledge and professional skills to administer our programmes and examinations. They are also involved with the Boards of Studies in the development of new assessment procedures and online learning opportunities for our enrolled candidates. Our College staff is the first contact for our Members, Fellows and enrolled and potential candidates and I do wish to note their contribution to the work of the College.

As our work and responsibilities increase in graduate education and examinations, the College recognizes it is time to consider the work of our volunteer Members and Fellows. It is likely that in the future we will not be able to expect volunteers to cover the amount of work now required. An example is the enormous workload of our registrars. Council has already increased the numbers of Assistant Registrar positions to support the MRACDS programme and the special field areas. Apart from balancing the workload, this will insure that several people have the knowledge and expertise in each area. The increasing requirements around accreditation and validation of ongoing education also signal further increases in work-load and in the not too distant future, the College may need to consider employing registrars at least on a part-time basis to recognize the professional expertise and experience required in the registrar positions. This will be a change for our College but one I believe will need to occur for continuing recognition of the College’s role in graduate dental education and professional development.

In the past few years the College has developed closer relationships with other bodies. This is evident in several areas. The Oral and Maxillofacial surgery programme recently underwent an accreditation review by the Australian Medical Council and the Australian Dental Council; a very significant achievement. We have signed agreements with a number of Australian Dental Schools to provide support for graduate students and conjoint final examinations to allow graduates to attain MRACDS in their particular field. This gives these dental specialists immediate access to College support and the opportunity at the appropriate time to progress to Fellowship if they wish.

We have a conjoint examination process with the Royal College of Surgeons of Edinburgh leading to MRACDS and M Orth in Orthodontics, an option that has been taken up by 39 graduates since its inception. We are in negotiation with the College of Dental Surgeons of Hong Kong around sharing expertise in our MRACDS programme and their programme in General Dentistry. It is important to emphasize again that none of these initiatives has come to fruition without the long-term groundwork by previous Presidents and their Councils.

The present Council has been responsible for putting several initiatives in place following decisions of previous Councils. These include the introduction of the first primary examination in Jordan, implementation of the Education Policy Board and implementation of the Finance and Audit Committee which is developing a process to audit all administration processes of the College to confirm they fulfill legal requirements. I am also very pleased to report that this Council has supported the introduction of Special Stream examinations in Dental Public Health. This specialist area has a great deal to offer our College and in turn the College can support those practising in this field including in hospital administration and community oral health care settings.

In order to support the changes and increase in College business, this Council has supported a very significant IT upgrade, which will support on-line learning in the College’s programmes. We have also considered the importance of communication with all dental professionals by involving dental hygienists and dental therapists in Convocation for the first time.

What does the future hold? The College’s role in bi-national continuing professional development has already increased and will become even more important with legislation changes in Australia this year. The role in providing peer support and mentoring particularly of new graduates and overseas dentists entering the workforce in Australia and New Zealand will increase and international linkages will continue to develop. I believe that the changes our College has made in the past 10 years indicate our ability to adapt to changing professional and legislative requirements and public expectations of our profession. Continuing adaptation beyond the present thoughts of many of us will be required in the future.

Turning to the Convocation. I wish to thank and warmly welcome our keynote speakers Dr Dieter Bosshardt, Dr Sonia Lezzy and Dr Brahmm Miller and I wish to acknowledge the Conference Organizing Committee: Dr Philip Cockerill – Committee Chair, Dr Christopher Wholley – Scientific Programme Chair, Dr Andrew Bochenek – College Councillor, Dr Fleur Creeper, Dr Richard Cook, Professor Lisa Heitz-Mayfield, Dr Andrew Savundra and Dr Nina Papas for the enormous amount of work and time they have contributed to preparing this Convocation. The programme provides an excellent range of speakers and topics and I know we shall enjoy the social events with colleagues. I wish you a successful time in Perth and hope you return to practice with renewed enthusiasm and a feeling of collegiality. In the increasingly complicated practice of dentistry, belonging to our College certainly reminds us that our colleagues are an invaluable source of professional support.

I now have very great pleasure in inviting our Guest of Honour, His Excellency Dr Ken Michael, Governor of Western Australia to open the proceedings of this 20th convocation.
OPENING ADDRESS BY HIS EXCELLENCY DR KEN MICHAEL, AC
GOVERNOR OF WESTERN AUSTRALIA

...
Education captures the mind and stimulates intellectual curiosity, showing the capacity to tackle and solve problems, demonstrating the ability to think creatively and logically, and having the ability to interact with others. This Convocation gathering is a case in point in this respect.

Science and technology play a key role in our everyday lives as well as in specific areas, such as dentistry, particularly in the rapidly changing technological environment we find ourselves in.

Science is about knowledge; technology is about the application of knowledge. It is also true, as many of you can attest in your own particular field, that science is about expecting the unexpected… discovering that which cannot be easily predicted. It is about seeking new ideas that can make a difference to the way we tackle issues and challenges. In your case, it is about seeking ways, amongst others, to improve dental techniques and practices and dental health care.

There is no doubt that today we are in an era of unparalleled advancement fuelled by curiosity, driven by science and powered by technology.

Research, in itself, is fundamental to change and improvements; it is fundamental to the incremental advances that make quality differences to the lives of humans, to their health and to their well being.

I am aware that the College fosters that degree of research and there have been outcomes that have been world-class, earning it a very strong and respected international reputation. The College itself acts as a catalyst for added momentum for study and research and this leads to further world-class dental research achievements.

Its role complements that of tertiary institutions by providing a postgraduate education at a high level. I am aware, too, that having attained eminence in postgraduate education, the College enjoys continued support and goodwill from all sections of the dental profession.

It has earned this support through incorporating practical study and research – creating a scholarly environment that promotes the pursuit and rigorous critical interpretation of new information, as well as the acquisition of knowledge and maintenance of professional standards.

Since its inception, the College has grown to include more than 1100 Fellows from all types of practice, both general and specialist.

Wherever they are around the world, Fellows share collegiality with dentists who have common interests and aspirations in striving for the heights of excellence in their profession, whether it be in private practice, government health service, military service, academia or postgraduate study. This collegiality fosters networks and access to innovation and new ideas that come from within the profession and from the interaction with other complementary associations and organisations.

Science and research is about preparing for the future. Your own Convocation acknowledges this in that it embraces many topics and fields that impact on Interdisciplinary Dentistry for the New Decade. It is an important forum that initiates discussion and the exchange of ideas, as well as stimulating debate and questions – all of which are critical to breakthroughs and advances in the dental and medical fields.

As well, the Dental Trade Exhibition, another important element of this Convocation gathering, showcases the latest advances in technology, equipment and materials which, in turn, present opportunities to the practitioner or new thoughts for the researcher.

All in all this Twentieth Convocation offers a great variety in presentations, key opportunities to expand your interest and knowledge and new technologies which can enhance your practices.

I wish you well in your discussions. I am sure this Convocation will be an enjoyable and memorable one for everybody.

I would like to leave you with a quote from Albert Einstein that I think is relevant to your deliberations and, indeed, somewhat reflective of one of your College’s objects. To some extent, it is also about my earlier reference to education; that it is all about capturing the mind and stimulating intellectual curiosity. Einstein’s view was, and I quote:

“The most beautiful experience we can have is the mysterious – the fundamental emotion which stands at the cradle of true art and true science.”

It now gives me much pleasure to officially open the Twentieth Convocation of the Royal Australasian College of Dental Surgeons and to wish you all an enjoyable and stimulating series of discussions and interactions with each other during the course of the program, together with the opportunity to meet old friends, make new ones and enjoy Perth and its surrounding environment.

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TWENTIETH CONVOCATION
ROYAL AUSTRALASIAN COLLEGE OF DENTAL SURGEONS
PERTH, WESTERN AUSTRALIA, MARCH 2010

MEMBERSHIP BY EXAMINATION
Adam Nicholas Keyes-Tilley
Patrick Ralph William Puckett
Bruno Vavala

MEMBERSHIP IN A SPECIAL FIELD

ENDODONTICS
Todd Barry Gracia

ORAL MEDICINE
Raj Gopinathan Nair

ORTHODONTICS
John Lindsay Brabant
Sheraz Ahmad Khan Burki
Peter David Roy Munt
Andrew Wijeyan Savundra
Robert Alexander Smith

PAEDIATRIC DENTISTRY
Peter John Gregory
Peter Joseph Willis Verco

PERIODONTICS
Louise Frances Brown
Martin Richard Cherry
Andrew Robert Hedberg
Sandeep Jain
Melanie Jane McAlpine
Albert Ee San Tan
Stephen Yeung

PROSTHODONTICS
Suzanne Mcewan Hanlin
Mei Ching Ng
Neil John Joseph Peppitt
David Gerald Sykes

FELLOWSHIP BY EXAMINATION

Rajiv Ahuja
Naser Faisal Albarbari
Emma Lynne Morelli
Patrick Ralph William Puckett
Bruno Vavala

FELLOWSHIP BY EXAMINATION IN A SPECIAL FIELD

ORAL AND MAXILLOFACIAL SURGERY
Narada DhitiMantha Hapangama
Paul Mark Sillifant

PERIODONTICS
Ivan Bernard Darby
Haifa Hannawi
Sushil Sarban Kaur
Derrick Zhi-Jie Lee
Binh Le Tuan Tran

ORAL MEDICINE
Agnieszka Monika Frydrych

PAEDIATRIC DENTISTRY
Salwa Abdullah Al-Habsi
NEW MEMBERS AND FELLOWS ADMITTED AT THE CONVOCATION
Professor Ian Arthur Meyers of Brisbane, Australia is well known for his work in many facets of dentistry, including academia, public health, with dental organizations and in the College’s Membership Programme. Professor Meyers graduated in Dentistry from the University of Queensland in 1982. Following clinical practice in both public clinics and the private sector, Professor Meyers returned as a Lecturer to the School of Dentistry. In 2001, he was made Professor and appointed Colgate Chair in General Practice Dentistry. Professor Meyers is currently in general dental practice and has an adjunct professorial position with the University of Queensland. He is the current President of the Queensland Branch of the Australian Dental Association.

Professor Meyers has been involved in a wide variety of research projects in the applied dental biomaterials area and has run many postgraduate and continuing education courses on diagnosis and conservative management of tooth wear. He is Chairman of the Australian Dental Research Foundation Advisory Committee and on the Board of Directors for the Australian Dental Research Foundation. In addition he is a member of the editorial board of The Australian Dental Journal and several other international journals.

Professor Meyers has made a significant contribution to the College through his input, with expertise in both teaching and clinical practice, in the development of the Membership Pathway, MRACDS. Professor Meyers has been involved from the inception of the programme at the level of the working party and is currently a member of the Board of Studies, General Dental Practice. Under his guidance the programme structure has ensured clinical relevance as well as high standards of both the educational and assessment components of the programme. The high level of interest of the profession in participating in the Membership pathway in General Practice is recognition of the contribution and standards set by Professor Meyers and the members of the Board of Studies, General Dental Practice.

Following A unanimous resolution of Council on 20 November 2009, Ian Arthur Meyers is formally admitted as a Fellow of the Royal Australasian College of Dental Surgeons.
Mr Les Wallace is a Fellow of the Institute of Chartered Accountants in Australia and is registered as a Public Accountant and a Company Auditor. Les together with Mr Ted Brodie were initially appointed as auditors of the College at the Annual General Meeting held in the November 1976. Following Mr Brodie’s retirement in 1994, Les has completed the audits of the accounts of the College to the present day.

From the College’s conservative fiscal base of the 1970s Les has worked closely with the Honorary Treasurer of the day and has made himself available to discuss in detail the financial accounts with members of the Finance Committee. During this long association with the College, Les has been able contribute with his advice and expertise to the College’s vision of evolution and expansion.

For his services to the College Les Wallace is presented with the Presidential Commendation of the Royal Australasian College of Dental Surgeons.
Mr Leslie Snape, Oral and Maxillofacial Surgeon in Christchurch, New Zealand, received his dental and medical training at the University of Bristol. He is a Fellow of the Royal Australasian College of Dental Surgeons, as well as a Fellow of the Faculty of Dentistry of the Royal College of Surgeons in Ireland, and a surgical fellow of both the Royal College of Surgeons of Edinburgh and the Royal College of Surgeons of England.

Mr Snape has held numerous consultant and teaching positions in England and New Zealand. He has published widely in the field of Oral and Maxillofacial Surgery and has presented at scientific meetings both nationally and internationally.

Mr Snape has made a notable contribution to Oral and Maxillofacial Surgery training within the College. He is a member of the Board of Studies for Oral and Maxillofacial Surgery being first elected in 2003. Since 1992, he has also been involved in a number of the Committees of the Board of Studies OMS, such as the Examinations Committee, the Education Committee, the Regional Surgical Committee, the Advanced Surgical Training Committee and the Curriculum Implementation Group. Mr Snape has been the Chairman of the panel of examiners in Basic Surgical Sciences for OMS and is presently an examiner for the Final Fellowship in Oral and Maxillofacial Surgery, being Chairman of the Court of Examiners for the last seven years. He is the Director of the New Zealand National Training Centre in Oral and Maxillofacial Surgery.

Following the unanimous resolution of Council on 20 November 2009, Mr Leslie Snape is formally presented with the Meritorious Service Award.
Professor Marc Tennant has made a significant contribution to Rural and Remote Oral Health and in particular the plight of Indigenous Australians, as well as Dental and Oral Health education. He is the Founder and Director of the Centre for Rural and Remote Oral Health at The University of Western Australia, a unique Australian centre leading innovation in research, service and education focused on people with unmet need. He is also Adjunct Professor at La Trobe University, Griffith University and James Cook University where over the last decade he has played a strategic role in the development of each of these new dental schools; focused on serving the Australian community.

Professor Tennant completed his Bachelor of Dental Science in 1986 at the University of Western Australia, Dental School. In 1989 he completed his Master preliminary and then in 1994 he then completed his Doctorate in vascular biology. Professor Tennant is an Associate Fellow of the Australian College of Health Service Executives, a Fellow of the International College of Dentists, a life member of the dental student society of Western Australia and recipient of an excellence in service award from the Health Consumers Council of WA for services to the WA community.

Within the Royal Australasian College of Dental Surgeons, Professor Tennant has made a notable contribution to the Primary Examination, FRACDS. He has been a lecturer in the Orientation Program and examiner in the field of Anatomy and Histology since the late 1990s. He is a member of the Primary examination Committee. Professor Tennant has contributed his expertise also in the area of examination and assessment protocols to allow for the expansion of the examination venues to Hong Kong, Malaysia and Jordan.

Following the unanimous resolution of Council on 20 November 2009, Marc Tennant is formally presented with the Meritorious Service Award.
Neil John Joseph Peppitt of Sydney, Australia, graduated Bachelor of Dental Surgery from the University of Sydney in 1979. In the period 1979 to 1985, Dr Peppitt was in general dental practice in Sydney and surrounding suburbs, mentored by a number of notable clinicians. In 1983 he completed a Master of Dental Science at the University of Sydney and has been in specialist prosthodontic practice in Sydney since 1985. Dr Peppitt has held the rank of Wing Commander of the Royal Australian Air Force, Specialist Reserve since 1991.

Dr Peppitt’s involvement with the Royal Australasian College of Dental Surgeons commenced with the successful completion of the examinations for General Fellowship, which was awarded in 1987. As seen this evening Dr Peppitt has been awarded Membership of the College in the Special Field of Prosthodontics. He is also a Fellow of the International College of Dentists and a Fellow of the Pierre Fauchard Academy.

Dr Peppitt took an active role in the College soon after gaining Fellowship with involvement in the New South Wales Regional Committee, and became Chair of this Committee and also Chair of the local organizing committee for the Thirteenth College Convocation in Sydney.

In 1996 Dr Peppitt was elected to the Council of the College. During his time on Council he became familiar with all facets of the College having served on numerous committees including the Nominations Committee, the Continuing Professional Development Committee, the Committee and then Board of General Dental Practice, the Examinations Committee and the Finance Committee. He became Honorary Treasurer from 2002 to 2004, then President-elect in 2004 to 2006 and finally President from 2006 to 2008. As President, Dr Peppitt directed the introduction of significant changes to the College including the Membership pathway in both general and specialist streams and the relocation of the College office. Dr Peppitt continued to contribute to the Council of the College, returning for a further year as Immediate Past President in 2009.

Dr Peppitt has also contributed to the profession of dentistry through his involvement in the New South Wales branch of the Australian Dental Association; as a member of Council and Executive and as a member of numerous subcommittees including the Continuing Professional Development committee and Chairman of the Recent Graduates committee. He was also President of the Academy.
of Australian and New Zealand Prosthodontists and Chairman of the Australian Council of Dental Specialists. In 2007 Dr Peppitt was a director of the Australian Dental Council and is currently a member of the University Course Review panel of the ADC, a member of its panel of approved assessors and has been involved in postgraduate programme Accreditation at the University of Melbourne and University of Adelaide for both the Australian Dental Council and the Dental Council of New Zealand.

In teaching, Dr Peppitt has contributed as a tutor, Lecturer, Clinical Supervisor and Consultant to both undergraduate and postgraduate students of the Faculty of Dentistry at the University of Sydney. Dr Peppitt is an external examiner in graduate programmes in Prosthodontics for Melbourne, Queensland and Sydney Universities. Dr Peppitt is a visiting Professor and external Examiner in Undergraduate Prosthodontics at the Jordan University of Science and Technology. He has given numerous lectures and presentations both nationally and internationally.

Dr Peppitt’s contribution to the community has been displayed though his special interests including in provision of treatment to indigenous groups in Papua New Guinea and in Lao Cai on the Vietnam/China border. He has also been involved in the Fiji School of Medicine, department of Dentistry.

No citation for Dr Peppitt would be complete without a mention of his sporting involvement. He has competed, coached and administered in Rugby, Surf Life Saving and Rowing, representing his University, State and Country.

It has been through these attributes of the clinician, the educator and the “team player” that have combined to afford the Royal Australasian College of Dental Surgeons a Councillor and then President that has brought the College and its membership though a dynamic period of change and expansion.”

Following the unanimous resolution of Council on 27 February Neil John Joseph Peppitt is formally admitted as an Honorary Fellow of the Royal Australasian College of Dental Surgeons.
Governor Michael, Distinguished Guests, Ladies and Gentlemen: I am honoured to be here as the invited presenter of the Robert Harris Oration.

Permit me to begin by sharing with you several thoughts and observations about presentations such as the one I am about to give. I certainly hope that I can tie together the materials in the time that I have been allotted for this oration.

First, like all of you, I have attended innumerable occasions, ranging from formal graduation events marking major milestones in an individual’s life, to numerous conferences such as this marvelous gathering, where a designated speaker addressed the distinguished audience with the hope and expectation that he or she would be able to impart some nugget of wisdom, some crucial piece of information, that perhaps might have a transformative effect in the personal or professional life of each audience member.

Alas, in searching my memory banks, I have been unable to recall more than a scant few of the morsels of wisdom that I must have been exposed to in these hundreds of addresses. In many cases, although I am quite certain that we must have had a speaker, I have not been able to recollect either the name or the position of that individual, nor a single thing he or she might have said.

My sense is that this lack of recollection is perhaps more the result of my receptivity to the content of the presentation than to the actual or philosophical value of what the speaker presented. Thus, I am under no delusions about the probable long term effects of any profound thoughts I might share with you this evening. Accordingly, I have determined that I would best serve my role here, and best serve you, by interspersing this oration with some of what I believe to be fascinating bits of information that will, I hope, so engage your curiosity or your professional acumen that you will have no difficulty remembering them, even years from now. Indeed, in the best of all possible scenarios you will actually be eager to share them with family, friends, and colleagues when you return to your homes.

Second, I am guided in the presentations I make by the wisdom of the three Bs:

Be entertaining;
Be brief, and
Be gone.

I can certainly guarantee that I will be successful on at least two of those criteria, though I hope to accomplish what we refer to in sports as a hat trick, which is achieving three goals in the event.
And third, I am acutely aware that I am absolutely unqualified to address you on topics that are related to your expertise as dental professionals. Indeed, I am both honoured and fascinated that you would even consider allowing an attorney to speak at your gathering! As you may know, there is a strong sentiment in the United States that a significant detriment to the practice of medicine and dentistry, and to the achievement of affordable health care, is the fact that lawyers are ever at the ready in our litigious society to second guess and sue for any medical result short of perfection. But, as I tell my many friends in the medical and dental professions, the true problem is that there are too many people with law degrees, and not enough lawyers; the former merely being concerned with maximizing their remuneration while the latter are dedicated to the betterment of society as a whole. But I digress.....

As you can see from the slide, my remarks will span a range of ideas. I hope that by the end of my talk I will have tied them together, shared some things that you will find interesting, and stimulated your curiosity to the point where you not only remember some of what I bring forward this evening, but will be encouraged to do some research on your own in the coming weeks and months.

We recently celebrated the 50th Anniversary of the founding of NASA and, last year, the 40th anniversary of man landing on the moon. The space programme has made enormous and positive contributions to the betterment of society and the amelioration of the human condition over the past decades that is, I would submit, often underappreciated. This is particularly and demonstrably true with respect to advances in the medical profession, and I would like to share one of the many examples of that with you now. The one that particularly fascinates me demonstrates not only the impact of the space programme on our lives but, as importantly, the importance of the collaboration of ideas, and the value of the interdisciplinary cooperation that marks space programmes. I think that I am safe in declaring that the Hubble telescope is perhaps the most well known and loved telescope in the world.

It has provided information about the cosmos, and humanity’s place in it, that has inspired us. It has provided images of our solar system, our galaxy, and our universe that are so scientifically provocative and, at the same time, so incredibly beautiful that they are works of art capable of being displayed in museums. A few examples:

What is often forgotten is that after its initial launch, Hubble was, on a mission success scale, an unmitigated disaster! Because of imperfections in its optics, the pictures that it was returning to earth were out of focus and blurred. Even if a servicing mission could be planned to send a shuttle crew up to the Hubble to possibly fix the problem, such a mission was years in the future, purely speculative, and fraught with danger.

What was to be done?

Well, a number of extraordinarily talented scientists from several disciplines, including computer science, collaboratively worked the problem and developed an algorithm that took the data and compensated for the flaw in the optics, much like an optometrist would correct a vision problem. The pictures were demonstrably better!

Of significant import for our purposes, that was neither the end of the story nor, I believe, the most interesting part. Through this interdisciplinary approach, and the cross-pollination that comes from open scientific knowledge sharing, a radiologist had the brilliant idea to see if a similar algorithm could bring increased clarity to X-rays of patients. It did, and the result was, to cite one example, the ability to get more interpretive resolution in mammograms which has saved perhaps tens of thousands of lives through earlier detection of anomalies.

I cite this example because it is indicative of the unknown and unanticipated ancillary benefits that have resulted from the space programme and the interdisciplinary collaborations that it has fostered over the years. We often hear about advancements in computer technology and everyday inventions like Velcro that are traceable to the Apollo and other space programmes. What is not often appreciated are the innumerable spinoffs that have made our lives easier and our knowledge, particularly in the field of medicine, so much greater. The Hubble story is but one example.

In researching for this presentation I had the opportunity to meet with the folks in NASA’s Human Spaceflight Directorate about the medical breakthroughs that are traceable to the space programme. I know that you are aware of the contributions in the dental profession that have resulted
from improvements in X-ray and computer technology as a diagnostic tool. Likewise, improvements in materials from resins to bonding agents have been made that are traceable to NASA spinoff technology or to NASA research grants.

One of the most promising developments currently being pursued is research into countering the bone loss that is an unfortunate side effect of both weightlessness and radiation faced in long duration spaceflight. NASA is developing drugs and treatments that will have, we believe, a major impact on osteoporosis and, as I know you can particularly appreciate, the dental issues that result from bone loss and ageing.

Indeed, one of the major hurdles to human spaceflight and the ability to explore our solar system is the toll that long duration spaceflight takes on the human body. If we solved all of the thrust, lift, and propulsion issues associated with a journey to Mars within the next year, we still could not send humans because we could not protect them from the physiological impacts of space travel. Much more research is needed.

As we meet here tonight, significant research into biomedical issues associated with long duration spaceflight is ongoing not just here on earth, but some 350 kilometres above us on the International Space Station, the ISS, which may well be the most awesome engineering and construction feat that mankind has ever accomplished.

The ISS is over 100 metres in length, 40+ metres in width and, as you can see, made up of a number of modules and solar power panels. Every piece of this incredible structure was made on earth and then assembled in space, and many of the constituent parts were mated for the first time when assembled in space, a truly phenomenal attestation to the engineering skills of the partners. The ISS travels at almost 28 thousand kilometres an hour, circling the globe every 90 minutes.

Now 98% complete, this symbol of international cooperation will be totally completed by the end of this year and will have a permanent crew of six researchers who will be resident aboard the ISS for six months at a time. [The United States has recommended that the international partners agree to extend the ISS to at least the year 2020 so that its potential as a research and development asset can be fully exploited. This month, the Heads of Agency from the United States, Canada, Japan, Russia, and the European Space Agency (ESA) will hopefully agree to that extension.]

In light of this distinguished audience, I specifically asked our Human Spaceflight Directorate what the plan was if a researcher/astronaut on the ISS had a dental issue. They have considered this eventuality [though I must say that if I were an astronaut I would not take a great degree of comfort in the plan, but then I suppose that it is a better plan than most people on the frontiers had as recently as 50 years ago!] Dental instruments in orbit are limited to an array of tools like picks, elevators, probes and forceps, and, of course, antibiotics suitable for use in dental infections.

They informed me that in combined spaceflight experience (Russian, US, ISS Partners) dental problems in orbit have been rare, but there have been successful treatments of dental infections in long duration flight.

The real plan is an aggressive prevention programme coupled with a very strict screening programme and some training for dental emergencies. NASA recognizes that dental problems could actually cause an ISS evacuation event. Accordingly, all ISS crew medical officers (astronauts/cosmonauts with extra medical training - not necessarily physicians) receive training in handling dental emergencies, including dental anaesthetic blocks, temporary fillings, drainage of dental abscesses and extractions.

One interesting thing I would like to bring to your attention is the courage of the spacewalkers who assembled the ISS as well as those who travelled to the Hubble telescope...
during its servicing missions, the most recent of which was just last year.

As I mentioned, the ISS travels at roughly 28,000 kilometres an hour. At that speed, even a small piece of debris could have sufficient force to puncture the spacesuit resulting in a catastrophic event for the spacewalker.

By way of explanation, a one gram object moving at 1000 km/h has the same force as a kilogram moving at one km/h. Now think of that kilogram moving at 28 km/h and the force it would exert and you start to get an appreciation of the problem and of why space debris of even the smallest size can result in disastrous consequences to spacewalkers or researchers aboard the ISS.

**PROPORTIONALITY**

While the dangers of an unanticipated encounter with space debris can be catastrophic 350 kilometres above the earth, how much more dangerous would such an untoward event be for a spaceship many tens or hundreds of thousands of kilometres from earth? Fortunately, space is so vast and so inconceivably empty that the chances of such an encounter are quite remote. Here is another factoid that I hope stays with you: an analogy to the emptiness of space. If you were to consider an area the size of Australia and equate it just to our solar system in terms of space, then five bumblebees scattered throughout the entire continent would be more crowded than our solar system.

We humans have a very difficult time trying to get our minds to comprehend the true vastness of space because we tend to be limited in our appreciation of distance. We also tend to vastly overestimate our place in our solar system, our galaxy, and our universe. For the next several minutes I would like to hue closely to the title I gave to this presentation: Aristotelian Ethics, Cosmology, and Proportionality.

Was Aristotle one of the first astronomers. Philosophically, Aristotle believed that virtue lay in avoiding excess. For example, on a scale from cowardly to foolhardy, Aristotle would commend the virtue of courage as a preferred midpoint. Likewise, between arrogance and reticence, Aristotle would counsel that we seek to be confident. As one of the earliest astronomers, however, Aristotle was perhaps guilty (if that is the word) of hubris because he assumed that the earth was the centre of the universe and that the sun and stars, as well as the then known planets, revolved around the earth.

Not that he was alone in this thought. In fact, his assumption was the consensus until some 2000 years later when Copernicus demonstrated that, in fact, the sun was the centre of our system. A century after Copernicus, Kepler and Galileo demonstrated that ours was not the only solar system, and this was followed by Newton and the gifted mathematicians who began to understand the great distances involved in the then visible universe. This historical lack of appreciation for the scale of the solar system and the known universe was quite understandable. Allow me to highlight our lack of perspective and proportion with the following example:

Assume that the world is EXACTLY 40 thousand kilometres at the equator, and that it is perfectly smooth all around that equator.

Now assume that some mischievous individual with 3 extra metres of steel belt material decides to cut the belt and weld in this 3 extra metres. For the sake of argument, let’s
assume that the belt, now slightly looser than before, doesn’t just fall off into space. This 3 extra metres has made a gap of some dimension between the earth and the girdle. The question is the height of this gap. Is it:

So small that one couldn’t even slide a hair thin wire under it?

Sufficient that one could push a golf ball through to the other side?

Large enough to comfortably crawl under to the other side?

Well, that is one example of our human tendency not to understand proportionality. While 3 metres added to 40 million metre circumference seems miniscule, so is the one metre increase in diameter to the 13 million metre diameter!!

Allow me to now get into the cosmology part of this presentation and to share some truly astounding figures with you.

We now know that not only is our sun the centre of our solar system, but we also know that our solar system is just one of many in our galaxy. How many? Well, first thing to understand is that our sun is a star, and as a star it is rather unremarkable in size and mass. It is rather puny.

It is also rather common. In fact, our galaxy, the Milky Way, has somewhere between 2 BILLION and 4 BILLION stars in it. Yes, BILLION!! And our galaxy is just one of BILLIONS of galaxies in the known universe. Leaving aside whether we actually understand the concept of a known universe, and leaving aside whether we are just in one of MANY universes, let’s play with some numbers. I asked my astrophysicist friend, Dr Ed Weiler who is referred to as the father of the Hubble telescope and now leads NASA’s Science Directorate, if there was an estimate of how many stars were in the observable universe and he his said yes. He then told me that there were $10^{23}$

100,000,000,000,000,000,000,000,000

He then started into a discussion about dark energy, antimatter, black holes and event horizons until, candidly, my head hurt.

What I was really after were his thoughts on the existence of extraterrestrial life. He then shared with me the remarkable discoveries in just the past several years:

Water on the moon,

Abundant water on Mars,

Water on Europa, a moon of Jupiter,

Water on Enceladus, a tiny moon of Saturn.

Indeed, water seemingly quite abundant in just THIS solar system!

Water, giver of life: … H₂O : hydrogen for fuel; oxygen to breathe …water to spawn life!

Now, assuming that only one in 10,000 solar systems can have planets that may contain water, we now have 10 to the 19th power solar systems that meet this definition. Let’s assume that only one in 10 million of these solar systems have a planet that replicates earth’s favourable distance from its star (not too close; not too far): we now have $10^{12}$ possible earths out there just in our known universe!

Well, if that’s the case then WHY haven’t we seen evidence of other life or been contacted? Again, I must fall back on some staggering numbers. Our solar system orbits within our Milky Way galaxy over a period of about 220 million years. This means that, since the beginning of human life on earth, our solar system has travelled only about 1/1000th of its orbit in our galaxy! Not much!

Now, consider the fact that Alpha Proxima, the nearest star to our solar system, is approximately 4 light years away. Even if we could build a spacecraft that travelled at 100,000 km/h, it would take us….. hold on…..

More than 42,000 YEARS to get there – to get to THE NEXT NEAREST SOLAR SYSTEM! So, interstellar travel? Hard to imagine. Inter-GALACTIC travel…… totally incomprehensible. When you start measuring distances in light years you are essentially saying no way to human exploration at those distances. So, we should, absent warp drive, restrict our ambitions to travel within our solar system.

How far is a light year? Light travels at approximately 300,000 km/s. There are 60 seconds in a minute, 60 minutes in an hour, 24 hours in a day and 365 days in a year. This makes 31,536,000 s in a year. Multiply this by 300,000 and the answer is 9,460,800,000,000 km in a light year.

The known universe is thought to be 14 billion years old and, roughly, some 28 billion light years across!

And, it is expanding!

Our spiral galaxy, the Milky Way, is a mere 100,000 light years across and about 1000 light years in thickness. I mentioned the incredible Hubble telescope earlier. I would be remiss, however, if I didn’t mention the next great thing in astronomy, the James Webb Space Telescope, JWST, a cooperative effort between the US, Canada, and ESA.

Hubble sits in an orbit about 650 kilometres above the earth, and current plans call for it to be de-orbited in 2015. [We are going to try mightily to have it avoid landing in Australia, by the way!] JWST, which is planned to be launched aboard an Ariane 5 rocket in 2014, will be placed at a Lagrange point some 1.6 million kilometres in space.

A Lagrange point is a point in our solar system where the gravitational pull of the sun and the planets is essentially nulled out, allowing an object to station keep indefinitely.

JWST will be 100 times more powerful than Hubble and, we can predict with some certainty, will lead to discoveries as yet both unimagined and unimaginable.
Now, back to Aristotelian ethics momentarily. I mentioned the *hubris* of presumption that gripped Aristotle, and indeed all of humanity, regarding humanity’s place and importance in the cosmos and in the grand scheme of things. Those of you with a theological bent will recognize that the obverse of presumption is despair. I suppose that one could say that with the travel times and distances involved, with the sheer magnitude of the known cosmos, and with the human, biomedical, and technical problems associated with space flight, I may sound as if I despair of human exploration and what it might bring.

Candidly, quite the opposite. I truly believe that we are in, and will continue to witness, the greatest era of exploration, both human and robotic, that can be conceived. I believe that those among you who choose to play a part in this can do so by considering the biomedical and dental problems associated with long duration spaceflight and contemplating whether you have a possible solution.

Exploration of the cosmos is not the province of any one nation; it is for all of humanity.

As Neil Armstrong so aptly stated when he set foot on the moon that July 20 1969, “That’s one small step for a man, one giant leap for mankind.”

I want to thank you for your invitation to share some time together. I try to finish speaking before people finish listening, and I hope that I have done so this evening, that I have at least succeeded on most of the Be’s, and that you will remember at least some of the factoids that were a part of this presentation.

In closing, let me share that I was delighted to learn last month that in a recent survey three of the ten most livable cities in the world were here in Australia: Perth, Sydney, and Melbourne. [Not a single American city made that list, by the way!]

Among the many factors that were considered in that survey, and figuring prominently, were the hospitality and the friendliness of the citizens. My wife, Kathy, and I have certainly experienced these here in our travels, and we look forward to meeting and chatting with you this evening and at the conference. Thank you for your attention.

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Editor’s Note: Brigadier General Wholley has graciously made his PowerPoint presentation available and it is appended as a file on the Annals CD-ROM. While all NASA images in this paper are in the public domain, the College gratefully acknowledges their permission to use them in this publication.
The Young Lecturer’s Award at this year’s convocation, sponsored by Colgate, was once again a highlight of the scientific program. This year there was keen interest in the award with six post-graduate students presenting and the judges were faced with an extremely difficult decision. The candidates and their presentation titles were:

Dr Robert Fell (University of Sydney): Correlation of serum and GCF adipokines in obese patients.

Dr Dieter Gebauer (Royal Perth Hospital): Athletic mouth guard designs, facial skeletal profile and their effects on upper airway respiratory functions / ventilation in athletes.

Dr Danny Sai-Wah Ho (University of Sydney): Clinical and radiographic evaluation of NobelActive™ dental implants: a prospective split-mouth comparative study?

Dr Yiu Yan Leung (University of Hong Kong): Coronectomy as the treatment of choice in wisdom teeth showing radiographic signs of close proximity to inferior dental nerve.

Dr Jessica O’Neill (University of Sydney): Early wound healing following a mechanical cleansing post-surgical protocol - a randomized controlled trial.

Dr William Zhang (University of Sydney): Incidence and magnitude of viridans streptococcal bacteraemia caused by flossing or scaling and root planing in patients with chronic periodontitis.

All of the presentations were of high quality and the judges commended all participants. The high calibre of the research and the exacting manner in which the lecturers delivered their presentation and answered questions; highlighted the fact that these more recent dental graduates and future members and fellows of the College all have bright futures in their chosen field. Unfortunately there could only be one winner and this was Dr Jessica O’Neill from Sydney. She was awarded a certificate and a cheque from Ms Angela Tascone from Colgate Oral Care (WA). The five other candidates were presented with Certificates of Achievement. Thank you to the judges Associate Professor Werner Bischof, Professor Andrew Smith and Professor Martin Tyas for what would have not been an easy decision. 

*Presented at the Closing Ceremony on Sunday 14 March 2010.
†Papers and Abstracts of these presentations are included in this Volume of the Annals.
ANNALS OF THE
ROYAL AUSTRALASIAN COLLEGE
OF DENTAL SURGEONS

SCIENTIFIC PROGRAMME
PAPERS AND ABSTRACTS
FROM THE
THE TWENTIETH CONVOCATION OF THE
THE ROYAL AUSTRALASIAN COLLEGE OF DENTAL SURGEONS

PERTH, WESTERN AUSTRALIA, MARCH 2010
AESTHETICS IN IMPLANT THERAPY: A BLUEPRINT FOR SUCCESS AND CHANGE

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ABSTRACT

High-end implant aesthetics requires precise steps from diagnosis through surgery to the restorative phase. These steps are not exclusive of each other. They are deliberate and require a clear understanding of what is possible and the skills that are required to carry out each procedure. Every small advancement will help in the initial and long-term stability of the treatment. This article will dissect implant treatment into key concepts and procedures, illustrating how these steps are crucial to a highly successful aesthetic outcome.

INTRODUCTION

Preserving hard and soft tissue anatomy from the moment of tooth extraction is essential to meeting the goal of achieving ideal soft tissue aesthetics in implant based oral rehabilitations.1 With this starting point in mind, the following concepts and techniques are considered and will be illustrated with clinical cases and supporting literature, with the goal of maintaining ideal gingival anatomy from the time of extraction through restoration and beyond.

RIDGE AUGMENTATION

This is commonly required prior to or in conjunction with implant placement, in order to position implants in a prosthetically directed position. There are many ways to correct bone defects, ranging from using autogenous block or particulated grafts of intraoral or extraoral origin, allografts in various forms, guided bone regeneration using barrier membranes frequently combined with bone or bone substitutes, ridge expansion techniques and distraction osteogenesis. To date, most clinicians have had good success with horizontal ridge augmentation efforts, but remain more challenged with vertical bone growth. Cases will be used to illustrate a broad range of treatment approaches as well as the rationale for material selection. Treatment limitations will be emphasized.

Although treatment outcomes in partially edentulous patients have long been recognized as highly successful in terms of integration, aesthetic successes lag behind, especially when dealing with sites with preoperative vertical ridge deficiencies.2,3 Recognizing the importance of an inter-disciplinary approach to implant placement has improved the aesthetic outcome goal. Orthodontic extrusion followed by extraction has become an integral element in the development of the site with vertically deficient bone. This technique requires that there is an intact periodontium around the tooth that is to be replaced with an implant. A slow extrusion and subsequent stabilization of the extruded tooth allows the coronal migration of the periodontal ligament (PDL), bone and gingival tissue complex in a site that initially presents with a vertical deficiency. The authors’ clinical observations have shown that extrusion to a tissue excess of 25-30% will result in close to ideal soft tissue contours at final restoration. Overextrusion simply complicates matters because landmarks are lost and the procedure necessitates a subtractive surgical process. Projected apical migration of the facial soft tissues caused by flap elevation, or by disconnection and reconnection of prosthetic components, can be compensated for in the development of the 25-30% excess tissue.

The importance of using an appropriate vector of root movement during the extrusion procedure in order to avoid adverse changes to hard and soft tissue cannot be overemphasized. Complications arising from orthodontic site development can be expected when the root torques facially during the extrusion process resulting in facial dehiscence. Equally problematic is the potential for causing gingival recession in cases where a root is severely facially displaced, requiring corrective soft tissue grafting procedures.

SURGICAL STRATEGIES

Minimizing extraction induced bone loss.

Meticulous extraction techniques are necessary to conserve existing bone for any implant placement protocol. This is often the most challenging aspect of the surgical treatment phase, since many of the teeth being extracted have little remaining coronal tooth structure to engage with forceps because of fracture level, extensive caries, or resorption lesions. A variety of instruments have been developed, including periotomes, new extraction forceps or vertical root/tooth extraction devices. These instruments can be beneficial adjunctive tools, helping avoid unintentional bone loss during the extraction procedure, as well as avoiding deliberate bone removal that is sometimes used to facilitate the extraction procedure.

* Presented at the Twentieth Convocation of the Royal Australasian College of Dental Surgeons, Perth, Western Australia. March 2010
The ideal time to place an implant.

There are several routinely used and well studied implant placement strategies, including delayed implant placement relative to the time of extraction (three or more months after tooth extraction), early implant placement following extraction (within weeks of extraction), immediate implant placement (at the time of extraction). One approach is not necessarily better than the other and the merits of each must be considered case by case. Notwithstanding this comment, immediate implant placement presents many advantages when the pretreatment soft and hard tissue frameworks are ideal or close to ideal.

Immediate implant placement.

Appropriate case selection for this procedure is important. Improper case choice is the most significant reason for potential complications associated with this treatment approach.1 This technique was first reported in 1978 by Schulte et al. and its advantages described by Lazzara in 1989 and subsequently others.2-4 Immediate implant placement may improve soft tissue aesthetics earlier in the healing process by preventing unfavorable soft tissue architecture changes that are linked to bone contour changes.5 Healing and implant integration may also benefit from the inherent potential for bone repair triggered by the extraction process. One might describe the site as “primed” or “destined” for healing.6

A key point in successfully applying the immediate implant placement technique is the development of appropriate case selection criteria. The literature provides information that helps develop basic guidelines, but personal experience ultimately refines the therapeutic approach.7 Retrospective assessment of more than 400 immediate implant placement cases over the last 10 years in the authors’ practice has produced aesthetic results that are equivalent to or better than conventional implant placement strategies, despite facial bone defects of varying degrees. This is in contrast to the report by Funato et al. that reported less aesthetic treatment outcomes in cases where the facial bone plate presented with dehiscences or fenestrations.8 The following are parameters that should be considered to ensure accomplishment in achieving a successful and aesthetic outcome:

a. No active infection or an infection that can be eliminated through the site preparation. Some clinicians elect to delay implant placement subsequent to tooth extraction in situations where there is active infection; however, many clinical case reports and retrospective analyses suggest that implant success rates are not necessarily adversely affected despite placement into previously infected sites.9-11

b. Adequate residual ridge architecture for implant positioning in a prosthetically driven position, with sufficient primary implant stability as determined by insertion torque. In practical terms, an implant inserted with 35-45 Ncm torque has sufficient stability for immediate placement and in some cases for immediate restoration. Implants placed with lower torque are at greater risk for osseointegration failure, especially if loaded.12

c. As important and frequently not considered by many clinicians, a variety of soft tissue grafting procedures are routinely used to improve the periodontal biotype and to decrease the risk for facial gingival recession.13,14 In doing so, crestal ridge remodelling may be diminished by enhancing the connective tissue component of the biologic width. This will be discussed in greater detail in the grafting component of this presentation.

Microsurgery and ‘incisionless’ surgery.

Technology has afforded dentists the ability to improve surgical and restorative outcomes through techniques assisted by magnifying devices and microsurgical instruments, often resulting in dramatically less traumatic procedures.

Flapless surgery may include working through an extraction socket or creating a punch-access in a healed site, but has the obvious limitation of restricting operator viewing of ridge anatomy. This is offset with the benefit of minimizing hard and soft tissue contour changes that are associated with flap elevation.15 This treatment approach can be used in situations where preoperative clinical and radiographic information confirm that the ridge form in the implant site is ideal and where ridge augmentation procedures requiring access for application of grafting materials are not required. Although conceptually an easy surgical strategy, studies such as the 10-year retrospective study of Campelo and Camera report that the level of operator experience has a significant impact on the treatment outcome.16 Their report noted that initial implant success rates were as low as 74.1%, but improved to 100% with greater operator skill. With this surgical approach, it is essential to pre-operatively evaluate the ridge contour, the position of adjacent roots and the location of critical anatomic structures, because the surgery is essentially “blind”. With this in mind, CT scans or tomograms are helpful, and probably should be considered essential to guarantee treatment success and safety.

With the objective of refining surgical treatment protocols, computer-assisted planning and implant placement minimizes chair-side operator errors by allowing accurate planning and virtual treatment on a computer screen. Some of these computer-based systems are coupled with flapless or incisionless surgical approaches, making treatment more rapid, less traumatic to hard and soft tissues, and often improving the post-surgical experience for the patient. The dentist must be knowledgeable about and be able recognize the potential benefits of these technological advances in each case being planned.

Furthermore, emerging diagnostic and planning guided software programs that reformat digital files into 3-D images also allow the clinician to preview the surgical site, to accurately plan and subsequently place implants in an ideal position with a clear knowledge of all relevant anatomic concerns prior to treatment. Although this revolutionary technology will undoubtedly influence all of our practices in the future, there are still inaccuracies between planned and executed implant placement as documented in recent studies.17,18
Immediate restoration

Immediate restoration has not been shown to adversely affect the biological integration process. Although some studies report lower implant success rates with this approach, many studies report success rates that are equivalent to conventional implant placement with delayed restoration. A consensus conference statement on the topic of immediate loading for single and partially edentulous sites provides clinicians with guidelines on parameters that should be considered in immediate implant loading.

THREE-DIMENSIONAL IMPLANT POSITIONING

Positional errors in implant placement can have a dramatic impact on the aesthetic outcome of the treatment. Even subtle positioning errors can produce significant negative soft tissue level and quality changes that cannot be corrected. Significant positioning errors often necessitate implant removal and ridge reconstruction followed by implant replacement, or submerging the implant and putting it to “sleep” by restoring the case with a fixed partial denture.

Today, there are clearly established guidelines that define the ideal positioning of implants relative to adjacent teeth and other implants in the aesthetic zone; they are essential to follow to ensure an aesthetic treatment outcome. These guidelines are considered applicable to any implant system being used. The following positional decisions must be considered to create a pleasing result:

1. Facial-palatal position:

   Guidelines on facial-palatal positioning have been established by several authors. A thin facial cortex surrounding an implant will be prone to resorption, resulting in an unstable buccal soft tissue contour and subsequent recession. Therefore, careful consideration of the diameter of the implant being placed is important. The tendency is to select an implant that obliterates the socket, but in doing so, this limits the space available for potential osseous regeneration. Optimal facial ridge contour is essential in the objective of ideal aesthetics for the final restoration. The goal of at least 2 mm of buccal ridge thickness is required for long-term soft tissue stability. Leaving a residual horizontal defect (HD) that can be grafted with a biocompatible and structurally stable bone grafting product is suggested to be ideal for long-term soft tissue stability. Adjunctive use of bone grafting techniques is advocated to correct residual horizontal defects (HD) greater than 2 mm between an implant and the walls of an intact extraction socket. The authors’ retrospective results suggest that use of a densely packed non-resorbable porous bovine bone material like Bio-Oss in the residual defect appears to support the buccal ridge contour, reducing its resorption and associated gingival recession. In the Chen et al. prospective study horizontal defects were filled with or without bone/membranes (Bio-Oss and Bio-Gide). Bio-Oss significantly reduced horizontal resorption of buccal bone. Vertical bone resorption occurred regardless of treatment. Marginal tissue recession occurred in 33% of sites (1-3 mm). They comment that resorption of buccal bone may have an adverse effect on the stability of the peri-implant mucosa and the soft tissue aesthetic outcomes.

2. Apical-coronal positioning:

   It is generally accepted that the optimal depth of the implant collar in the aesthetic zone is approximately 3 mm apical to the ideal buccal free gingival margin, but may vary with some implant designs. Implants that are too deeply positioned will result in greater crestal bone remodelling because of the deeper positioning of the implant-abutment microgap relative to the ridge crest. The consequence is an increased risk for soft tissue recession because of remodelling of both buccal and proximal marginal bone, or in cases where there are thick bony walls, an increased risk for deep pocket formation and chronic inflammation. The risk of negative change to papilla form increases since the integrity of the adjacent periodontium becomes even more important to the aesthetic outcome. On the other hand, implants that are not adequately submerged may present an obstacle to the development of an ideal crown form, because of inadequate room to develop normal emergence contour.

3. Mesial-distal positioning (Fig. 1):

   The position of an implant relative to adjacent teeth must be considered since this can significantly affect papillary support. It is also important in the positioning of adjacent implants. The established guidelines are that an implant should be positioned a minimum of 1.5 mm away from an adjacent root in order to avoid inducing bone loss at the adjacent tooth due to the lateral component of crestal bone remodelling.

   Implant positioning mesio-distally is equally important when it comes to adjacent implant placement. In situations where adjacent implants are placed, it is recommended to leave a minimum of 3 mm between implants, in order to avoid the coalescing of adjacent remodelling zones resulting in a vertical bone loss pattern, which translates into blunting of the inter-implant papilla. The authors’ clinical results suggest that ideally at least 4 to 4.5 mm should be maintained to support long-term stability of the inter-implant bone peak. However, implant designs that reduce crestal remodelling through platform-switching may allow a reduction of spacing between implants because of enhanced crestal bone stability.

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Fig. 1. – Ideal implant positioning for aesthetics includes correct proximal orientation between teeth and implants, and adjacent implants.
IMPLANT AND ABUTMENT DESIGN
CONSIDERATIONS
The type of implant selected for use by different clinicians is unlikely to be based on differences in clinical success/survival, but more likely on perceived advantages of design for the area being treated, versatility of the system, user-friendliness, product reputation and the availability of technical support. With conventional implant and abutment designs, angular defects or a circumferential sauceration effect occurs. There are several areas of research focused on improving hard and soft tissue topography around and between implants. Several theories exist as to why crestal bone changes develop after restoring the implant, and this has spawned interest and research in the following:

A. Although there is a clear trend for increased use of textured or roughened implant surfaces, because of the reported enhanced bone-to-implant contacts compared with machined implants, a recent systematic review of randomized controlled trials by Esposito with machined implants, a recent systematic review of textured or roughened implant surfaces, because of the improved bone-to-implant contacts compared with machined implants. Several theories exist as to why crestal bone changes develop after restoring the implant, and this has spawned interest and research in the following:

1. Use of pre-fabricated and modifyfable zirconia abutments allowing placement of an abutment at the time of surgery will be illustrated. This approach eliminates or reduces prosthetic component removal, thereby minimizing disruption of the biologic attachment. Controversy exists on how finishing procedures may impact on the flexural strength and structural stability of zirconia. Careful preparation or surface treatment of these abutments needs to be considered to avoid introduction of flaws that could propagate resulting in fracture.

THE GINGIVAL BIOTYPE
Although not well researched or reported in the dental literature, the importance of adequate keratinized mucosal tissue volume and height, and the role of connective tissue grafts in implant therapy is an area of current focus as it relates to implant aesthetics. Facial recession over an implant restoration is still a commonly reported complication. The soft tissue biotype has a significant impact on soft tissue stability and hence on the aesthetic outcome of the restorative treatment. As a result, connective tissue graft (CTG) procedures and other tissue grafting techniques have an important role in enhancing soft tissue constancy around implant restorations. CTGs are routine peri-implant surgical procedures that have customarily been used for regeneration of tissues over exposed roots and for correction of minor ridge deficiencies. Today, they are routinely incorporated into implant surgical procedures to change the gingival biotype from thin to thick, to develop tissue height in sites with facial soft tissue deficiencies and to improve tissue bulk in areas with mild to moderate pre-operative ridge concavities that develop following tooth loss. Incorporating the CTG procedure at the time of implant placement has produced superior soft tissue results in terms of tissue stability. The enhanced vascularity afforded by microsurgical flap design and careful tissue handling results in unparalleled graft success and more importantly, in predictable soft tissue levels. Figure 2 illustrates graft harvesting from the palate using a trap-door approach. This technique will be described in detail. In the authors’ experience, grafting around implants with a thin biotype has significantly reduced the complication of post-restorative facial tissue recession.

PROVISIONALIZATION
This must be viewed as the non-surgical refinement of the soft tissue architecture and considered a final step.
in the surgical protocol rather than the first stage of the restorative procedure. Although it is clear that the soft tissue architecture initially formed around a healing abutment is rarely ideal, the gingival framework will develop following the final restoration. This process can take up to two years. Provisionalization allows refinement of the soft tissue framework prior to the final impression. Figure 3 illustrates a scalloped ridge anatomy as developed with a screw-retained provisional restoration. As a result of provisionalization, a precise transfer of information to the technician/ceramist about the clinician’s developed and the patient-approved soft tissue framework is possible.

**IMPRESSION TAKING PROCEDURES**

A predictable technique involves customizing the impression coping with composite to more accurately register the subgingival prosthetic envelope anatomy. Tissues that have been well defined with a provisional restoration may still be prone to collapsing when the restoration is removed if the gingival biotype is thin or if the tissue is inflamed. Customizing an abutment based on registration or indexing of the provisional crown form most accurately allows transfer of information about the desired crown and abutment contours to the ceramist. This is done extra-orally and will 100% accurately reproduce the idealized soft tissue anatomy as developed by the provisional restoration. Figure 4 illustrates stock impression copings prior to customization. Commonly used impression techniques will be illustrated.

**ZIRCONIA**

The advantages of Zirconia abutments over titanium abutments in the aesthetic zone include:

*High flexural strength/resistance to fracture* for restoration of anterior implants (Zirconia approximately 1000 MPa flexural strength, Alumina approximately 600-700 MPa).

*Excellent bio-compatibility and low plaque-retention.*

Digidi *et al.* found higher inflammatory mediator levels, more angiogenesis, increased blood flow and oedema with titanium than zirconium. Scarano *et al.* reported that removable an acrylic device in the molar-premolar region with titanium surfaces had 19.3% of surface covered by plaque, vs. zirconium with 12.1% of surface covered by plaque, and Rimondini *et al.* showed that titanium surfaces appeared to be coated uniformly with biofilm structures, whereas zirconium surfaces were colonized by clusters of bacteria. This was considered to be of decisive importance for peri-implant soft tissue health. Interestingly, Mustafa *et al.* found that zirconia that was milled and not modified by laboratory procedures showed enhanced fibroblast binding over polished or veneered zirconia.

Coronal movement of the cement line thereby facilitating the cementation process and avoid cement entrapment.

Enhanced tissue colour by avoiding the greying effect of titanium abutments. Jung and co-authors using an *in-vitro* pig jaw model reported that unless gingival tissues are 3 mm thick, that all materials have an impact on tissue colour as assessed by spectrophotometry. The authors’ observations are that tissues are generally less than 2 mm thick at the free gingival margin level, with most tissues in the range of 1 mm thick. As a result, using a titanium abutment would have a profound impact on tissue colour, unless the cement line is deeply submerged.

**CERAMICS**

Rationale for considering all-ceramic restorations for teeth and implants:

*High clinical success rates*: A comparison of all-ceramic restoration vs. metal-ceramic restorations produced similar 5-year survival rates for single implant restorations and fixed partial dentures. The major reasons for failure in the ceramic fixed partial dentures were technical and biological complications and not related to framework failure.

*Complications*: peri-implantitis and soft-tissue complications 9.7%, bone loss > 2 mm 6.3%, implant fractures 0.14%, screw or abutment loosening 12.7% (outlier study), screw or abutment fracture 0.35%, ceramic or veneer fracture 4.5%. Potential reasons for chipping will be reviewed.

*Aesthetic outcomes of implant-supported restorations*: These are rarely reported in the literature. Only seven of 26 studies...
evaluated by Jung et al., in a meta-analysis assessed aesthetic outcomes. In these studies, 8.7% of cases were deemed to be unacceptable or semi-optimal from an aesthetic perspective. The major limitation in current outcomes assessments is that there are no standardized aesthetic criteria. Figure 5 highlights a pleasing aesthetic result on adjacent implants in the positions 11 and 21.

Marginal fit of all ceramic restorations: discrepancy before and after cementation will be discussed and supported with documented outcomes in the literature.66, 67

This clinical scenario still presents a persisting aesthetic challenge. Side-by-side implant placement has been notoriously difficult from an aesthetic perspective, regardless of the placement strategy used. Achieving ideal soft tissue form between adjacent implants is unpredictable because simultaneous and multiple tooth loss often leads to resorption of the labial bone plate and flattening of the interproximal bone scallop.68 The sine qua non is that it its difficult to maintain papilla architecture between implants, and even more challenging to recreate it when it is deficient at the treatment onset. Using newer implant designs and surgical and restorative strategies to minimize hard and soft tissue remodelling may improve the probability of maintaining ideal soft tissue outcomes. The importance of ideal surgical strategies and the potential benefits of new implant designs that support ideal hard and soft tissue levels around adjacent implants are underscored and are described in the article and textbook chapter by Leziy and Miller.48, 69 A retrospective radiographic and aesthetic evaluation of scalloped implants and a case series report indicated that there are limited advantages to using this implant design.70, 71 In contrast, McAllister recently described enhanced interproximal tissue preservation with scalloped dental implants and discusses the potential limitations or flaws in the design of these former studies.72

Implant placement and timing strategies can also contribute to enhancing the soft tissue result. Rungcharassaeng and Kan recommend sequential implant placement in order to minimize remodelling or loss of the inter-implant bone and soft tissue.73 Interestingly, their report suggests that allowing an implant to integrate and to support a restoration before the extraction of an adjacent tooth and the placement of a second adjacent implant stabilizes the proximal hard tissue levels and increases the likelihood of maintaining the papilla form. The authors’ unpublished results with this technique suggest that results are equivocal to simultaneous placement of adjacent implants in terms of papilla architecture.

From this discussion on implant aesthetics, it is clear that significant preplanning and an understanding of the diverse implant placement strategies and adjunctive procedures have a significant impact on minimizing adverse hard and soft tissue contour changes from the time of tooth extraction. The goal of this review is to encourage the clinician to consider and explore changing concepts such as minimally invasive surgical procedures, new implant and abutment designs, the role of the biotype in tissue aesthetics and stability, and advances in restorative materials and their management. It is also the intent of this review to emphasize that implant treatment in the aesthetic zone requires a wide knowledge base in both the surgical and prosthetic aspects of treatment to achieve optimal aesthetic outcomes as a treatment goal.

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ABSTRACTS OF PAPERS
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PERIODONTAL TISSUE REMODELLING DURING ORTHODONTIC TOOTH MOVEMENT

The purpose of orthodontic treatment is to move teeth into a new position in an efficient way without creating too much adverse effects on periodontal and dental tissues. However, teeth can only be moved when periodontal tissues are remodelled. While bone remodelling would be sufficient to move a tooth, other tissues are involved as well. Tissues affected include bone, periodontal ligament, cementum, dentine, and gingiva. The type magnitude, and duration of applied force determine location, extent and length of tissue alterations. From histological studies it is known that pressure and tension sites can be distinguished during orthodontic tooth movement. On the tension site, periodontal ligament fibres are stretched and there is activated blood flow and enhanced osteoblast and cementoblast activity, which leads to increased bone and cementum formation. On the pressure site, an intricate chain of events occurs in bone, the periodontal ligament, and the root surface. Orthodontic tooth movement elicits both physiologic and pathologic tissue responses to externally applied forces. Superimposed on the physiologic adaptation of alveolar bone, orthodontic tooth movement is accompanied by minor and normally reversible injury to the tooth-supporting and dental tissues. Thus, events associated with both mechanotransduction to various cell types and formation and resolution of tissue necrosis need to be considered.

Most experimental studies on tissue alterations during orthodontic tooth movement have been performed in animals, such as rats, dogs, cats, and monkeys. There have always been concerns regarding extrapolation of such findings to the human situation. While basic biological mechanisms may not really differ, the magnitude of strain as well as speed and extent of tissue alterations may vary considerably from one model to another. It is known, for instance, that both normal tissue development and tissue alterations incident to orthodontic treatment proceed at a much faster pace in rats than in humans.

In the following, an attempt will be made to include as much data as possible from human experimental studies to describe the sequence of events on the pressure sites separately for the three compartments bone, periodontal ligament, and the root surface. At the end, an important system of molecules that regulate tissue remodelling induced by both mechanical and inflammatory stimuli will be presented.

A) Sequence of Events in Bone

Osteoclastogenesis in orthodontic tooth movement is brought about by two related events: periodontal ligament tissue damage and mechanical deformation of the alveolar process. Mechanotransduction involves sensing the mechanical signal by cells, transduction of this mechanical signal into a biochemical message, transmission of the biochemical signal to the effector cells, and the effector cell response. Osteocytes are candidates for being the mechanosensing element in bone. They may turn off the inhibition of osteoclasts and, therefore, trigger local bone resorption. Soft connective tissue damage like necrosis elicits a sterile inflammatory reaction. Inflammatory mediators (cytokines and other signalling molecules) are important initiators of osteoclastogenesis. Osteoclast progenitor cells appear at sites of compression within days after force application. Osteoclast induction first occurs in vascular and marrow spaces of the alveolar crest. Clearance of osteoclasts from compression sites is initiated by osteoclast apoptosis.

B) Sequence of Events in the Periodontal Ligament

Orthodontic tooth movement leads to a local compression of the periodontal ligament. The resulting tissue alterations in the periodontal ligament include a reduction in width, vascular changes, tissue damage, and eventually remodelling. More specifically, the chronological sequence of biological events at pressure sites can be summarized as follows: (1) Vascular changes like disturbances in blood flow, increase in vessel density and number, and vasodilatation with increased vessel permeability; (2) Exudation of blood plasma and release of platelets and erythrocytes into the extravascular space (haemorrhage); (3) Cell death in the compressed tissue area (hyalinization); (4) Coagulation and extravasation of leukocytes; (5) Invasion of the necrotic tissue compartments by monocytes, macrophages, and multinucleated giant cells; and (6) Remodelling of the necrotic tissue through tissue resorption, granulation tissue formation, and development of a provisional soft connective tissue that may later mature and become functional.

C) Sequence of Events on the Root Surface

The wound healing process in the necrotic periodontal ligament involves the participation of various inflammatory cells, such as neutrophils, monocytes, macrophages, and multinucleated giant cells. Many multinucleated giant cells are seen three weeks after force application at sites of active necrotic tissue removal. The presence of multinucleated giant cells coincides with early signs of root resorption. It has, therefore, been suggested that there is a causal link.
between removal of necrotic periodontal ligament tissue and root resorption. Odontoclasts, which resorb cementum and dentine, arise from the monocyte/macrophage lineage. It may, thus, be argued that cementum and eventually dentine are resorbed, because of the presence of osteoclast precursor cells in the necrotic periodontal ligament undergoing remodelling. Alternatively, the possibility cannot be excluded that multinucleated giant cells transform into functional odontoclasts when they come into contact with the mineralized root surface. Whatever leads to osteoclast differentiation, root resorption may be regarded as an inevitable side effect of orthodontic tooth movement.

When and where root resorption starts is likely related to the sequence of events occurring in the damaged periodontal ligament and this may depend on many factors, including type of movement, anatomy, force magnitude and duration, and species. While in human teeth the very first signs of root resorption may be observed as early as one week after force application, cells capable of initiating root resorption may arrive earlier on the root surface of teeth in rats and mice. Histology unequivocally indicates an association between predicted compression sites and the incidence of root resorption. Furthermore, a progression of hard tissue resorption into the root over time has been observed. This progression may occur in the absence of a significant, continuous pressure stimulus, and even last after the removal of necrotic periodontal ligament tissue. After the withdrawal of odontoclasts, the resorbed root surface may eventually become repaired with repair cementum.

D) Signalling molecules

Numerous signalling molecules, such as inflammatory mediators, growth factors, and neuropeptides, are expressed during orthodontic tooth movement. Both mechanical stress and tissue necrosis evoke biochemical responses. Since recruitment, differentiation, and activation of osteoclastic cells is central to successful orthodontic tooth movement, much research has focussed on the regulation of bone resorption and apposition. Normal bone remodelling depends on a delicate balance between bone formation and resorption. Bone resorption is regulated by a system consisting of receptor activator of nuclear factor kappaB (RANK) and its ligand RANKL, which are members of the tumour necrosis factor ligand and receptor families, and osteoprotegerin (OPG). RANKL is expressed by bone marrow stromal cells, osteoblasts, and certain fibroblasts, whereas RANK is expressed by osteoclast precursors and mature osteoclasts. The binding of RANK to RANKL induces osteoclast differentiation and activity, and regulates their survival. OPG, however, which is produced by bone marrow stromal cells, osteoblasts, and certain fibroblasts, is a soluble decoy receptor for RANKL that competes for this binding. Thus, OPG is a natural inhibitor of osteoclast differentiation and activation. Any interference with this system can shift the balance between bone apposition and resorption. The expression of macrophage colony-stimulating factor (M-CSF) plays an essential role in this regulatory system. Furthermore, it has been shown that a number of pro-inflammatory cytokines and growth factors, in particular interleukin 1 (IL-1) and TNF-α, regulate the expression of RANKL and OPG. The immune system modifies the balance between bone formation and resorption in a complex process involving T- and B-lymphocytes, dendritic cells, and cytokines. By the expression of RANKL on B cells, T cells, and marrow stromal cells, and the expression of RANK on osteoclast precursors, mature osteoclasts, T-lymphocytes, B-lymphocytes, and dendritic cells, these cells can directly influence bone resorption. The multifunctional roles of RANK, RANKL, and OPG constitute an important link between bone remodelling, periodontal ligament remodelling, and root resorption and repair during orthodontic tooth movement.

BONE REGENERATION I: BIOLOGIC BASIS OF BONE HEALING

Bone plays an essential role in periodontology and implant dentistry. A sufficient amount of living bone is required to anchor teeth and to place an endosseous dental implant in jawbone. Periodontitis, peri-implantitis, but also a simple tooth extraction reduce the ridge height. To compensate for this bone loss, bone augmentation procedures are widely used. Guided tissue regeneration (GTR), and guided bone regeneration (GBR) are accepted options to enhance bone formation. Very often, these procedures are used in combination with bone grafts or substitute materials to further enhance the formation of bone. Fortunately, it is bone’s nature to possess a unique regenerative potential, which is probably best illustrated by fracture repair. Bone is able to heal fractures or local defects with regenerated tissue, or “regenerate”, of equally high structural organization, without leaving a scar. The mechanism of this healing pattern is often considered as a recapitulation of embryonic osteogenesis and growth. Since bone has such a unique spontaneous healing capacity, the trick in reconstructive surgery is to harness this great regenerative potential to enhance bone formation for clinical applications.

The regenerative capacity of bone has limitations, however, and may even fail if certain conditions are not fulfilled. Factors that impede or even prevent bone repair are, among others, failure of vascular supply, mechanical instability, oversized defects, and competing tissues of high proliferative activity. However, several options, alone or in combination, to promote and to support bone formation are available, including

1) osteoinduction by growth factors,
2) osteoconduction by bone grafts or substitutes,
3) transfer of stem cells or progenitor cells that differentiate into osteoblasts,
4) distraction osteogenesis, and
5) guided bone regeneration (GBR) using barrier membranes.
Osteoinduction is achieved by growth factors released from autologous bone particles or added as recombinant proteins in a carrier transplanted into the defect. Osteoconduction can occur on autografts, allografts, xenografts, and alloplasts. Osteoconduction facilitates bridging of larger defects by offering a solid scaffold onto which bone can be deposited. The substitution rate of the bone filler material varies greatly and depends on the bone graft or substitute material used. Transfer of stem cells or progenitor cells that differentiate into osteoblasts can be achieved by using cancellous bone grafts or bone marrow aspirates. Distraction osteogenesis uses the principle of canalizing bony callus formation into longitudinal compartments, confined by continuously stretched collagen fibre bundles. This technique yields impressive results. Guided bone regeneration is a well-established procedure that is based on the principle of protecting bone regeneration against overgrowth of tissues formed by rapidly proliferating non-osteogenic cells. It is successfully applied for alveolar ridge augmentation.

Adequate bone augmentation or treatment of any bone defect by any technique requires a profound understanding of bone development and morphogenesis at the cellular and molecular levels.

BONE REGENERATION II: EXPERIMENTAL EVALUATION OF BONE FILLERS

In many patients, there is a local deficiency like in post-extraction sites requiring a bone augmentation procedure. Guided bone regeneration (GBR) is a well-established procedure based on the principle of protecting bone regeneration against overgrowth of tissues formed by rapidly proliferating non-osteogenic cells. Bone fillers are often used in combination with a barrier membrane for GBR procedures. They are used in reconstructive surgery to replace portions of bone, augment bone, enhance bone repair through osteoconduction, provide mechanical membrane support, and stabilize the blood clot. A bone filler must be safe, nontoxic, and biocompatible and should provide an osteoconductive scaffold and allow ingrowth of blood vessels. Several options for a grafting material currently exist, including autologous or allogeneic bone and xenogeneic or alloplastic bone graft substitutes. These materials may display one or more of the properties that are commonly described as

1) osteoconductive,
2) osteoinductive, and
3) osteogenic.

Osteoconductive materials possess a matrix that serves as a scaffold or solid framework that is used as a template for bone deposition. Materials with osteoinductive properties contain proteins that stimulate and support proliferation and differentiation of progenitor cells to become osteoblasts. Osteogenic means that the material contains osteogenic cells (osteoblasts or osteoblast precursors) that are capable of forming bone if placed in the proper environment.

Autologous bone is a preferred bone graft material, because it possesses osteoinductive, osteogenic, and osteoconductive properties. However, the harvesting of autologous bone may require an additional surgical intervention, which increases the operative time, costs, intraoperative blood loss, pain, and recovery time. Moreover, it is associated with an increased risk of donor site morbidity (e.g., increased postoperative pain, nerve injury, blood vessel injury, haematoma, infection, hernia formation, and cosmetic disadvantages). Finally, the supply of autologous bone graft may be limited. To reduce the shortcomings of autografts, bone substitute materials may be used. While allografts are obtained from another individual within the same species, xenografts originate from another species. Alloplastic bone graft substitutes are synthetically derived.

To reduce the disadvantages of natural bone graft substitutes, more and more synthetic bone substitute materials, mainly calcium phosphate ceramics, are being developed. In very demanding clinical defect morphologies, however, the rate of hard tissue degradation has to be taken into consideration. In these cases, a substitute material with a very limited degradation over time is preferred for the volume stability of augmented ridges. It seems, however, that the search for the ideal bone substitute material is still going on.

Comparisons between biomaterials require standardized defect models that are clinically relevant. In this regard, the mandibular bone defect model in minipigs has proven advantageous to test the effects of bone fillers on bone formation as well as on graft and substitute degradation. In a series of experiments by our group, non-critical size, self-contained bone defects in the mandible of Göttingen minipigs were filled with β-tricalcium phosphate (β-TCP), collagen sponge (CS), demineralized freeze-dried allografts (DFDBA), coral-derived hydroxyapatite (CHA), deproteinized bovine bone mineral (DBBM), biphasic calcium phosphates (BCP) consisting of hydroxyapatite (HA) and β-TCP, non-sintered HA embedded in a matrix of silica gel (HAS), coagulum (C) (= negative control), and autologous bone particles (autograft) (= positive control). All defects were covered with expanded polytetrafluoroethylene (ePTFE) membranes. After healing periods ranging from 2 to 52 weeks, the animals were sacrificed and bone specimens were processed for histology and histomorphometric evaluation.

All five minipig studies showed very consistent results. In the first study, less favourable results were obtained for CHA and DFDBA. For all studies, significant differences among bone filler materials were observed concerning 1) the speed of new bone formation; 2) osteoconductive properties; and 3) degradation/substitution rates. During early stages of healing, autografts accelerated bone formation in comparison with the tested bone substitute materials.
During later healing periods, however, the increase in bone formation for the tested bone substitutes was higher than for the autograft. Fillers with β-TCP showed a high degradation/ substitution rate and stimulated new bone formation during the remodelling phase, whereas HA-based fillers were characterized by a low substitution rate.

The minipig was introduced as a model to study bone healing in association with filler materials because of its close similarity to humans in terms of spontaneous bone healing and structure. The non-critical size defect model with self-contained defect morphology in the mandibular angle of minipigs has proven to provide very consistent results for the testing of bone fillers. Based on the reliability of this model, the following considerations and clinical recommendations for implant dentistry can be made: 1) Application of particulate autografts directly onto the implant surface in peri-implant defects accelerates bone formation and offers patients shorter healing periods with GBR procedures. 2) The required autograft harvesting within the same site and omits morbidity. 3) HA-based bone fillers with a low substitution rate are routinely used on top of the autografts. This concept, called “contour augmentation”, is particularly useful to optimize implant outcomes in the aesthetic zone. 4) The augmented region is routinely covered by a non-crosslinked collagen membrane to serve as a barrier during early wound healing and bone formation.

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ROOT CEMENTUM AND PERIODONTAL REGENERATION

Periodontal diseases are high-prevalence infections of periodontal tissues. Periodontitis causes the destruction of the tooth attachment apparatus. Untreated periodontitis results in progressing attachment loss and may eventually lead to early tooth loss. Chronic periodontal diseases can be treated. In the first place, the infection must be under control. This is mainly achieved by removal of the biofilm. Reducing the bacterial load results in resolution of inflammation, which in turn arrests further attachment loss. In second place, an appropriate regenerative procedure may be applied. Regeneration is defined as a reproduction or reconstitution of a lost or injured part of the body in such a way that the architecture and function of the lost or injured tissues are completely restored. Thus, histology continues to be the only reliable method of evaluating the efficacy of a therapy aimed at achieving periodontal regeneration.

According to the World Workshop in Periodontics of the American Academy of Periodontology (1996), the requirements for a periodontal treatment to be considered a regenerative procedure are:

1) Human histology demonstrating new cementum, periodontal ligament and bone coronal to the former defect base;
2) Controlled human clinical trials demonstrating improved clinical probing attachment and bone; and
3) Controlled animal histological studies revealing new cementum, periodontal ligament, and bone.

Based on these criteria, a few treatment options can be regarded as regenerative techniques. These include guided tissue regeneration (GTR) and enamel matrix proteins (EMPs). Nevertheless, periodontal regeneration in humans may still be regarded as an ambitious goal. A critical stumbling block for improving periodontal health is our inability to predictably regenerate the root-periodontal ligament interface. Indeed, new attachment of connective tissue fibres to the root surface is a very critical aspect. Since formation of cementum is indispensable for the attachment of periodontal ligament fibres to a previously diseased root surface that was modified in connection with periodontal therapy, much emphasis has been devoted to understanding cementogenesis. Concerns include predictability and amount of new connective tissue attachment as well as strength of the regenerated interface between the treated root surface and new cementum. The recognition of these difficulties made cementum a major target in periodontal research. Structural biologists are equally challenged as scientists from developmental and cell biology. Issues that need clarification include determination of:

1) the origin of cementoblasts during development and regeneration;
2) the nature of cell differentiation/growth factors;
3) molecular factors that are selective for the genesis of a cementum variety providing maximum attachment function; and
4) conditions that result in an improved binding of regenerated cementum to the treated root surface.

At least four different cementum varieties are known in human teeth. Acellular extrinsic fibre cementum (AEFC) has an important attachment function and grows very slowly. In contrast, cellular intrinsic fibre cementum (CIFC) is not involved in periodontal ligament fibre attachment to the root surface but grows rapidly. Concerning interfacial strength, different mechanisms have been proposed leading to the formation of the dentino-cemental junction. And what do we
really know about the origin of precursor cells and molecular factors that trigger cementoblast differentiation? It must be freely admitted that the origin of cementoblast precursors and the molecular factors regulating their differentiation are not understood. And this is true for both development and regeneration. Advancements in the understanding of all these issues are considered imperative for further studies aimed at improving periodontal regeneration.

**REGENERATIVE CONCEPT OF ENAMEL MATRIX PROTEINS**

Although the peculiarities, biological difficulties, and technical complications associated with periodontal wound healing and tissue regeneration are well known, regeneration of the periodontium is still a major goal in the treatment of teeth affected by periodontitis. For many years, research has attempted to use biologically active molecules to achieve periodontal regeneration. Among these molecules are extracellular matrix proteins, cell attachment factors, and growth/differentiation factors. A tremendous amount of work resulted in an enormous number of original articles that document the efficacy of added growth factors or related bioactive agents in animal and human periodontal defect models.

Compared with growth factors like bone morphogenetic proteins (BMPs), enamel matrix proteins (EMPs) emerged relatively lately as a therapeutic option for periodontal regeneration. Even more astonishing is that their entry into dental practice occurred long before an adequate number of studies was available in order to give a scientifically sound explanation for the positive effects of EMPs on periodontal wound healing and regeneration. EMPs are commercially available as a therapeutic agent for periodontal applications under the brand name Emdogain.† This product consists of an enamel matrix derivative (EMD), water, and a carrier, propylene glycol alginate (PGA). Clinically, Emdogain is used for periodontal regeneration of teeth affected by periodontitis, root coverage procedures, and tooth replantation. Many clinical studies have shown positive effects of Emdogain with regard to periodontal defects. Furthermore, numerous histological studies have shown formation of new cementum and new bone with inserting connective tissue fibres. Despite this large body of clinical and histological data, the biological mechanisms underlying the supportive effects of EMPs appear to be less clear.

Traditionally, EMPs are associated with amelogenesis. Besides having functions in the mineralization of enamel, EMPs are also considered to function as signalling molecules for cell differentiation. While more information is available on cell differentiation processes occurring during crown development, far less is known about tooth root development. That Hertwig’s epithelial root sheath (HERS) is indispensable for root formation is general knowledge, its role in cementogenesis, however, remains obscure. Based on circumstantial evidence the original idea emerged that there is a causal relationship between EMPs and cementogenesis. Over a period of more than a decade back from now, more than 100 non-clinical and non-histological studies formed a basis that allowed the identification of a comprehensive picture of what appears to be responsible for supporting periodontal regeneration. Summarizing these findings, it can be concluded that EMPs have effects on many different cell types. Overall, the available data show effects on: (1) chemotaxis, cell attachment, and cell spreading; (2) cell proliferation and survival; (3) expression of transcription factors; (4) expression of growth factors, cytokines, extracellular matrix constituents, and other macromolecules; and (5) expression of molecules involved in the regulation of bone remodelling. In particular, EMPs support the regrowth of periodontal ligament, cementum, and bone, and have beneficial effects on wound healing, whilst slowing down the expansion of gingival epithelial and connective tissue cells. Furthermore, EMPs have a vehicle PGA in particular, have antibacterial properties. Therefore, it may be concluded that the broad spectrum of activities of EMPs can explain both the observed enhanced wound healing and the new formation of periodontal tissues following therapeutic application of Emdogain.

All these beneficial effects of EMPs could mislead dentists into an uncritical clinical application. However, this regenerative technique does not relieve the dentist of responsibilities. As with so many other sensitive techniques, important aspects to be considered as determining variables include:

1. appropriate patient and defect selection;
2. correct application of a regenerative device or technique; and
3. the dentist’s experience and skills.

Finally, it is striking to realize how little biology is considered. Minimally invasive surgical techniques for improved wound stabilization and sufficient time for healing should be applied as well. Finally, it still should be kept in mind that the structural and interactive complexity of periodontal tissues is likely one of the reasons why it is so difficult to regenerate the periodontium.

**OSSEOINTEGRATION OF DENTAL IMPLANTS**

A prerequisite for successful osseointegration is the establishment of a direct bone-to-implant contact (BIC) without formation of any intervening soft connective tissue. Osseointegration, in a more comprehensive way, is characterized as “a direct structural and functional connection between ordered, living bone and the surface of a load-bearing implant”. Unlike in bone fracture healing, osseointegration unites bone not to bone, but to an implant surface, which actually represents a foreign material or a biomaterial. From this point of view, the biomaterial

† Emdogain, Straumann, Basel, Switzerland
characteristics play a decisive role to achieve a stable union between the implant and the surrounding bone. Implant materials must be non-toxic and biocompatible. A bio-inert material does not release any harmful substances and does not elicit an inflammatory or foreign body reaction. Commercially pure titanium is recognized as being a bio-inert material and, therefore, widely used to replace missing teeth.

A freshly installed implant must be perfectly stable. Immediately after installation, there is only primary stability. This primary stability is required for the retention of the implant and considered essential for undisturbed new bone formation (i.e., osseointegration). While the primary stability (old bone) decreases over time, the secondary stability (new bone) builds up. Direct bone healing around a dental implant is initiated by a lesion created during drilling of the bone bed. Fortunately, bone has an exceptional capacity for self-healing, repair, and regeneration. This inherent regenerative capacity of bone has probably to do with its vital functions. There is a clear-cut healing sequence around a dental implant installed into a fresh bone defect. This healing sequence encompasses the following events: (1) Protein adsorption from the blood to the implant surface; (2) coagulum formation; (3) granulation tissue formation; (4) formation of a provisional matrix; (5) appositional bone formation on old bone surfaces and woven bone formation in the provisional matrix; (6) bridging of the defect gap between the implant surface and the surrounding tissues by newly formed bone; (7) bone formation along the implant surface; (8) reinforcement of woven bone by parallel-fibred bone; and (9) bone remodelling that replaces the woven and parallel-fibred bone by lamellar bone.

As mentioned above, an important step in the osseointegration process is the transition from primary (physical bonding) to secondary stability (biological bonding). There are differences in time and space in the sequence of the osseointegration process. Since these differences have a profound effect on the histologic aspects of osseointegration, the events occurring in cortical bone must be distinguished from the events taking place in the cancellous bone compartment. The trabecular bone compartment does not or not significantly contribute to primary stability. However, the fastest bone deposition onto the implant surface and the fastest coating with bone occurs right in this compartment. In contrast, primary stability is mainly achieved in the cortical bone compartment through pressfit in a surgically prepared congruent implant bed. Furthermore, the devitalized bone must be removed before new bone can be deposited onto the implant surface. This is achieved by activation of a remodelling process, which involves bone resorption by osteoclasts followed by bone deposition. This way, the necrotic bone becomes replaced by living bone and secondary stability can build up by bone deposition onto the implant surface, albeit later than in the cancellous bone compartment.

In recent years, great efforts have been made to speed up osseointegration by modifying specific surface properties such as topography, structure, chemistry, surface charge, and wettability. Particular attention was paid to increased surface energy and enhanced wettability. Surface modifications are now regarded as a critical factor to improve blood clot stabilization, accelerate neovascularization, and enhance proliferation and differentiation of osteoprogenitor cells.

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THEY’RE ONLY BABY TEETH; WHO SHOULD CARE?

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ABSTRACT

Despite significant improvements in our understanding of the pathogenesis of dental caries, it remains one of the most common chronic diseases of childhood. Given that few very young children actually attend dental health services, there is a role for non-dental healthcare professionals in the prevention of dental disease and the promotion of oral health. This presentation will take an evidence-based approach to explore opportunities for increased collaboration between dental and non-dental healthcare professionals to optimize the health outcomes for children. The role and responsibilities of the dental profession in developing this model of shared care will also be discussed.

INTRODUCTION

Despite a decline over the past fifty years, dental caries remains the most common chronic disease of childhood. It is also one of the most commonly reported medical conditions in children in Australia¹ and costs the Australian community over $5 billion per year (not including indirect costs to individuals such as time off work etc.).² Disturbingly the decline appears to have slowed and indeed there is recent evidence of an actual increase in caries experience particularly in young children.³ Whilst the proportion of 5-year-olds in Australia who are caries free may not have changed significantly the ‘dmft’ has risen from its lowest level of 1.28 in 1996 to 1.83 in 2002 which is almost a return to the levels recorded at the start of the 1990s. In addition inequalities in the distribution of dental disease appear to be increasing. The majority of the burden of dental disease is now experienced by a relatively small proportion of children with most of this disease remaining untreated.⁴ So does this matter? Whilst there has been fierce debate around the world as to the benefits of restoring curvaceous primary teeth the fact remains that untreated dental caries can have a detrimental effect not just on children’s dental health but also on their general health and well-being. If left untreated dental caries can progress to cause pain and sepsis⁵ which may require hospitalization, intravenous antibiotics and extraction of the affected tooth/teeth under general anaesthesia. Unfortunately, dental caries remains one of the most common causes of hospitalization in young children in Australia.⁶ In addition to the direct costs associated with such an admission, the burden experienced by families of children affected by acute dental problems is not insignificant. In a recent study children attending a tertiary paediatric hospital emergency department with a facial swelling of dental origin, were found to have seen multiple health service providers (mean 4.5 ± 1.98) over a period of time that ranged from 3 to 63 days (median 15.5 days) prior to accessing definitive care.⁷ However perhaps even more significantly poor dental health is known to impact upon growth and cognitive development by interfering with nutrition, concentration and school participation.⁸ ⁹ The cost of these impacts are currently unclear. However what is known is that children who experience dental caries in their primary dentition are significantly more likely to continue to experience dental problems in their permanent dentition.¹⁰ Given that dental caries is essentially a preventable condition the questions ‘Why is there still such morbidity associated with this disease?’ and ‘Who should be taking responsibility for reducing this burden?’ need to be asked.

Both the Australian Academy of Paediatric Dentistry and the Australian Dental Association, like their counterparts in the United States and Europe recommend that a child should be seen by a dental professional soon after the eruption of the first tooth.¹¹ The purpose of this initial visit is to provide anticipatory guidance regarding good oral health habits including dietary counselling and appropriate fluoride use, as well as early identification (and referral) of those infants at elevated risk of developing caries. However in reality this rarely happens with only 12% of 2-year-old children in Australia having seen a dentist.¹² In contrast however infants and young children are taken to see General Medical Practitioners (GMPs) and Maternal Child Health Nurses (MCHNs) frequently during the first couple of years of life, often as part of a routine ‘well child check’.¹³ Encounters such as these with non-dental healthcare providers offer strategic opportunities for promoting oral health. However the perception that oral health is somehow separate from general health exists both in the minds of the public, the dental profession and the medical community as well as persisting in the educational structures and service delivery models that exist today. Undergraduate dental students are taught in dental schools and hospitals, which often exist in isolation from the ‘rest of the body’ medical institutions. Dental services are delivered under a primarily business model through the private sector and have, for example, been included in Medicare only to a very limited extent. Conversely contemporary undergraduate medical curricula rarely include any oral health content despite the fact that disorders of the oral cavity are not infrequently symptoms of other systemic diseases (e.g., inflammatory bowel disease, haematological deficiencies etc.). This historic systematic separation of teeth from the rest of the body may contribute to the dental neglect of vulnerable communities such as young children as confusion exists around who is actually responsible for their oral health. In a recent study exploring

¹ Presented at the Twentieth Convocation of the Royal Australasian College of Dental Surgeons, Perth, Western Australia. March 2010
the barriers to a model of shared care to promote oral health in infants and young children in rural Australia, dental professionals did not believe that they had a primary role in the oral health of pre-school aged children but felt that others, particularly MCHNs did. However in turn the non-dental health care professionals (such as the MCHNs and GMPs) were not confident in assuming this role.14

So what are the solutions? Whilst improved access to appropriately trained oral health professionals is one approach, the increasingly inequitable distribution of this workforce means that this strategy alone is unlikely to be successful. Rather a simultaneous expansion of the ‘oral health team’ to include non-dental healthcare professionals including GMPs, MCHNs and indeed other non-healthcare workers who have close contact with ‘at risk’ groups such as young children, should be considered. Internationally a number of strategies have been described including training primary healthcare providers to give preventive advice, perform caries risk assessments and apply prophylactic fluoride varnish. Such programmes have been associated with an increase in the provision of preventive dental services to young children and subsequent reductions in future dentally related costs.15, 16 The barriers to these types of interventions include a lack of confidence/knowledge amongst the non-dental health care professionals,17 the level of awareness regarding accessibility to appropriate dental services to which a child can be referred18 and inadequate or inappropriate funding. In some US states Medicaid reimbursements have been introduced for fluoride varnish applications and delivery of anticipatory guidance in an attempt to promote the expanded role of primary care providers (predominantly paediatricians) in to the oral health arena.19 In other places comprehensive integrated models of preventive (dental and medical) care have been introduced through engaging a wide range of community agencies involved in early child health and development.20, 21 These are all examples of collaborative partnerships working across disciplines and most involve the dental profession taking on the leadership role as the ‘oral health champion’ to re-orientate training and service provision to reduce oral health inequalities.

It is to this leadership role that the dental profession, both at an individual and at an institutional level must aspire. Dental schools need to be proactive in forging closer ties with their medical, nursing and allied health counterparts. Obvious examples include the development of a comprehensive oral health curriculum for medical students.22 To be successful this has to be done in a collaborative and inclusive manner taking into account the competing demands of an increasingly content heavy medical curriculum and focusing on relevance and synergy with existing workstreams.23 By fostering such ties, dental schools may not only promote oral health within the non-dental workforce but if done thoughtfully can also increase the exposure of dental students to the broader health environment. In doing so future dental graduates may themselves, be better equipped to meet the demands of an increasingly complex patient population.24 In Australia as in the United Kingdom there is also a role for the learned colleges in providing clinical leadership. An example is the American Academy of Pediatrics who recently published an evidence-based policy document defining the role of the paediatrician in promoting oral health in terms of expected knowledge, skills and behaviours.25 A similar document is currently under preparation as a joint publication between this college (Royal Australasian College of Dental Surgeons) and the Royal Australian College of Physicians (Division of Paedics and Child Health). Other collaborative ventures might also include the development of generic leadership training programmes across different disciplines through their colleges26 and the co-ordination of truly ‘interdisciplinary’ meetings which broaden the focus away from specific medical/dental disciplines to consider children and their families as part of a more holistic approach to healthcare. The dental profession needs to rise to the challenge by becoming proactive in the process. Failure to recognize this will mean that either the inequalities will persist, which is morally unacceptable for a developed country, or others will step in to the leadership void.

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Molar Incisor Hypomineralization (MIH) describes a clinical condition where one or more first permanent molar and incisor teeth are affected. The hypomineralization can be mild or exceptionally severe. Demarcated opacities are defects of altered enamel translucency: the affected enamel is white-cream or yellow-brown in colour, of a normal thickness with a smooth surface and has a distinct boundary adjacent to normal enamel.¹

The care involved in treating children with these affected teeth should aim at managing the child’s behaviour and anxiety, and to provide a durable restoration under pain-free conditions. These challenges include adequate anaesthesia, suitable cavity design, and choice of restorative materials. Restorations in hypomineralized molars appear to fail frequently, and there is little evidence-based literature to facilitate clinical decisions on cavity design and material choice.

Molar teeth with hypomineralization typically present with enamel breakdown and discoloration. When examined under transmission electron microscopy hypomineralized defects of different severities follow the natural incremental lines of enamel formation. Cuspal areas are usually only mildly affected and cervical enamel appears sound.² Children with MIH present to the dentist with sensitivity to hot and cold foods and drinks, inability to eat certain foods, and an inability to brush or clean teeth adequately. It is at this initial stage that the dental practitioner has a role in correctly diagnosing the condition. Often clinicians confuse hypomineralized molars with dental caries, chronological hypoplasia and a spectrum of enamel defects. Once the correct diagnosis is made the parent and child can be directed towards the most appropriate treatment protocols. It is important to involve an orthodontist early on in the treatment planning process for they can determine the possibility of extraction of the affected molar teeth with orthodontic correction of the residual space.³

In very mild cases of MIH treatment may simply involve regular review and maintenance. If there is sufficient enamel, placement of an appropriate fissure sealant may be sufficient to maintain the tooth in function and form for many years. By virtue of the inability to create retention amalgam has limited use in teeth affected by MIH. Glass ionomers are useful materials to act as interim restorations in the early stage of treatment. They can decrease the sensitivity of the teeth and also are easy to apply. They suffer due to excessive wear and fracture. Composites and composite resins tend to also suffer due to wear and fracture. As an interim restoration in children, the stainless steel crown is often the restoration of choice. Molar teeth with MIH tend to be hypersensitive and often, local anaesthesia is insufficient to adequately anaesthetize the teeth. The practitioner is also dealing with a group of patients, i.e., children who may be nervous and apprehensive. If managed inappropriately then these children can develop quite significant dental fear and phobias. It is hence important to identify any nervous and apprehensive children and take appropriate means to treat them. If the clinical situation warrants them, the use of intravenous sedation techniques and general anaesthesia should be utilized.

REFERENCES

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Fig. 1 – Two presentations of MIH, a milder (left) and a more severe form (right).

Fig. 2 – Glass Ionomer cement (left) and a stainless steel crown (right).
BISPHOSPHONATES AND THE DENTAL PRACTITIONER –
A GUIDE TO MANAGEMENT
Raymond Williamson, BDS Syd., MDsc PhD W.Aust., FRACDS, FFDRCS(Irel),
FDSRCS(Eng), FRACDS(OMS)*


*R Raymond Williamson is Professor of Oral and Maxillofacial Surgery in the School of Dentistry, University of Western Australia and in the Maxillofacial Unit, Royal Perth Hospital.

INTRODUCTION

Bisphosphonates are a group of drugs used in the treatment of various metabolic and malignant bone diseases. They inhibit bone resorption and thus bone renewal by suppressing the recruitment and activity of osteoclasts. Intravenous bisphosphonates are used as an important part of the chemotherapeutic treatment of bone cancers such as Multiple Myeloma and metastatic disease from cancer of the breast, prostate and lungs. They have been shown to have a significant impact on the quality of life for patients with advanced cancer that involves the skeletal system. More recently oral bisphosphonates have been increasingly used to treat osteoporosis, Paget’s disease and paediatric osteogenesis imperfecta.

A possible association between bisphosphonate use and the appearance of osteonecrosis of the jaws (ONJ) first appeared in the literature in late 2003. In September of that year, Wang et al. described three cases of osteonecrosis of the alveolar bone in female patients undergoing chemotherapy for metastatic breast cancer. Two of these patients developed ONJ following tooth extraction and the other developed ONJ spontaneously resulting in an oro-antral fistula. Initially the authors reported the osteonecrosis as resulting from the chemotherapy, but later reported that the most likely cause was the bisphosphonates. Marx also published a paper in September 2003 in which he tracked 36 cases of painful bone exposures in the maxilla and mandible which were relatively refractory to conventional treatment. In late 2003, Carter and Goss also reported five cases of refractory osteonecrosis.

Marx defines bisphosphonate induced osteonecrosis of the jaws as a condition characterized by exposure of bone in the mandible or maxilla persisting for more than eight weeks in a patient who has taken or currently is taking a bisphosphonate and who has no history of radiation therapy to the jaws. Most bodies recommend that the treatment of established cases ONJ begin with palliation and infection control as the primary goals; with control of the progression of the disease using long-term courses of antibiotics, chlorhexidine mouthwash and periodic minor debridement of sequestra and wound irrigation. Extractions and all types of jaw surgery should be avoided. Unfortunately, these measures do not always control the symptoms of ONJ and the progression of the disease process. Therefore this paper will outline a guide to management of ONJ for the dental practitioner which will include both conservative and surgical management.

THE PREDISPOSING FACTORS CAUSING OSTEONECROSIS OF THE JAWS.

Osteonecrosis is a pathological process in which there is a temporary or permanent loss of blood supplies to the bone which causes bone tissue to die and the bone to collapse. This condition is also known as avascular necrosis, aseptic necrosis or ischemic necrosis. The clinician should keep in mind that osteonecrosis of the jaws has been recognized as a pathological condition for many years and may arise from a variety of causes, as shown in Table 1; not just from bisphosphonate therapy.

<table>
<thead>
<tr>
<th>Table 1: Predisposing Factors causing ONJ</th>
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<tbody>
<tr>
<td>1. Bisphosphonate therapy</td>
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<tr>
<td>2. Periodontal disease</td>
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<td>3. Dentoalveolar surgery</td>
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<tr>
<td>4. Prior trauma</td>
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<tr>
<td>5. Corticosteroid therapy</td>
</tr>
<tr>
<td>6. Immune-compromised state predisposing to increased risk of infection</td>
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<td>7. Possible vascular insufficiency</td>
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<td>8. Underlying hypercoagulable state secondary to underlying malignancy</td>
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* Presented at the Twentieth Convocation of the Royal Australasian College of Dental Surgeons, Perth, Western Australia. March 2010
The true incidence of ONJ is difficult to determine as the use of oral and intravenous bisphosphonates is widespread and osteonecrosis is likely an under-recognized entity, particularly in cancer patients as they obviously have other priorities in their treatment. However, there has clearly been an increase in the observation and reporting of this entity over the last six years coinciding with the prolonged exposure to potent bisphosphonates for the management of symptomatic malignant bony disease. Risk of the development of ONJ also varies with the type of bisphosphonate used and duration of exposure, with more potent agents increasing the risk with shorter durations of exposure. A local study by the author’s Adelaide group* revealed that the incidence of ONJ in osteoporosis patients on weekly oral Alendronate* was 0.01% to 0.04%. If extractions were carried out then the frequency of ONJ was to 2.1% to 13.5%. The frequency of ONJ in bone malignancy cases, treated with IV Zolendronate† or Pamidronate‡ was 0.88% to 1.15%. If extractions were carried out then the frequency of ONJ was 6.67% to 9.1%. The median time for onset of ONJ was 12 months for IV and 24 months for oral bisphosphonates.

CLINICAL PRESENTATION OF OSTEONECROSIS OF THE JAWS.

The most typical presentation of ONJ is in the form of a non-healing extraction socket, presence of exposed bone, gingival swelling or purulent discharge: and the ONJ may present more than six months post extraction. Occasionally, pain in the jaw bone may be the only symptom without any evidence of radiological abnormalities. Eighty percent of patients report an antecedent dental procedure prior to presentation. ONJ may also present in the mouth in a variety of manifestations from as simply as a painless ulcer under a denture through to a fulminating infection with exposed sequestrae which have draining sinuses in the mouth and on the skin. Table 2 lists the more common clinical presentations of ONJ.

STAGING FOR THE APPROPRIATE CONSERVATIVE AND SURGICAL MANAGEMENT.

Mehrota and Ruggiero7 reported a three stage system of ONJ appropriately based on clinical and radiographic findings which may be used to direct specific local and systemic therapy. Stage I disease as characterized by asymptomatic detection of exposed bone without soft tissue infection, may be managed conservatively with a non-surgical conservative approach to avoid further osseous injury. In addition, daily irrigation and oral antimicrobial rinses (0.12% chlorhexidine gluconate) are recommended. Clinical follow-up with an oral surgeon or dentist is recommended at least every three months. Dentures may be worn but should be adjusted to avoid further trauma to bone and soft tissues and should be removed at night. Stage II disease characterized by presence of symptoms around the area of exposed bone secondary to soft tissue swelling and/or bone infection may require culture-directed long-term and maintenance antimicrobial therapy, analgesic management, in addition to conservative measures outlined for stage I disease. Occasionally, minor bony debridement may be necessary to reduce sharp edges for reducing trauma to surrounding tissues. Stage III disease is characterized by the presence of a pathological fracture (not related to metastatic disease), exposed bone associated with soft tissue infection, which is not manageable with antibiotics alone due to the volume of necrotic bone. This degree of necrosis usually requires surgical debridement/ resection to reduce the volume of necrotic bone in addition to conservative measures of analgesics, culture directed oral/ intravenous antibiotics and oral antimicrobial rinses.

GUIDELINES FOR PREVENTION.

The most important point in management of ONJ is its prevention. As risk factors and precipitating factors are now better understood, prevention of this entity with specific precautions would be ideal. Prior to initiating bisphosphonate therapy, it is recommended that all patients undergo a routine dental clinical examination and an appropriate radiographic study. All patients should be educated about this possible complication and instructed to avoid elective invasive dental procedures that may not heal completely prior to starting therapy. Once started on maintenance bisphosphonate therapy, patients should have routinely scheduled oral assessments at a frequency determined by dental and haematology/oncology care givers depending on general oral health and concomitant risk factors. Dental surveillance includes a review of oral care, examination of dentures, if any, and adjustments as needed to avoid tissue injury, and routine dental cleanings without soft tissue injury. It is also recommended that tooth extractions be avoided and instead endodontic therapy be undertaken where appropriate. When invasive dental procedures are to be performed electively, some investigators have recommended withholding intravenous bisphosphonates for 1 to 3 months before the procedure* and resuming treatment after oral healing is complete. Although this short period of interrupting the exposure to bisphosphonates is unlikely to change the bone osteoclastic and remodelling environment, it may abrogate the anti-angiogenic properties of bisphosphonates and allow for soft tissue healing. As the patients on bisphosphonates have a reduced capacity for bone healing and remodelling,

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† Novartis Pharmaceuticals Australia, North Ryde NSW

<table>
<thead>
<tr>
<th>Clinical presentation of osteonecrosis of the jaws</th>
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<tr>
<td>• Nonhealing extraction socket</td>
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<tr>
<td>• Presence of exposed bone</td>
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<tr>
<td>• Gingival swelling</td>
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<tr>
<td>• Purulent discharge</td>
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<tr>
<td>• Nonhealing ulcer</td>
</tr>
<tr>
<td>• Exposed bone may be detected on routine oral care</td>
</tr>
<tr>
<td>• Pain in the jaw bone may be the only symptom without any evidence of radiological abnormalities</td>
</tr>
<tr>
<td>• 80% of patients report an antecedent dental procedure prior to presentation</td>
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<tr>
<td>• 66% of cases occur in the mandible</td>
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<td>• 34% of cases occur in the maxilla</td>
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when teeth need to be removed, they should be removed using a surgical approach, with removal of all sharp bone, so that the socket is saucerised and the soft tissues closed primarily without tension.

When a patient presents with Stage II ONJ that has become progressive, despite more than three months of conservative measures, including long-term antibiotic treatment, the infected area should undergo radical debridement of all necrotic bone. All patients undergoing surgical debridement should be given one gram of amoxycillin preoperatively and then a two week postoperative course of amoxycillin (500 mg, TDS). Where patients are allergic to amoxycillin, they may given clindamycin (600 mg pre-operative dose and 450 mg QID post-operatively). Depending on the extent of the debridement required cases may be either treated under local anaesthesia or general anaesthesia. The surgical debridement involves removal of all necrotic bone, smoothing of any sharp bony edges and saucerisation of any bony sockets. At operation, it is not uncommonly found that the necrotic bone can be clearly delineated from surrounding bone and hence outline the margin for debridement. Dental extraction socket margins should be reduced in height, particularly mandibular lingual plates and maxillary buccal plates, in order to reduce the depth of the bony defect so as to aid soft tissue drape over the surgical site. Buccal advancement flaps should be raised with particular attention paid to the flaps sitting passively when sutured to achieve primary closure of the surgical site. Long-term synthetic resorbable suture material may be used to hold surgical flaps in place. Patients should be examined at one week, two weeks and then at monthly intervals for three months postoperatively. Patient should be reassured that they will be slow to heal due their medication. Patients should then be followed at three monthly intervals and asked to contact the clinic if they feel that they have any problems between these appointment times. Where patients had been followed up for more than one year postoperative x-rays may be taken. Stage III cases should be referred to an oral and maxillofacial surgeon for management.

A recent report has show that if patients, with established ONJ, are given tetracycline (100 mg minomycin once daily) for three weeks prior to surgical debridement, then at time of debridement the dead bone can more clearly be seen using a UV light of 480 nanometres. Although bone turnover in patients on bisphosphonates is reduced, there is still enough bone turnover for the tetracycline to be taken up by vital bone, which thus glows under a UV light, making it much easier to see the demarcation between nonvital and vital bone at time of debridement.

**CASE REPORT**

The author was referred a patient from a general practitioner who had been treating a 46 year lady who was on IV bisphosphonates for metastatic breast disease. He had been following the currently accepted conservative guidelines for patients on bisphosphonates and endodontically treating a right maxillary canine. On presentation the buccal plate overlying the treated tooth (right maxillary canine) had sequestrated and when the sequestrum was removed a large mucosa defect exposing the underlying bone and ONJ was seen. This patient was quite distraught and depressed as she had lost most of her self-esteem. Along with the stress of being treated for breast cancer and its metastases and the obvious implications of this to her life expectancy, she was
now in a situation where she did not have hair and could not wear a partial denture. Figure 1 shows the patient’s clinical picture just after sequestration of the buccal plate overlying the right maxillary canine. Figure 2 shows the patient’s x-ray prior to debridement surgery. Figure 3 shows anterior maxilla eight months post debridement. This patient was now able to wear a partial denture over the surgical site. In addition she had purchased a wig and the difference in her self-esteem was very gratifying to see. One should never lose sight of having empathy for one’s patients.

CONCLUSION

Bisphosphonates are an important part of the chemotherapeutic treatment for patients being treated for bone related cancers. Complications, such as ONJ related to bisphosphonate use, are low, but patients should be monitored regularly by their treating physician and dentist so that the complications are recognized early and managed, with prevention being the key.

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THE USE OF VIRTUAL REALITY TOOLS IN SURGICAL EDUCATION

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ABSTRACT

Advances in computing, specifically those used for simulation and games technology has allowed for exciting developments in dental and surgical education. At the same time concerns are being raised that students with relatively little training, practise to improve their skill on patients with all of the inherent risks that may occur. Simulation in dentistry has been practised for many years and so the concept is not new to the profession. New tools have been developed that both enhance teaching and learning and are also useful for assessment of students and trainees. The challenge of virtual and simulated reality tools is to have the required fidelity to improve teaching and learning outcomes over the currently utilized methodology.

INTRODUCTION

Simulation has long been used in dentistry but in the last decade or so issues of patient safety, regulatory requirements, patient shortage, the need to teach communication, to achieve competency and to show leadership and most importantly the educational requirement for an evidence and validation of the process has occurred.

Prevailing trends in simulation are those of a huge demand for simulation but limited supply of infrastructure. The challenges to simulation development include a lack of a plan, failure to train instructors, problems with scenario development, engagement with the faculty and, of course, funding. Funding organizations require a return on investment in simulation. There is scrutiny of cost, systems testing/human factors, orientation, retention of skills, economic efficiency and compliance with regulatory requirements. Simulation must provide effective competency training, team and communication skills and may be valuable in the teaching of unusual and critical events.

In the development of simulation tools there are threats; these include, unused or underutilized equipment, design failures in the facility and audiovisual components. In addition, inadequate training and funding for training often results in under use of the equipment. Most simulation tools are designed to develop competency but rapidly can become a summative assessment tool.

If one accepts that the role of simulation is to achieve competence then the Dreyfus competency pyramid, is worth examining (Table 1). This puts competency at the level of the practitioner, but not of the expert. Concern is raised that competency therefore, is a lowest common denominator and not of the expert. Concern is raised that examining (Table 1). This puts competency at the level of competence then the Dreyfus competency pyramid, is worth.

| Knowledgeable practitioner: Sees the situation as a whole and acts from personal conviction |
| Practitioner: Acting consciously from long term goals and plans |
| Experienced Beginner: Incorporates aspects of the situation |
| Novice: Rule based behaviour, strongly limited and inflexible |

In simulation, quality is the ability to immerse the student and does not relate to the fidelity of the simulator. It is critical that the Infrastructure has to meet its designed function and that the simulation facility has to do what it is designed to do.

DISCUSSION

Why do we need simulation and virtual reality for dental and oral surgery? There has been availability of human jaw bones and teeth, but this is less so now for a variety of ethical and infection control issues. Dentistry has many years of experience in simulation from old-fashioned phantom head mannequins though OSSIM† to DentSim‡.

There is however no really good animal or simulation model for dento-alveolar surgery. In designing a good tool it is required to maximize the real drilling and instrumentation experience. The tool needs to instil the initial learning of surgical anatomy, and to relate this to planning and drilling techniques. In terms of teaching and learning a virtual reality system has to have the haptic of the differences between

TABLE 1

Dreyfus - Competencies

* Presented at the Twentieth Convocation of the Royal Australasian College of Dental Surgeons, Perth, Western Australia. March 2010

† A-Dec, 2601 Crestview Drive, Newberg, Oregon 97132 USA.
the hardness of tooth and bone. Further developments of an oral surgery model by adding modules for endodontics, periodontics and implant dentistry is also a consideration in making the development multidisciplinary within dentistry. Teaching staff shortages are a constant problem and so remote mentoring can resolve some of these issues.

The advantages of virtual reality training are that there is a freedom to fail, which is possible on a cadaver model but unethical on a live human. It is possible for the student to practise until competency standards are met. The simulations are standardized and repeatable. As there are minimal occupational health and safety risks, the system has greater availability and access than a conventional simulator laboratory. Machinery being available twenty four hours a day allows greater flexibility in rostering students and consequently less need to buy as many workstations.

The development of a dento-alveolar surgical simulation system was an initiative of a multidisciplinary team from the University of Melbourne§ and facilitated by cooperation with a commercial venture Forsslund Systems|| from Stockholm, Sweden. Initial experiments were undertaken in Melbourne and Sweden and further development is now underway at the University of Western Australia.

Clinical data from computerized tomography scans of jaw bones and teeth were obtained. Digital segmentation of anatomy into ‘objects’ was performed and the objects were given properties such as colour or texture. This together with a two handed force feedback probe gives a haptic, three dimensional virtual reality tool. Clever technology is not the be all and end all of this. The tool has to be shown to be at least equivalent to conventional teaching methodology and the use of educational measuring tools is part of the ongoing experimentation. The educational strengths of the system are being analysed and it is recognized that in some areas the reality of the simulation is rather less important than was first thought. It has been shown that trainees very actively engage in learning and develop perceptual skills more rapidly than with conventional learning method.

CONCLUSION

Despite all of the advantages of patient safety, training quality and the possibilities of surgeon credentialling should virtual reality surgical training be implemented, when it usually involves significant financial investment and training of teaching staff in new skills? In terms of some surgical skills systems, for example, those for laparoscopy and anastomosis, there is significant evidence to show that there is a quantitative gain in the speed and quality of skill acquisition. For the jaw and third molar model the jury is still deciding upon its verdict.

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RIDGE PRESERVATION: DOES IT ACTUALLY WORK?

Ivan Darby, BDS, PhD, FRACDS(Perio), DGDPCEng, FADI*

ABSTRACT

Post-extraction the alveolus undergoes modelling which reduces height and width. This may present a problem for subsequent crown and bridge or implant therapy. Ridge preservation is the use of grafts and/or membranes to try to minimize the loss of the alveolar ridge. Extraction sockets have been filled with autogenous, allogeneic and alloplastic materials. Membranes or soft tissue were used to contain the graft. More recently biodegradable sponges and materials coated in growth factors have been tested. Studies have primarily looked at either maintenance of vertical and horizontal dimensions or the healing of the socket and how much of the graft material is incorporated into the newly formed bone. Irrespective of method or materials, there seems to be some maintenance of the alveolus. Bone fill seems to occur in preserved extraction sockets, but in most cases with a high percentage of residual graft particles. In general, there is a lack of evidence to show that ridge preservation aids in correct tissue healing.

INTRODUCTION

The outcome of implant dentistry is no longer measured by survival, but success, which is a measure of biological or technical complications. Success can also mean the implant is in the optimal position for restoration. The loss of bone post-extraction may leave an inadequate bone volume for correct 3-D implant placement. Ridge preservation is the attempt to minimize the loss either by use of a particular technique or by grafting materials placed in the socket. It has commonly been used to facilitate implant placement, but is it effective?

Healing of Extraction Sockets

Healing of an extraction socket is characterized by internal changes that lead to formation of bone within the socket, and external changes that lead to loss of alveolar ridge width and height.1

When a tooth is removed, there is haemorrhage followed by formation of a blood clot that fills the entire socket.2 The concomitant inflammatory reaction stimulates recruitment of cells to form granulation tissue. Within 48 to 72 hours the clot begins to break down as granulation tissue begins to infiltrate the clot especially at the base and periphery of the socket. By four days, the epithelium proliferates along the socket periphery and immature connective tissue is apparent. After seven days, the granulation tissue has completely infiltrated and replaced the clot. At this stage, osteoid is evident at the base of the socket as uncalcified bone spicules. Over the next two to three weeks (three to four weeks after extraction) this begins to mineralize from the base of the socket coronally. This is accompanied by continued re-epithelialization which completely covers the socket by six weeks post-extraction. Further infill of bone takes place with maximum radiographic density at around 100 days.

A number of factors may affect the healing of sockets.1 The size of the socket is important with wider sockets requiring more time to bridge the defect compared with narrower sockets. The sockets of teeth with horizontal bone loss heal more quickly as the reduced level of the alveolar ridge means less infill is required. Bone does not regenerate to a level coronal to the horizontal level of the bone crest or to the level of the neighbouring teeth i.e., 100% socket fill does not occur.

Schropp et al.3 studied the effect of a single tooth extraction of premolar or molar teeth on bone healing and soft tissue changes using clinical and radiographic measurements as well as digital subtraction radiography. They showed that major changes take place in the 12 months following an extraction with an average of 50% reduction in the width of the alveolar ridge. Two thirds of this reduction occurred within the first three months. This loss averaged between 5 and 7 mm and was similar at all sites in the mouth. Importantly, most of the subjects did not wear a denture after extraction. Immediately after tooth extraction the width of the ridge was an average of 12 mm (8.6 -16.5 mm) and 12 months later 5.9 mm (2.7 - 12.2 mm). Given that a standard body implant requires a minimum of 6 to 7 mm of bone dimension, many of these sites would not be suitable for implant placement. The authors conclude it would be advantageous if this loss of bone dimension could be prevented.

A recent study by Araujo and Lindhe4 showed that in the first eight weeks following extraction in a dog model there is marked osteoclastic activity resulting in the resorption of the facial and lingual crestal walls. They noted that the reduction of height was more pronounced at the facial wall and was accompanied by a horizontal loss on both facial and lingual walls. Bone dehiscences or fenestrations present at time of extraction, particularly in the facial or lingual walls, are most likely to be filled by fibrous reparative tissue, which may occupy considerable space in the socket itself.

Ridge preservation

Ridge preservation is defined as any procedure undertaken to minimize bone loss due to extraction and to maximize bone formation within the socket. Many techniques use the principles of guided tissue/bone regeneration.
Methods and Materials

Currently, the most effective method of maintaining alveolar width and height is the presence of a tooth. Therefore, if possible, the tooth to be extracted should be retained for as long as possible and extracted in keeping with the timing of the implant placement. Pain and infection may require immediate removal of a tooth.

The use of techniques that minimize the amount of trauma occurring during an extraction should be used. These include severing the periodontal fibres by periotomes or luxators and gentle lifting of the tooth from the socket by forceps (Fig. 1). Multi-rooted teeth can be sectioned and the individual roots elevated out (Fig. 2). Raising a flap will increase the loss of buccal alveolar bone.

Some papers have suggested debriding the socket or perforating the cortical plates to induce more bleeding. To date neither has been shown to be more effective than letting the socket heal normally. Removal of chronically inflamed tissue and foreign bodies is still necessary.

Soft tissue coverage of the socket has been proposed for optimum healing and aesthetics. However, there is no evidence that soft tissue coverage alone is beneficial. It can be difficult to mobilize sufficient tissue, especially at posterior sites, to cover an extraction socket and may result is soft tissue or aesthetic complications. In any event the socket will epithelialize in six to eight weeks. At this time point there should be sufficient of the socket left to ridge preserve, although there is no evidence for the outcome of this in the literature.

The materials used for ridge preservation are those that have been used for guided bone regeneration or guided tissue regeneration and reflect what is available commercially. Table 1 shows the range of bone graft materials and types of membranes that have been reported in clinical studies. For a full list of the authors readers are referred to Darby et al.

Sponges made of polylactic/polyglycolic acid or collagen have been placed in extraction sockets to preserve the ridge. The collagen sponges also acted as a carrier for growth factors.

In addition to the great variation in the materials used, there is not surprisingly great variation in the methods used. These involved a combination of bone grafts, membranes and soft tissue coverage and are shown in Table 2.

Figure 3 shows the sequence of ridge preservation in a lower premolar site and subsequent re-entry at eight months.

Outcomes of ridge preservation

Many of the studies investigating ridge preservation have looked at bone formation or dimensional changes. In general, ridge preservation procedures are effective in limiting horizontal and vertical ridge changes. There is no evidence to support the superiority of one technique over another. Deproteinized bovine bone mineral (DBBM) does seem to be a more reliable material than demineralized freeze-dried bone.
RIDGE PRESERVATION: DOES IT ACTUALLY WORK?

Table 1.
The different types of bone graft materials and membranes that have been reported in the dental literature in ridge preservation studies.

<table>
<thead>
<tr>
<th>Bone graft materials</th>
<th>Types of membranes</th>
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<tr>
<td>Demineralized freeze-dried bone allograft</td>
<td>Expanded polytetrafluoroethylene</td>
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<tr>
<td>Deproteinized bovine bone mineral</td>
<td>Collagen</td>
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<tr>
<td>Autologous bone</td>
<td>Polyactic/Polyglycolic Acid</td>
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<tr>
<td>Bioactive Glass</td>
<td>Titanium</td>
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<tr>
<td>Hydroxyapatite</td>
<td>Acellular dermal matrix graft</td>
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<td>Calcium sulphate</td>
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<tr>
<td>Solvent-preserved cancellous graft</td>
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<tr>
<td>Irradiated cancellous allograft</td>
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<td>Solvent-dehydrated allograft</td>
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Table 2.
The various combinations of materials and soft tissue manipulation reported in ridge preservation.

<table>
<thead>
<tr>
<th>Bone graft material, membrane and soft tissue advancement</th>
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<tr>
<td>Bone graft material and soft tissue advancement</td>
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<tr>
<td>Membrane and soft tissue advancement</td>
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<tr>
<td>Bone graft material alone</td>
</tr>
<tr>
<td>Membrane alone</td>
</tr>
<tr>
<td>Bone graft material and collagen wound dressing</td>
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<tr>
<td>Sponge</td>
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</table>

bone allograft (DFDBA) or autologous particulate grafts. The use of membranes required soft tissue coverage to maximize outcomes. Exposure of expanded polytetrafluoroethylene (ePTFE) membranes was common and resulted in a much reduced bone infill and dimensional stability. The exposure of collagen membranes was less frequent and less detrimental. Given the diversity of soft tissue closure and concomitant procedures, it would appear that ridge preservation can be successful even if primary closure is not achieved. However, it is recommended when a particulate graft is used to hold it in place. There seems to be no difference with tooth type, position or reason for extraction in the outcome, and the use of antibiotics cannot be supported or denied given the heterogeneity of the available literature.

The amount of bone formed at ridge preserved sites varies between techniques, materials and timing of sampling. Irrespective of graft material, some bone is formed and varied between 18 and 64%. The longer the sampling time after the ridge preservation procedure the more bone there was at the site. When materials with a slower substitution rate are used, residual particles are to be expected at the time of implant placement. The effect of the residual graft material on osseointegration and survival/success outcomes of the implant therapy is unknown.

Very few papers have reported the effect of ridge preservation on facilitating implant placement. Many mention that implants were placed, but often implants could be placed in untreated control sites. An interesting finding by Sandor et al. and Fiorellini et al. was that ridge preserved sites required much less grafting than untreated sites at the time of implant placement.

The longevity of the grafted sites and the implants placed at these sites has been poorly reported. The majority of the literature does not report on implant survival and the grafted sites are only followed until they are biopsied at time of implant placement. Sandor et al. showed approximately 94% survival three to seven years post-placement and Norton and Wilson 89% 18 months post-placement. The longest follow-up period has been by Sclar. He used the Bio-Col technique, where DBBM is placed into the socket, a collagen plug is placed on top and is loosely sutured into position with the epithelium allowed to grow over the plug. He reported a 94% survival rate in 248 ridge-preserved sites in his private practice over six to 73 months.

CONCLUSION

The recent 4th ITI consensus conference concluded that "ridge preservation procedures result in greater orofacial dimension of bone than when no ridge preservation procedures are performed". These authors suggested that when an implant is to be delayed for more than a two to three months post-extraction then ridge preservation procedures should be considered for maintaining as much bone volume as possible. Whilst there is no firm evidence of ridge preservation on implant success, it would seem appropriate to use these procedures. However, the best ridge preservation method is to keep the natural tooth for as long as possible.

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NOVEL APPROACHES IN 3-DIMENSIONAL FACIAL PROFILING TO
ESTABLISH FACIAL AESTHETIC OBJECTIVES IN THE TREATMENT OF
FACIAL DYSMORPHOLOGIES

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ABSTRACT

When confronted with facial dysmorphologies, three-dimensional (3D) facial harmony is preferably assessed with regard to normality. This, however, presents two major challenges. The first challenge is to define normality. What makes non-dysmorphic faces appear normal? The second challenge is to situate the craniofacial dysmorphology with respect to normality. What makes the dysmorphic face not appear to be normal? To tackle these challenges, a novel approach based on a Face Space is proposed. In essence, faces are represented as points in a High-dimensional space, the dimensions of which capture important sources of allowed facial variation within a normal population. To establish an aesthetic objective of a given dysmorphic face, the novel concept of the “normal equivalent” of that face via robust projection into the Face Space is proposed. This technique is demonstrated on an artificial example in which smiling whilst showing teeth is considered a surrogate for facial dysmorphology.

INTRODUCTION

The aim of multidisciplinary treatment of facial dysmorphology is to achieve pleasing aesthetics with a functional dentition and airway. Conventional planning prioritizes dental alveolar and skeletal discrepancies. Facial profile outcomes are most certainly considered but difficult to predict. More recently there has been a shift in philosophy in the treating of facial dysmorphologies where facial profile is the priority with functional requirements of the airway and dental occlusal relationship considered secondary. This has been referred to as FAB; Face-Airway-Bite.

Criteria for treatment objectives for the dentition and airway are well established but for facial aesthetics are more problematic. Facial aesthetics has been described by a set of facial proportions that was first described by the Greek sculptors and now known as the Lysippan Canon of Proportion. These were modified by the renaissance artisans as a set of neoclassical canons that are with some modification the benchmark in facial aesthetic reconstruction today.

The treatment objectives for reconstructive surgical procedures are to achieve normality. This indirectly poses the problem of defining normality first, which can only be achieved based on proper normative reference data. Coming from a clinical background the most commonly known imaging device for this purpose is a Computer Tomography (CT) scanner. A disadvantage however, is the level of irradiation absorbed by the subject during CT scanning, limiting the reference database to patient data and incomplete head scans or deceased subject data. Furthermore, CT images are acquired of subjects in a horizontal, supine position. As a result, due to gravitational forces, facial shapes extracted from CT images will differ from the typical facial shape when viewed in a standing upright position. Alternatively, the advent of 3D surface scanners, being able to capture the facial profile with a high accuracy and quality, gives the possibility to scan a person in an upright position, without being harmful. These types of 3D scanners are rapidly being introduced into clinical practice and allow for the construction of reference facial databases in order to define normality.

Simple measurements, indices and ratios measured on normative reference data have been used successfully to characterize specific aspects of craniofacial shape and have been used until now. However, these measurements often fail to represent complete three-dimensional morphology of the head. When specific measurements are used individually, they oversimplify and when they are used collectively, they are difficult to interpret.

Because no objective standard for three-dimensional facial shape has been satisfactorily defined, outcome planning and analysis of facial dysmorphology still relies on subjective visual judgment today. A first attempt to standardize complete 3D shape is the use of archetypes. Archetypes are averaged or generic facial profiles constructed from a dataset and where first used in for the diagnosis of syndrome faces. Very recently archetypes from normative data were used as references for the treatment assessment of dysmorphologies. However, there is some evidence that these generic heads are not well represented in the population. That is, an averaged face does not equate to a typical face. The average face is too perfect and, as such, appears to be artificial. The means to establish a patient specific typical or normalized reference would be more desirable.

In this paper a novel approach to establish facial aesthetic objectives or standards in the treatment of facial
dysmorphologies in a patient specific way is proposed. The concept of an archetype is extended into a Face-Space (FS) in which faces are represented as points in a High-dimensional space, the dimensions of which capture important sources of allowed facial variation within a normal population. To establish an aesthetic objective of a given face, the novel concept of the normal equivalent (NE) of that face via robust projection of the face into the Face-Space is proposed. The Face-Space can be considered as an objective standard for normal 3D facial shape and in conjunction with the normal equivalent provides a means to objectively plan and assess the treatment of facial dysmorphologies.

MATERIALS AND METHODS

Normative Data acquisition

Ethics approval for the project The Characterisation of 3-Dimensional Facial Profile in Young Adult Western Australians was granted from the Princess Margaret Hospital for Children (PMH) ethics committee (PMHEC 1443/EP) in Perth, W.A. 3D surface scans of healthy young people between the ages of 5 and 25 were collected using a 3dMD facial scanning system. Facial data that were collected were represented as a complete surface. Shape data consisted of a dense number of points each with its own x, y and z component in 3D space. This collection of 3D points can exist as a point cloud or wireframe. To enable the standardization of shape represented by point clouds a method\textsuperscript{11} that automatically achieves anatomical correspondence between faces was employed because of the impracticality of indicating thousands of corresponding points manually.

Normative Face-Space construction

The result is a normative database in which every facial surface is represented by the same number of points (12000) with the same connectivity, such that for every point on one facial surface the corresponding point on every other facial surface is known. This enables the creation of facial archetypes and the statistical analysis of 3D facial shapes in a Face-Space. By averaging densely corresponding points for all faces an average face is constructed. Additionally, using the knowledge of the densely corresponding points, faces are represented as a single point in a high-dimensional (12000 x 3) coordinate system or Face-Space. The next step is centreing the data around the average which is equivalent to translating the origin of the Face-Space to the centre of the point cloud formed by all the faces. Finally, a probability distribution is associated to the Face-Space by fitting a multivariate normal distribution to the point cloud using PCA. This results in a correlation ranked set of principal components (PCs) modelling the inter-subject variance and covariance. The most prominent spread of variation within the dataset is always extracted by the first PC, and the second widest variation by the second PC, etc. This type of variations extracted is entirely dependent on the distribution of the dataset being studied and hence in this study will only model variation of non-dysmorphic facial profiles.

This normative Face-Space contains a more complete description of the underlying data then what has been known previously. Besides the creation of just an average reference face, variation present in the normative population is modelled as well using the set of principal components. Hence, the Face-Space describes typical and the limits of differences within the normative population and therefore defines normality for complete 3D facial shapes.

Normal Equivalent construction

Assessment of a facial profile with atypical or dysmorphic parts is done via a robust projection of that face into the Face-Space. During the projection, the dysmorphic parts of the face can be isolated and colour coded images/maps can be generated that assist the treating clinician in defining the problem. These maps depict confidence limits, representing the belief that local facial features and parts are within normal allowed variation or not. By removing regions of the face considered as dysmorphic the remaining components can be mapped to the normative face space to provide a complete facial map that is within prescribed normative limits. This generates a normalized facial profile which is termed the normal equivalent (NE) of the dysmorphic face. This NE can be considered a patient specific typical or normalized reference to compare or assess the dismorphic face against.

Fig. 1 – An artificial example: expression as dysmorphic surrogate to illustrate the proposed approach. From left to right, the original surrogate example, the Normal Equivalent after projection of the surrogate into the normative Face-Space and the confidence map (using a gray-coloured confidence range from 0 (black) to 1 (white)).
RESULTS

Four hundred faces from WA have been processed, with ages ranging from 5 to 25 years, into a normative Face-Space. All faces were scanned without an exaggerated smile showing the teeth. In order to illustrate the technique an artificial example was constructed and scanned as a single face with an exaggerated smile whilst showing the teeth. With regard to the normative model this exaggerated smile is considered atypical and hence is used as a surrogate for facial dysmorphology.

The result is depicted in Fig. 1. From left to right the original surrogate scan, the Normal Equivalent after projection of the scan into the normative Face-Space and the confidence map are shown. The Normal Equivalent still strongly resembles the original surrogate scan (patient specific) but is now within normal allowed variation. Indeed, the exaggerated smile that made the surrogate scan atypical to the normative database is reduced up to a point where the teeth are not shown anymore. The remaining smile is possible within the variation of the normal population encoded in the normative Face-Space. The confidence map nicely depicts the areas of the original surrogate that are atypical (black) and typical (white) according to normality. This map is very useful in defining the problem and can assist the treating clinician during assessment. The map shows that the areas of the mouth where the teeth are shown are indeed atypical as expected. Furthermore, it also shows that other areas, like the chin and cheeks, are strongly affected by the exaggerated smile and became atypical as well. When examining the person in question it is indeed so that these areas changed a lot when showing the teeth and that these results are very plausible and promising.

CONCLUSION

When confronted with facial dysmorphologies, 3-dimensional (3D) facial harmony is preferably assessed with regard to normality. Because no objective standard for normal three-dimensional facial shape has been satisfactorily defined so far, outcome planning and analysis of facial dysmorphology still relies on subjective visual judgment. Simple measurements taken on normative reference data have been used successfully in the past but failed to represent complete three-dimensional morphology of the head. The use of archetypes presented a promising alternative. However, there is some evidence that these generic faces are not well represented in the population and the means to establish a patient specific typical or normalized reference would be more desirable.

A novel approach to establish facial aesthetic objectives or standards in the treatment of facial dysmorphologies in a patient specific way is proposed. The concept of Archetypes was extended into a Face-Space (FS) which besides an average also captured important sources of allowed facial variation within a normal population. Using the Face-Space a normalized facial profile could be generated, called the normal equivalent of a given dysmorphic face. This NE can be considered a patient specific normalized reference to assess the dsmorphic face against. This technique was demonstrated on an artificial example in which smiling whilst showing teeth is considered a surrogate for facial dysmorphism. The results were very promising. In order to illustrate the value in clinical practice the application of this technique on real clinical cases is planned.

ACKNOWLEDGMENTS

The authors would like to thank Miranda Norquay from the Princess Margaret Hospital for Children (PMH) in Perth, WA for providing the high quality 3D Scans. The data have been used to generate the results. This work was also supported by the Australian Research Council (ARC) grant DP0772650.

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ASPECTS OF WEAR AND TEAR OF TOOTH STRUCTURE

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ABSTRACT

Lifestyle factors and the increased longevity of the dentition due to greater life expectancy have resulted in greater wear and tear (cracking) of teeth. Often there exists interplay between damage and repair. An understanding of these mechanisms of damage and repair will assist the clinician in correct diagnosis and treatment planning. Preventive strategies as well as interdisciplinary measures are required for optimal outcomes. However, are some of our restorative interventions causing further damage to tooth structure?

INTRODUCTION

Lifestyle factors and the increased longevity of the dentition due to greater life expectancy as well as a desire of patients to retain their dentition have resulted in greater wear and tear (cracking) of teeth. Teeth are subject to a variety of processes of wear that include etching, attrition, abrasion, erosion, and more controversially stress-corrosion (abfraction). Teeth may also crack (tear) as a consequence of parafunctional forces and prior restorative work that has the potential to introduce micro-cracks that can propagate to initiate tooth fracture. It is the objective of this article primarily within the framework of the author’s research to outline the mechanisms of this damage and demonstrable repair that may occur in dentine which is a biological response by the pulp and an intrinsic quality within dentine. However, are some of our restorative interventions causing further damage to tooth structure?

TOOTH WEAR

Teeth are subjected to wear processes due to longer retention of the dentition, parafunctional habits and dietary effects from consumption of acidic drinks and wine. Tooth wear is shaped by interactions between acid wear, erosion, attrition, abrasion and dentinal sclerosis.1 It is generally accepted that non carious cervical lesions (NCCLs) occur on surfaces exposed to brushing. However, studies have shown that factors other than dentifrice-abrasivity play important roles in the formation of these lesions.2 Clinical observations still favour the possibility that excessive oral hygiene practices, such as brushing and flossing, produce cervical lesions by abrasion.3 The tooth surfaces on which NCCLs develop have been shown to be those least protected by serous saliva from the major salivary glands.4 It may be that dentinal tubules opened up by erosion are initially repaired by salivary pellicle or by mineral deposits from either the saliva or the odontoblasts as intratubular dentine. Areas of dentine in cervical erosions which are sensitive, display patent dentinal tubules. Teeth without symptoms exhibit occluded tubules.5

In a recent scanning electron microscopic (SEM) study that examined the patency of tubules, the formation of intratubular dentine (sclerosis) or pulpal reparative dentine beneath the lesions of tooth wear was shown.6 The premise is that patent tubules are required to transmit the stimuli to pulpal neurons and dentine experienced via the hydrodynamic mechanism.6 Conversely, tubules narrowed by intratubular dentine, obliterated by sclerosis or closed by reparative dentine on the pulpal wall to form dead tracts will not transmit pain stimuli. As the lesions of tooth wear progress episodes of dentinal sensitivity, or lack thereof, may occur as repair takes place beneath the lesion through the formation of sclerotic dentine.

Beneath the amelo-dentinal junction (ADJ) are great numbers of fine, terminal branches of odontoblastic tubules (Fig. 1). The odontoblasts are not receptor cells capable of transmitting signals to nerve fibres. Nerve endings are present only in the tubules of the deepest dentine, of the

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* Presented at the Twentieth Convocation of the Royal Australasian College of Dental Surgeons, Perth, Western Australia. March 2010
predentine and within the subodontoblastic neural plexus of the pulp. However, odontoblastic processes are bathed in a tissue fluid which fills the dentinal tubules and their branches up to the ADJ. It is currently believed that rapid movements of this fluid are sensed as pain by nerve endings in the pulp. This ‘hydrodynamic’ theory holds that an outward flow of tissue fluid occurs when the tubules are opened. This stimulates mechanoreceptors, the nerve endings in the pulp, that give rise to dentinal sensitivity. However, the rate of fluid flow within open tubules depends on their width. Terminal branches of tubules near the ADJ, have smaller widths than the tubules within the deeper dentine and predentine. As tubule diameters double, a 16-fold increase in fluid flow occurs, because fluid-flow depends on the fourth power of the radius of the tubule. This may be one reason why the dentine just below the ADJ, when first exposed by attrition is not sensitive. However, the most important biological reason why superficial tubules and their narrow branches do not spill dentinal fluid, is that dentinal tubules beneath attrition wear facets are occluded by the process of dentinal sclerosis.

When enamel is removed by wear, the underlying dentinal tubules become filled with an amorphous calcified tissue called intratubular dentine which is secreted by the odontoblasts. Initially, the diameters of tubules are narrowed by the build-up of this material within their walls. Subsequently, the odontoblastic processes retract, leaving behind tubules virtually occluded by intratubular dentine (Fig. 2). Dentine so modified is called sclerotic dentine (Fig. 3). Sclerotic dentine can extend within the tooth crowns from the ADJ to the pulp. Thus, dentinal sensitivity is repaired and symptoms are relieved by closing of the narrow, superficial tubules by intratubular dentine. Tracts of sclerotic dental tubules are formed beneath wear facets. Reparative dentine seals not only sclerotic dentine from the pulp surface but also empty tubules of “dead tracts”. As the nerves and mechanoreceptors in the pulp become isolated from the worn dentine surface, they no longer react to stimuli on wear facets.

As acid exposure to teeth is considered a primary factor in the development of NCCls any comprehensive treatment plan needs to address both dietary modification to decrease the acid exposure and wear and the reasons for the lack of salivary protection. While palliative measures are often employed, the dentine beneath NCCls is sclerotic and therefore poses challenges for restoring these lesions for sclerotic dentine does not respond to etching or to bonding in the same manner as normal dentine. Current dentine bonding techniques rely on the formation of a hybrid layer enhanced by the demineralization of the dentine to form micro-porosities that allow penetration of the bonding agents. It is difficult to achieve sufficient demineralization of sclerotic dentine to attain optimal bonding through resin tags. Debonding, marginal leakage and loss of cervical restorations may then occur as a consequence. Other studies suggest that NCCL restorations fail as a result of the flexure of the tooth from excessive occlusal stress transferred to the cervical area. When bruxism is postulated to be the primary cause of NCCls located at the cemento-enamel junctions (CEJ) and that tensile stresses are thought to be responsible for breakdown of cervical tooth structure, then clinicians will seek mechanical and technical solutions rather than adopt preventive strategies to arrest acid wear. Thus, the clinical diagnosis, conservation and restoration of non-carious cervical lesions should take into account the protective properties of serous saliva on the surfaces of acid wear, abrasion and of the extent of sclerotic dentine beneath NCCLs.

### CRACKED TEETH (TEARING)

A cracked tooth is a frequent dental complaint with patients seeking treatment often presenting with a protracted history of pain of varying intensity. While intermittent pain on biting and thermal sensitivity are the most consistent complaints associated with these teeth, cracks in teeth may result in a wide range of symptoms from occasional
Discomfort to severe and prolonged pain. Symptoms are often dependent on the depth and direction of the crack and the tissues involved. Cracks in teeth can occur in both horizontal and vertical directions and may involve enamel, dentine, pulp and/or the periodontium. Cracks in posterior teeth often originate from an internal line angle at the floor of a restoration and often involving a marginal ridge extending in a mesio-distal direction. Vertical root fractures are longitudinally orientated fractures of the root that extend from the root canal into the periodontium.

Clinicians regard unsupported enamel as a brittle structure as it is the underlying dentine that gives structural strength to tooth structure. Dentine is a highly mineralized tissue, which forms the bulk of the teeth. It is a hydrated compound that contains fluid filled tubules surrounded by highly mineralized peritubular dentine embedded in intratubular matrix. Hydroxyapatite crystals, the main inorganic material, provide strength, while collagen fibrils provide toughness. Dentine is able to resist fracture as the orientation of collagen fibrils counter the directional effect of the dentinal tubules, thereby exhibiting crack stopping behaviour. Also, Pashley (1990) has suggested that the fluid filled dentinal tubules could function to hydraulically transfer and dissipate the occlusal forces applied to teeth. From the perspective of theoretical mechanics, the structural stability of dentine is a function of mineralization and of moisture content.

Fracture of dentine is a function of crack initiation and crack propagation. Kahler et al. demonstrated that dentine possessed fracture-toughening mechanisms that impede crack propagation. This study clearly demonstrates the presence of micro-cracking for the first time in dentine (Fig. 4 - 7). Crack growth resistance of a material is a consequence of intrinsic micro-structural damage mechanisms operating ahead of the crack tip, and extrinsic crack tip shielding mechanisms that operate behind the crack tip. Intrinsic mechanisms are an inherent property of the material that control crack initiation. Extrinsic mechanisms, which include crack deflection, inelastic or dilated zones that surround the crack wake, and bridge formation (ligament toughening) between the crack surfaces acting in the crack wake, are responsible for resistance-curve behaviour (R-curve).

In this study, the optical observations reveal fracture mechanisms of dentine that show a number of extrinsic toughening mechanisms, such as micro-cracking (Fig. 4a, 4b), occurring ahead of the crack tip and ligament development (Fig. 4b, 4c) behind the tip. These ligaments across the crack tip greatly contribute to the greater toughness of dentine as the closure forces generated reduce the magnitude of the stress at the crack tip. This mechanism is primarily responsible for the high toughness of fibre-reinforced materials. In addition, dilatancy about the crack tip was observed as indicated by the fluid ingress and egress (Fig. 5). The size of this zone appeared to be much larger than the narrow zone of micro-cracking about the crack tip. During loading, a region of hydrostatic tension and superimposed shear stresses develop about the crack tip. These stresses are able to induce dilation of a region about the crack tip in a similar manner to the development of a plastic zone about the crack tip of a metal.

Clinically, the significance of this work is the importance of maintaining the dentine during cavity preparation. Dentine should be retained for the structural strength that it provides the tooth and its ability to resist fracture propagation. Excessive removal of dentine cannot be recommended and this is in accord with the principles of minimally-invasive dentistry. Despite the fracture-toughening mechanisms observed in dentine, recent research indicates that the trend to place resin composites in posterior teeth may be introducing further damage to tooth structure. A recent study has demonstrated substantial interfacial failure of the enamel-resin composite bond and cracking in the enamel adjacent to the interface (Fig. 7, 8). The author proposed simple analytical models that may allow further research to reduce the deleterious effects of polymerization shrinkage.
stress that introduce damage as a consequence of restorative intervention.22-25 Despite the considerable improvements in the development of resin composites the concept of ‘total etch and total seal’ is not a paradigm that can be reliably achieved.

ACKNOWLEDGMENTS

The author gratefully acknowledges the assistance of Professors Michael Swain and William Young for their assistance and guidance in the relevant studies.

Figures 4a, 4b, 4c, 5 and 6 have been reprinted from Kahler B, Swain MV, Moule A. Fracture-toughening mechanisms responsible for differences in work to fracture of hydrated and dehydrated dentine. *Journal of Biomechanics* 2003;36:229-37, with permission from Elsevier.

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Hydrated dentine

![Hydrated dentine diagram](image)

Fig. 6. – Schematic illustration of the toughening mechanisms operating during the fracture of hydrated dentine. Note the extensive ligament formation bridging the crack and the visco-elastic/plastic energy dissipation zone about the crack tip. (Reprinted with permission from Elsevier).

Fig. 5. – Optical micrograph illustrating the development of water droplets just behind the crack tip formed moments after the crack arrested following crack extension. (Reprinted with permission from Elsevier).

Fig. 7. – A representative occlusal cavity restored with resin composite. Black arrows indicate the presence of a “white line” and cracking in the enamel. The white arrow shows a gap or failure of the adhesive bond at the tooth-restoration interface.


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GENERAL WELL-BEING IN THE NEW DECADE – IMPORTANT CONSIDERATIONS

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ABSTRACT

Chronic diseases have created a growing burden of ill-health as populations age, become more obese and as survival with many conditions improves. Cardiovascular disease, cancer and anxiety/depression merit priority by being common and treatable. Genomics aid diagnosis and understanding but have limited impact on management. Early diagnosis requires comprehensive annual clinical reviews, in which dental practitioners have an important role. Relevant imaging can be helpful. Useful early interventions include tactical lifestyle measures, weight control, appropriate supplements and low dose pharmacotherapy.

Well-being requires avoidance of major illness and preservation of optimal health. Chronic systemic diseases are on the increase, as we age, become more obese and as effective treatments increase survival. Disease management is enhanced by early diagnosis of treatable conditions with strategic screening. Numerically, the major disease areas which reduce quality of life and cause disability are cardiovascular, cancer, musculoskeletal disease and depression.

Coronary and hypertensive heart disease become symptomatic in the second half of life, cause considerable morbidity and account for almost half of deaths. Strokes mainly occur after age 60, cause major disability, contribute substantially to dementia and account for more than 10% of deaths.

More than one half of us will develop cancer, usually later in life but sometimes tragically earlier. Prevention and early diagnosis are priorities. Reduction in sun, tobacco and alcohol exposure are fundamental in prevention. Skin, colorectal, breast and prostate cancer, the commonest malignancies, are mostly sporadic and this has spawned increasingly effective diagnostic screening, based on various forms of cross-sectional imaging or digital photography which can be archived and compared.

Symptoms related to mental health occur in about one third of us, mildly in many more, often from early in life. Depression often emerges in mid-life and is expected to account for more disability than any other illness later this century. Overlap with more identifiable and treatable anxiety disorders is considerable. These degrade sleep and quality of life, impede healthy lifestyle and contribute to psychosomatic symptomatology and hypertension.

Alcohol and other substances give acute stress and other symptom relief but over time reduce quality of life, exacerbate mood and fatigue disorders and contribute to violence and motor vehicle accidents.

Intercurrent infections take an enormous toll across all ages. Antiviral drug development has proven problematic but with sufficient investment and focus, has rendered HIV disease manageable. Timely vaccination lessens and often prevents a range of serious viral infections, well demonstrated with influenza, hepatitis B and childhood exanthemata. Early appropriate use of antibiotics can be life saving in acute bacterial infection. Peri-operative topical antiseptics and antibiotics have substantially reduced wound infection morbidity.

All gingival and dental infections are increased in diabetes, meriting more aggressive surveillance and management. There is a substantial association between periodontal and coronary disease but this may be largely related to associated obesity and less healthy lifestyle. The most sensitive marker of systemic inflammation, C-reactive protein, predicts coronary events but this relationship has not been shown to be independent of obesity, diabetes, hypertension and hypercholesterolaemia.

Genomics have better defined most diseases and dominate contemporary clinical research. Although heredity contributes substantially to all diseases, family history and genetic testing have to date only had a limited role in clinical practice. The main clinical application has been precise early diagnosis or exclusion of genetic disease in the relatives of patients presenting with confirmed disease. The accuracy of predicting cancer risk with genetic testing is improving but clinical application is limited to high-risk kindreds. Personalised genome analysis based healthcare in routine clinical practice appears some way off.

Annual clinical reviews are fundamental for individual health inventory but are not routinely funded, except in the context of insurance. Compliance with recurrent examinations can be problematic because of cost and because many individuals find detailed and predictive clinical consultations confronting.

Dentists are in a strategic position because clinical practice is based on regular clinical reviews. As well as surveillance for oral pathology, the dentist has the opportunity to conduct something of a systemic inventory, in particular related to planned dental procedures. Collaboration with general practice and referral to medical specialists can significantly enhance patient care.
In terms of prevention and management, healthy lifestyle measures are fundamental. Most importantly, these include modest portion nutrition with as much food variety as possible. Regular modest exercise improves energy and well-being but has a limited impact on weight. Adequate leisure time with family and friends and sensible working hours and structure are priorities.

More than two thirds of western populations are overweight or obese. Obesity is associated with fatigue and daytime somnolence. There are complex relationships of obesity with anxiety and mood disorders. Weight reduction thereby may improve these and quality of life.

Weight reduction with bariatric surgery can lower mortality 40%. The almost 60% reduction in coronary mortality is due to the greater than 60% reductions in hyperlipidaemia, hypertension, type 2 diabetes and obstructive sleep apnoea. Cancer mortality was reduced almost 60%. Weight loss by dietary discretion should confer pro rata benefits. Statistical modelling from published trials data suggests that as little as 1 kg weight loss is associated with a 3-5% reduction in coronary risk in high risk individuals. Pharmacotherapy may facilitate weight loss.

There is abundant evidence for benefits from ω-3 marine oil supplements, probably because most of us normally consume insufficient fish. There is robust evidence that ω-3 marine oil supplementation reduces blood pressure, thrombotic events and depression.

It may be prudent for many to take a comprehensive vitamin and mineral supplement to make up for incidental unanticipated dietary deficiencies. This is clinically warranted during weight loss programs, pregnancy and in rehabilitating alcoholics but is likely to have broader applicability, especially with chronic disease. Long-term pharmacotherapy has been shown in hypertension to consistently reduce cardiovascular diseases, so called primary prevention. There is an increasing role for long term drug therapy in the management of established chronic diseases, so called secondary prevention. Indications of long term drug treatment in appropriately selected patients are unequivocal. These trials have provided a basis for calculation of cost-effectiveness. Multi-national clinical guidelines increasingly reflect published data rather than simply committee consensus.

Drug therapy carries the risk of side effects and adverse drug reactions. These may at the least reduce quality of life and at worst may threaten life. Most drug effects are dose-related and some research is now focussed on establishing least necessary dose. Aspirin is now routinely recommended as an antithrombotic in arterial disease at 75 mg daily. Outcomes are superior when thiazide diuretics and digoxin are used at lower doses. Higher doses of atorvastatin than 10 mg daily, not necessary in patients who achieve weight loss, are of marginal additional benefit but are associated with a marked increase in the incidence of side effects.

Combinations of drugs acting through different physiological mechanisms are increasingly used in complex chronic diseases like hypertension, type 2 diabetes mellitus and rheumatoid arthritis. Additive efficacy enables lowering individual drug doses, with the dividend of fewer side effects, which are usually not additive. These are the principles of polypill pharmacotherapy and multi-centre trials have begun to confirm clinical utility.

Regular medical surveillance, precision diagnostics, healthy lifestyle, tactical nutrition supplements and strategic pharmacotherapy are all priorities for optimal long term health and well-being.

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E-health and the national electronic medical record are on our doorstep. As an integral part of the healthcare system, dentistry needs to get on board with this national initiative. How prepared is the dental profession for this? How can a culture of online clinical records be promoted and what protocols and infrastructure exist for this to occur? The lack of government restriction means that dentistry should be taking full advantage of what is possible. The benefits and barriers to adoption of online records will be presented to provide a frame of reference for the next major shift in electronic communication.

### INTRODUCTION

The increasing use of information systems and networks, together with converging technologies, has created a radical shift in how we access and use information. Information is now a resource and our dependence on it is unmistakable. Access is through fixed, wireless and mobile technologies, and our interconnectedness via the Internet surpasses national and international boundaries. Importantly, it supports our critical infrastructure, functions and services. There is little argument that information systems can garner significant cost savings and strategic advantage for any information dependent organization. This cost saving is principally in the timely delivery and storage of information for legitimate purposes or use by the organization. It creates an opportunity for great benefits in sharing information. Unfortunately, it also creates vulnerabilities by increasing exposure to security threats. To keep up we need to develop new ways of using the technologies and new ways of thinking and interacting with the technologies.1 It has and will continue to change our environment and the way we live and work. The result of this trend is that health providers are availing themselves of broadband technologies and information systems. Yet, healthcare adoption of these technical innovations has moved slowly worldwide.2 In 2009 it was quoted that whilst medicine has only 10% electronic records, dentistry has a mere 2%.

This paper aims to raise awareness of the possibilities that the electronic environment and its associated technologies can bring. It includes the current drivers for change and the numerous benefits that dentistry can realize. Further, it raises the issues the dental profession needs to be aware of in order to create a frame of reference for understanding the changes that have occurred and will occur in the future.

### NATIONAL E-HEALTH INITIATIVE

There is a need to establish a national health information infrastructure to address both individual patient health and national health concerns. From the patient perspective improving patient safety and health care quality through reducing errors, occurrences of interactions and allergies etc. are highly desirable. This is only achieved through complete patient records, with test results and radiography available at the point of care. Thus an integration of multiple sources of patient and support information and guidelines is required.

Increasingly all health practitioners are being encouraged to use information technology to make their businesses more efficient and accountable. This impetus for adoption of information technology comes from several vectors. Primarily this comes from Government to meet national policy and regulation. The goal of which is a comprehensive patient health record. The secondary driver is closer to home such as health practice administrators and managers to improve operational excellence and cost savings.

The cornerstone of the e-health innovation in Australia is the Healthcare Identifiers Bill presented to the Australian Federal Parliament in February 2010.4 This legislation sets the foundation for the integration of patient information across primarily the public health system. In Australia the majority of dental services are privately funded regardless of dental insurance cover. Public services exist for concession card holders but are run by the State and Territory governments and not federally.5 Unfortunately, the provision to include allied health, which includes dentistry, is noticeable by its absence in the current e-health initiative. The Australian Dental Association (ADA)6 highlighted the issue of inclusivity in the e-health program which is based on participation agreements by dental practitioners with an existing commonwealth recognized Health Provider Organization. Further, the AHA cites the issue of many dental practitioners still being paper-based, and therefore non e-health prepared. This is potentially a major obstacle to the creation of a national e-health system without government financial incentives for adoption and education. The general practice health practitioner cohort has been provided with the Practice Incentive Program to modernize their practices by installing medical information systems and adopting electronic clinical records and e-prescribing.7 It is inconceivable to have a national e-health record...
without dentistry, as it would be deficient without pharmacy, laboratory results and other branches of allied health care.

So how does dentistry fit into this? There has been national and state condemnation of the quality of dental record keeping. For instance, the Dental Board of Western Australia (2008) in its annual report cited poor record keeping as disappointing with the occurrence ranging from carelessness to incompetence. The majority of dental services in Australia are not driven or overseen by the Government. Currently, Medicare funding is only available for dental services to those with chronic conditions and complex care needs (with referral by the GP) capped over a two year period and some specifically funded programs such the Teen Dental Plan. Regardless of the position of the government of the day, the dental profession needs to take advantage of the positive impact that the electronic environment can have on the business capacity and the quality of patient care.

**DENTAL INFORMATICS**

The development and adaptation of technology into the dental arena needs to be both planned and appropriate. The term dental informatics (similar to medical and health informatics) covers a myriad of facets of the use of computers and technology in healthcare. It is not solely about electronic charting and records: it is about electronic health records and decision making tools together with data analysis. The major issue that this new discipline has to address is the adoption of the technology and its integration into workflow. Like many applications of computing, the initial road has been problematic with user issues being a major stumbling block. As is the case with medical informatics, dental informatics is a technological venture with a scientific basis that is situated predominantly in the domain of informatics rather than in clinical dentistry. Unfortunately too it is similarly, still, ill-defined.

Arguably, the application of computing in dentistry is broader than electronic records. It is about applying scientific development to medical and dental techniques which has always been complex. Yet in dentistry it has significant potential in the use of artificial intelligence techniques in a richer computing environment, both visual and predictive. At a patient level this is a potential that general medicine can only dream about. To date, the inclusion of visual representations rather than true images has meant programs were of limited use. However, technical advances mean that the ability to image data will radically change the future of digital charting. Another aspect of dental informatics is dental decision support, particularly for dental training. Such systems can provide support which can use evidence based approaches. The advancement of dental informatics will harness the benefits of electronic systems whilst exploring new opportunities.

With dental informatics as a discipline base, it is important to appreciate the wide range of benefits it can provide. **BENEFITS**

There are many advantages in creating an electronic environment around dental practice. As Fig. 1 indicates this can be viewed as a continuum of the opportunities created by technology.

The benefits are located across a spectrum from basic to highly sophisticated, both in the types of technology employed and the benefits that these bring.

At level A there are immediate benefits in electronic administration in single data collection points and management of multiple sites. Billing and business programs can result in improved control of cash flow.

At level B a reduction in overheads commences. This includes lower advertising costs by using email and text messaging, lower printing costs, appointments, recalls, missed appointments, electronic claims which also improve cash flow and improve financial management.

At level C we begin to see advances in both practice management and clinical capabilities. From a management perspective, the protection of information and data loss from fire, theft and natural disaster can be minimized. Electronic records of all types reduce storage space, improve the security of records and facilitate multiple concurrent accesses. The question that needs to be at the forefront of decisions at this

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**Fig.1. – Continuum of opportunities derived from technology**

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<td>Electronic Patient Information Transfer</td>
<td>Information Sharing Research</td>
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Fully Paper Based | Fully Electronic

- E-Banking
- Appointments
- E-Claiming
- E-messaging (email)
- Computerized Charting

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level is how much is your data worth to your practice and what would be the impact of its temporary loss or permanent destruction?

From a clinical perspective, automatic recalls and improved proactive preventive services can be utilized. Electronic records are reproducible, searchable, accessible, legible, can be sorted and allow single data entry for multiple uses e.g., clinical charting and financial management. Paper records are usually written in chronological order, so recording information electronically can facilitate a more logical format. Viewing of information in different formats such as chart, graphs, and colour coding is easily achieved electronically, making the information more useful and easier to access. Importantly, the general health status and health information on a patient, particularly in complex cases, can be automatically linked to medical references and associated support information. Lastly, it provides a complete and accurate record to support patient treatment and fulfills the legal documentation should it be required.

At level D the exciting opportunities begin. Digital radiography and photography has significant cost and time savings in addition to the health benefits for the patient in less radiation. It allows for instantaneous viewing of images with greater accuracy. It provides the ability to investigate further in real-time, thus providing for better and more immediate diagnosis. It also facilitates remote consultations which are a radical shift for the practice of dentistry. In addition, since patient education is an important part of dentistry using 3-D imagery can enhance motivation and understanding by patients. Research into the content of dental records has revealed that more work needs to done on the specification and standardization of what is included in the dental records since this is not consistent in either the paper or electronic record. One often forgotten benefit at this level is that it is easier to have a proper protocol in place and for it to be followed consistently electronically, as it allows for organization of apparent disorganized and disparate information.

At level E the initiation of a World Wide Web presence significantly assists in advertising and patient services location, as 60% of people look for people, business and services via the Web. It also provides another avenue for advertising.

At level F there is enhanced inter and intra-practice communication due to the integration of technology with work flow and this also makes remote consultations possible.

At level G there is unlimited potential! Educational opportunities proliferate with the use of electronic records systems, particularly in the area of dental training. More importantly, the rapid advances in dental techniques and procedures come from the accumulation and analysis of patient data, which is difficult to collate when in paper form. Indeed large scale collection of data on the oral health of Australians is currently not possible. In addition to these general areas, activities such as forensic identification using dental records (disaster victim identification) can be vastly improved. There are significant problems in identification using dental records where dental records are illegible; where there is a lack of adequate charting; lack of uniformity in charting; changes in dentition; where inadequate dental radiograph exist or through human error. Similarly after major disasters, such as Hurricane Katrina, where records are destroyed, a national health database can benefit those who are displaced.

Ultimately, the integration of patient clinical data, charting, images and x-rays allows proper recording of information and retrieval from the same user interface. We then have the technical knowledge and data to support advancements of dental techniques and procedures using the accumulation of health information. Yet, whilst all these opportunities are possible there are also factors holding back the development and adoption of this electronic revolution.

**BARRIERS**

The obstacles to the adoption and effective use of electronic records can be roughly categorized into privacy issues, technical security and human factors.

Privacy and confidentiality concerns are regularly raised as the predominant obstacles to the implementation of electronic solutions and to sharing information. This is a valid concern. However, with the appropriate security controls in place the benefits far outweigh the risks. Part of this equation is deciding the level of risk the practice is prepared live with. This is done inherently with the paper-based record as risks to privacy and confidentiality are the same risks. The same laws apply: there are no separate laws for electronic information.

Another key concern has been the safety and security of records, particularly in the event of a catastrophic event. Data protection has been an obstacle in adopting electronic systems – yet this is essentially a myth. The choice of system to meet the needs and philosophy of the practice is important and this requires planning. The protection that you afford the systems you put in place form part of this choice. In reality the use of electronic records in which the appropriate integration of systems, redundancy and storage is used makes such records more secure and more accessible.

Some of the more common technical security concerns include:

- Broadband connection which allows fast access and searching for information, yet the same facilities assist unauthorized access to information for malicious purposes or financial gain;
- Traditional malware – viruses and worms;
- Mobile devices such as flash technology (USB and thumb drives, iPods, PDAs) which make it easier to copy and walk away with information and thus can be more easily stolen;
- The potential for application flaws is real security threat as dental software is specialized and the developers’ main focus is on functionality and not security. Such flaws may result in exploits that could allow escalation of privileges either within the database or the underlying operating system. The challenge between functionality and security is not new one and will continue to be a tussle for the foreseeable future;
• Insecure disposal of storage and back up media.\textsuperscript{23} The discipline of digital forensics allows for retrieval of data from even wiped disks. If as researchers we can do this, so can the criminals; and the integrity of the information as alteration of information appears to be easier and less easily detectable raises concern.

The human aspect is where most security fails. It is the human facet of implementation and day to day security procedures that are at risk. This is not surprising since security is not a dental practice’s core business, but if we are to protect the electronic systems that we depend upon, it needs to be an essential element of routine activity. The successful introduction of technology, its integration into workflow, and realizing its benefits can be dependent upon staff training – an oft ill-considered and unaddressed component of technology acceptance.\textsuperscript{24}

Human threats come from both internal and external sources. Internally these include practice staff and authorized third party service provider. Externally these range from recreational hackers to organized criminal networks. The technical focus for many years has been on protecting a network from the outside and the security controls available for this are robust. The use of firewalls and intrusion detection systems are commonplace (although not always installed to their maximum protective capacity). There is no shortage of advice on the technical aspects of protecting electronic information. Yet the potentially most harmful security incidents can occur from within the practice by people who have legitimate access to information. Incidents may be accidental or malicious, but all types are potentially more harmful as authorized access raises less concern and incident alarm. The legitimate user is called the insider threat and is often less seriously considered particularly in trusting, health oriented environments.\textsuperscript{2}

‘Trust’ is an inherent characteristic of health service providers; however, it also contributes to a more insecure environment. Research into a similar environment (Australian General Practice) indicates that the implementation of security is poorly applied due to a lack of knowledge and a complex working environment. The factors that contribute to ineffective information security are related to trust, capability, costs, time, lack of knowledge, and attitude, together with deficiencies in knowledge of legal requirements, use of technology, and awareness of insecurity impacts. The practice of information security in the health environment is made more complex by confusion over the legal requirements of electronic information protection and a lack of knowledge of information security standards. Unfortunately security standards are written for security and information technology specialists and therefore their use by non-technical staff is difficult. Further, most of the standards apply to the technical aspects of security and are not context or profession specific. For instance, issues of data availability (service provision) and data quality are key factors in healthcare and therefore require more specific protection. Further, the general nature of standards means that the application of them to a specific context requires time and resources to develop. Typical health practices have neither time nor resources to allocate to this task. Further, as technology becomes more commonplace and more electronic health records are utilized, implementation of even basic security measures can be problematic for those whose core business is not security.

Finally, a reactive obstacle is the transition from paper to the electronic setting which is not necessarily a smooth transition; neither is it an automatic one. Change management should be carefully considered both from an operational and workflow perspective as well as from the human psychological viewpoint. Often the psychological barrier is to adopting a new method of doing a task rather than the use of the technology itself. It is not necessarily a more complex process that needs to be adopted but rather just a different way of doing things.\textsuperscript{23}

Ultimately the best protection, in conjunction with the technical solutions, is the creation of a culture of security. The human element is still the real variable in the security equation.

WHERE TO FROM HERE?

As e-health advances, electronic health records will become the standard for care, and may even become mandatory. This demand will come from governments, insurance companies, and patients. The USA already has legislation for this to be in effect by 2015 and chartless records will not be a choice.\textsuperscript{13} At present many computer applications are only at the “edge of what is possible computationally”.\textsuperscript{11} Increased utilization will have dental images and analytical tools as their basis. What is needed is a longer term view, despite possible short term costs. The most important reflection should be how the electronic environment can help to improve the quality of care for your patients in a more efficient manner. Electronic health records can provide greater protection and better use of patient information and thus improve the quality of patient care.

Embrace the opportunities presented to you in the networked age and do not be apprehensive. The advances and changes will happen with or without individual practitioner participation. Now is the time to make the mental shift and come along for the journey.

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REPAIR OF CRITICAL SIZE DEFECTS IN THE RABBIT CALVARIUM WITH THE USE OF A NOVEL SCAFFOLD MATERIAL

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Andrew A Heggie, MBBS, MDSc, BDSc, FRACDS (OMS), FFDRCS, FACOMS
Jason Portnof, DMD, MD

ABSTRACT

A number of materials have been implanted into skull defects to determine if improved healing outcomes can be achieved. In some instances, packing or implanting bone-inducing alloplasts into a standardized skull defect results in better healing than an untreated defect. AlloDerm® is a skin derived acellular collagen membrane and has characteristics that are known to be effective in promoting bone growth. It has not been previously investigated for use in cranial bone healing. The aim of the investigation was to determine if implanting this novel scaffold into skull defects will improve the quality of bone repair. Six rabbits received AlloDerm grafts into critical-sized calvarial defects. The rabbits were sacrificed at two months and the specimens examined histologically and radiographically. At the time of sacrifice, it was found that while bony growth had commenced at the margins of the defect and as isolated islands within the graft, there did not appear to be a major benefit in using the material described.

INTRODUCTION

The management of large bony defects in the skeleton is an ongoing challenge for the surgeon due to the volume and contour of the deficit requiring repair. This is of particular importance in the paediatric patient with craniofacial anomalies as the primary malformation is often complex and must be addressed with a series of interventions spanning from infancy until adulthood. Skull defects may result from congenital conditions, such as cutis aplasia, and post-traumatic or post-surgical conditions and infection. Current approaches for the reconstruction of bony defects include autogenous and vascularized grafts, allografts, alloplasts and distraction techniques.1-3 Repair of large calvarial defects in young children poses a significant challenge due to the limitations of the autogenous bone volume available. Calvarial bone cannot be readily split for reconstructive use until approximately 8 years of age. The treatment of hard tissue defects may add significantly to the costs of health care worldwide due to the need for follow-up surgery in many cases.5

Autogenous bone grafting remains the current gold standard for the reconstruction of bony defects in the craniofacial skeleton. However, autogenous grafts can be limited by the shape and volume of donor bone, donor site morbidity, and the outcome may be compromised by unpredictable resorption and/or remodelling. A range of materials of both synthetic and biological origin has been used in the reconstruction of skull defects.1,3,6,8 Traditional biocompatible materials include hydroxyapatite bone substitutes and alloplasts such as porous polyethylene (Medpor)† and titanium mesh. While the biocompatible materials generally provide greater structural support, they do not integrate well and do not remodel over time. Advances in the development of materials with osteoconductive and osteoinductive properties have occurred but relative to autografts there are still disadvantages.6 Salyer and co-workers studied demineralized, perforated, allogeneic bone implants in craniofacial surgery with good results and concluded that the effectiveness and safety of bone implants is largely determined by the type and quality of processing. Seventy-two patients underwent grafting with allogeneic grafts prepared with the protocol of the Pacific Tissue Bank (Los Angeles, USA) and were followed for up to two years clinically with a good outcome.10 The same group published the results of cranioplasty in the canine skull using demineralized perforated bone.11 They confirmed that demineralized perforated bone matrix implants were well accepted into 10 x 15 mm calvarial defects with little tissue reaction and minimal osteoclastic activity at three months post-implantation. This study suggested that demineralized bone matrix implants have an osteoinductive capacity and found no statistical significant difference in the outcome of the formation of new bone following insertion of demineralized perforated bone matrix implants of tibial donor site versus calvarial donor site origin.

Shand and co-workers investigated the incorporation of fresh frozen irradiated (FFI) membranous allogeneic bone grafts into critical-sized calvarial defects in the rabbit.12 Radiographic, histological, and fluorescent microscopic analysis of specimens revealed that FFI membranous grafts were well incorporated into rabbit calvarial defects. After 12 months revitalization of the entire graft was incomplete, however, neovascularization, bone marrow regeneration, and new bone formation was evident throughout the

* Presented at the Twentieth Convocation of the Royal Australasian College of Dental Surgeons, Perth, Western Australia. March 2010
† Porex Corp., Georgia, USA
REPAIR OF CRITICAL SIZE DEFECTS IN THE RABBIT CALVARIUM

Ascherman et al. examined the use of quick-setting hydroxyapatite (HA) cement and absorbable plates in 10-mm-diameter cranial bone defects in rabbits. They demonstrated growth of new bone into the HA cement was found along the periphery in all specimens at six months.

In another study calcium phosphate cement and autogogenous calvarial graft was compared in 8-mm-diameter bone defects in rabbit calvaria. This group demonstrated that new bone formed in both groups and regeneration increased with time. However significantly more new bone formed in the autogenous bone graft than formed in the calcium phosphate cement group. Calcium phosphate cement showed results at six weeks that presented similar to autogenous bone at three weeks.

There has been a need to develop accessible, widely applicable alternatives to the current bone replacement strategies. Tissue engineering using stem cells, scaffolds and nutrients are under development but there is, as yet, no suitable formula for predictable graft construction.

A number of acellular dermal grafts with a regenerative tissue matrix have been developed. One of these, AlloDerm®, has been used for a range of procedures including abdominal wall repair, breast reconstruction and other reconstructive approaches. Studies have reported favourable outcomes in primary palate repair and in palatal fistula repair. A small number of recent papers has reported on the promising results with the use of AlloDerm in the reconstruction of bone defects including post-mastoidectomy wounds, periodontal alveolar defects, nasal deformities, and anterior and middle cranial fossa defects. AlloDerm consists of a dense network of extracellular matrix fibrils made up of collagens, elastin, fibronectin and a complex array of endogenous dermal proteins. AlloDerm has inductive properties due to stem cell populations that target the graft material, deposit in the graft and adhere to the matrix. These cells then differentiate into tissue specific cell types and a new matrix is formed in the graft material. While these reports are promising, the outcome of acellular dermal grafts in cranial defects has yet to be determined.

It was the aim of this investigation to conduct a pilot study to evaluate the effect of AlloDerm on bone regeneration in critical-sized calvarial defects in the rabbit.

METHODS AND MATERIALS

The study was approved by the Ethics Committee of The Royal Children’s Hospital of Melbourne. Six adult New Zealand white rabbits (Oryctolagus cuniculus) were given an endotracheal general anaesthetic. The scalp was shaved, prepared with Betadine and infiltrated with local anaesthetic (bupivocaine HCl 0.5%, adrenaline 1:200,000) and a midline incision was made from the fronto-nasal to the occipital regions, the pericranial tissues were elevated and the calvarium exposed and a critical sized defect outlined (Fig. 1A). A 15 mm circular osteotomy was performed with a surgical drill. The full thickness calvarial bone flaps were removed from the dura and AlloDerm grafts were shaped and placed into the defects and the wounds closed with 4/0 vicryl sutures (Fig. 1B). Amoxycillin was administered for 5-days post-operatively. The rabbits were sacrificed at eight weeks using intravenous thiopentone. The calvarium was resected en bloc. Plain skull radiographs were taken at the time of surgery and at the time of sacrifice, together with computed tomography (CT) scans following sacrifice. The specimens were then divided into eight coronal sections and examined radiographically and histologically. The specimens were decalcified, processed, embedded in paraffin before sectioning and staining with haematoxylin-eosin and Masson’s trichrome. A point counting morphometry technique was used to estimate the relative volume of new bone within the grafts.

RESULTS

All of the rabbits recovered following surgery. Macroscopically, there was no evidence of infection nor loss of graft material. Plain radiographs and 3-dimensional CT
scanning demonstrated the deposition of new bone along the periphery and limited areas of osteoid within the graft site (Fig. 2, 3).

Histological examination revealed collagen fibres and fibroblasts and some bony in-growth at the periphery of the defects and islands of osteoid within the AlloDerm. However this bone regeneration was partial (Fig. 4 A, B, C). The osteoid formation within the grafts tended to be close to the dural surface or at the margins adjacent to the calvarial bone.

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<th>Magnification</th>
<th>Ratio (new bone/total bone area)</th>
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<td>X 5</td>
<td>841/2142</td>
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<td>X 5</td>
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The point counting morphometry technique demonstrated variable new bone formation within the grafts between 26 to 39%, with a mean of 31% (Table 1).

**DISCUSSION**

The reconstruction of skull defects has been investigated for many years, yet the ideal graft or material has yet to be developed. In the authors’ pilot study, using acellular dermal matrix, rabbits were sacrificed at two months after graft placement. Pripatnanont and co-workers reported that rabbits are often utilized in calvarial bone regeneration studies because rabbit physiological bone healing is similar to that of humans and the rate of healing is approximately three times that of humans. Hence, from a physiologically perspective eight weeks in the rabbit may be compared with six to eight months in humans.

In a study using different proportions of autogenous bone (AB) and deproteinized bovine bone (DBB) (Bio-Oss, Geistlich pharma AG, Switzerland) to repair 10 x 10 mm calvarial defects in rabbits, new bone formation was assessed. It was determined through histomorphometric and radiographic analysis that autogenous bone chips presented more bone formation at eight weeks. However this was not statistically significant. It was also determined that the composite grafts in the proportion 1:2 (AB:DBB) generated significantly higher bone content than the 1:4 group.

Biologic bone tissue engineering, including the use of recombinant human BMP-2 (bone morphogenetic protein), has expanded the field of bone reconstruction. BMP-2 is a purified, isolated osteogenic biomaterial that serves as a chemical messenger to induce bone formation. While demineralized bone matrix products theoretically inherently contain some BMPs, the synthetic, recombinant BMPs are...
provided in much higher concentrations. Por et al. described the combination of recombinant human bone morphogenetic protein 2 (rhBMP2) and struts of either metal or resorbable plates. The results of this study confirmed that complete bony regeneration occurred in the rhBMP2 groups only.

The use of composite allogeneic and alloplastic bone substitutes including demineralized bone matrix (DBM) putty, calcium phosphate cement, and native purified purified bone morphogenetic protein (BMP) to close 15 mm diameter parietal bone defects in rabbits was also studied. It was demonstrated that the unfilled (control) defects, defects covered with resorbable (LactoSorb) membrane, and those filled with calcium phosphate cement alone all healed with a fibrous scar. In contrast, defects reconstructed with DBM putty in combination with resorbable membrane and calcium phosphate in combination with BMP healed with bone bridging the entire defect at 12 weeks.

The present study recorded that acellular dermal grafts did not make an appreciable difference to bone healing over the experimental period, but research is ongoing by many groups worldwide to promote bone growth and repair. The era of transplantation of autogenous tissues to skeletal defects is likely to be replaced by tissue regeneration techniques in the near future.

CONCLUSION

In this pilot study examining acellular dermal grafts within calvarial defects and utilizing 3D computed tomography, plain radiographs and histological examination new bone was evident at the graft-calvarial margin and within the implanted AlloDerm graft. In conclusion, within AlloDerm grafts in critical sized calvarial defects bone regeneration was demonstrated at eight weeks but was limited.

ACKNOWLEDGMENTS

The authors would like to thank the Australia and New Zealand Association of Oral and Maxillofacial Surgeons Education and Research Foundation and the Melbourne Research Unit for Facial Disorders, University of Melbourne, for their support. Dr. Portnof was also supported by the Stryker ANZAOMS Fellowship at the Royal Children’s Hospital of Melbourne.

REFERENCES

UNDERSTANDING ADHESIVE DENTISTRY

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ABSTRACT

This review paper firstly provides an outline of the development of resin-based adhesives. A simple classification method is described based on whether an acid etching agent requiring a washing and drying step is used. These systems are called etch and rinse systems. The other adhesives that do not have the washing and drying steps are referred to as self-etching adhesives.

The advantages and disadvantages of these groups of adhesives are discussed. Methods of adhering to the tooth surface are provided, especially where the resin-based adhesive reliability is difficult to control.

INTRODUCTION

The surgical treatment of dental caries and restoration replacement remains a major part of the time to treat patients in any modern dental practice. Philosophically, it has been a long-standing aim for all of us to retain as much tooth structure as possible. Even in the times of GV Black, one of his treatment tenets was to retain tooth structure. In recent times, the introduction of Minimal Intervention or Minimally Invasive Dentistry (MID) has moved the philosophy the next step along to avoid surgical treatment of caries lesions or at least to keep cavity preparations as small as possible.

MID has been achieved due to the development of adhesive restorative materials. The two broad groups of adhesives are the resin-based materials and polyalkenoate acid-based cements. This paper will concentrate on the resin-based materials.

A BRIEF HISTORY

The quest to develop a resin-based adhesive is not new. Buonocore is a name synonymous with the development of the acid-etch technique in 1955 with the classic paper titled ‘A simple method of increasing the adhesion of acrylic filling materials to enamel surfaces’. However, the work of Oskar Haggar predated Buonocore’s when, in 1949, he developed a glycerolphosphoric acid dimethacrylate adhesive, Sevriton Cavity Seal, an adhesive intended for use with Sevriton filling material. This material is, in part, a precursor to the modern day phosphate ester type adhesives. Although not well known, Kramer and McLean identified, using light microscopy, the penetration of this adhesive into the surface of dentine. It could be said this was the first time a hybrid layer was identified and predates Nakabayashi’s landmark paper of 1982 by 30 years. However, the first attempts at bonding to dentine were not successful. It took another 20 or so years before researchers again revisited the idea of attempting to bond to dentine using resin-based materials. During this period however, the acid-etch technique for bonding to enamel became well established for anterior tooth-coloured restorations.

The next step forward in resin-based restorations was the introduction of Bis-glycidyl dimethacrylate (Bis-GMA) by Bowen in 1962, which revolutionized the tooth-coloured restorations. This resin remains one of the common matrix resin components for current resin composite filling materials.

About the same time as Bowen developed Bis-GMA, Masuhara was investigating the use of tri-n-butyl borane (TBB) as a co-catalyst to facilitate bonding to dentine. This system was incorporated into the product marketed as Palakav. Work continued on researching various materials in an attempt to form a stable bond and one strong enough to hold a restoration in place as well as to counteract forces from polymerization shrinkage.

In 1965, Bowen introduced N-phenyl-glycine and glycidyl methacrylate (NPG-GMA) used in Cervident, but the clinical ‘success’ was short-lived. It was not until 1979 when Fusayama and his group published the paper ‘Non-pressure adhesion of a new adhesive restorative resin’ in the Journal of Dental Research that a new era of adhesive dentistry commenced. This work was criticized due the use of phosphoric acid on the dentine, which was believed at that time to cause damage to the pulp (Fig.1).

At about the same time Nakabayashi published his 1982 paper describing the layer forming a new type of dentine that was made up of dentinal collagen and resin from the TBB, 4-methacryloyloxyethyl trimellitic acid anhydride (4-META), polymethylmethacrylate-based adhesive, Super Bond. This became to be known as the ‘Hybrid Layer’ and has been the subject of intensive research that continues even now.

At about the same time Nakabayashi published his work in English, 3M introduced the first version of Scotchbond to Australia. Scotchbond was a two-part adhesive mixed then placed on the cavity surface which then penetrated the dentine smear layer forming a weak bond after enamel etching. Acid etching of the dentine remained contentious even up to the early 1990s. During this time the explosion of dentine bonding systems began with such systems as

* Presented at the Twentieth Convocation of the Royal Australasian College of Dental Surgeons, Perth, Western Australia. March 2010
GLUMA® which used glutaraldehyde and 2- hydroxyethyl methacrylate (HEMA) to bond to dentine in conjunction with the mild etching of EDTA. This system showed some promise clinically. The use of HEMA in adhesive systems from this point became virtually universal due to its ability to bond in a moist environment such as cut dentine due to its hydrophilic nature.

The time of greatest advance in dentine bonding came during the 1990s. Dentine etching methods were changed with the introduction of maleic acid or weaker concentrations of phosphoric acid, the introduction of various priming agents, and later the combination of the priming agents and adhesives. However, the weaker acid etch based systems did not last long due to the etched enamel surface being quite difficult to detect and thus lost popularity with practitioners. At the same time, Kanca described the wet bonding technique, which changed the way bonding was approached, although it failed to simplify the bonding method.8

In 1993, the concept of using an acidic resin to etch the enamel and dentine surface was introduced in Japan by the Kuraray Company. This concept has now been widely adopted by manufacturers as an alternative method to the traditional use of phosphoric acid to etch the enamel and dentine simultaneously. This method has now been extended to the point where manufacturers have combined all of the tooth surface treatment steps into one to achieve adhesive to enamel and dentine. Unfortunately, the rapid succession of new adhesives and techniques has led to most practitioners either being confused or unsure of which is the ‘best’ resin-based adhesive to use clinically.

To answer this question it is necessary to take a step back and analyse what occurs when various adhesives interact with the tooth surface. The concept of generations of adhesives has also served to confuse practitioners even further as there is not a true chronology of the so-called generations of adhesives as they have been developed. The simplest way of classifying resin-based adhesives is to follow the classification proposed by Van Meerbeek’s group.7

Fig. 1. – Phosphoric acid-etched dentine surface showing the collagen fibre network remaining after the hydroxyapatite has been lost. It is this layer that must be infiltrated by resin to form a good hybrid layer.

TYPES OF ADHESIVE SYSTEMS

Resin-based adhesive systems can be divided into two broad groups. The first type of adhesive is one that uses an etching agent such as phosphoric acid on the enamel and dentine surface and is rinsed off with an air-water spray. These systems are called ‘etch-and-rinse’ systems. The other broad group of systems that do not have a rinse step can be called ‘self-etch systems’. Within these two broad groups the adhesives can further subdivided by the number of steps used to complete the adhesion process.

Etch and rinse systems:

Three-step – these systems use a separate etch, priming agent and resin adhesive. The priming agent is usually a solution of HEMA in a solvent such as water, ethanol or acetone. Its purpose is to make the etched dentine surface more receptive to the application of the hydrophobic bonding resin, which is the third step.

Two-step - these systems have a separate etch and then the priming and bonding steps are combined into a single procedure. These systems require the use of the very technique sensitive ‘wet bonding’ method. Most of these systems have a volatile solvent of either ethanol or acetone to aid diffusion of the primer-adhesive solution into the etched dentine surface.

Self-etch systems:

Two-step – these systems have an etch and priming step where an acidic resin solubilizes the smear layer and etches the underlying enamel and dentine while it simultaneously primes the tooth surface in readiness for the adhesive. The excess self-etching primer is blown off and with this much of the dissolved smear layer is also blown out of the cavity. The adhesive is then applied and usually air-thinned.

One-step – this group is the newest and simplest of the resin-based adhesive systems. The etch, prime and adhesion steps are combined into a single process. These systems are either two-bottle or one-bottle solutions. The smear layer is again solubilized but remains on the tooth surface. These systems often contain more water than other adhesive systems; this is to help maintain the low pH needed for etching the tooth surface. However, a drawback is the ‘all-in-one’ adhesives can dissociate more easily as well as incorporating of water into the bond layer.

Each of the two broad groups of resin-based bonding systems have advantages and disadvantages in their use. The etch and rinse systems have been available for the longest period of time and current clinical evidence indicates the three-step etch and rinse systems show reliable long-term results.8 The disadvantage of these systems is that the stripping of almost all the hydroxyapatite from the dentinal collagen means that complete envelopment of the collagen fibrils is almost impossible and will then create a location for the bond to deteriorate over time. When the hydroxyapatite is completely removed from the dentine surface, the remaining collagen fibre network tends to collapse and shrink after the washing and drying step. With the 3-step systems, the primer, presumably due to its very low viscosity and ability to wet the collagen fibre network is able to infiltrate the

Bayer Dental, Germany
collapsed collagen, restore its shape to almost the original form allowing penetration of the adhesive in the third step of the bonding process. This same bonding process is more difficult for the 2-step etch and rinse materials. Hence the need for the ‘wet bonding’ technique that is achieved by leaving water between the collagen fibrils after the etching, washing and drying steps. The tooth surface has to be left with enough moisture such that collagen fibril shrinkage does not occur. However, the method is extremely difficult to consistently achieve, therefore the technique sensitivity of this bonding method is very high and consistent bonding is difficult to achieve.

The self-etch systems have been shown to be less technique sensitive than the etch and rinse systems. This was shown when novices in bonding were able to achieve outcomes in a laboratory bond test not dissimilar to experienced researchers. However, questions have been raised about the ability of the systems that use a milder pH self-etching solution (around pH 2) to adequately etch enamel that has developed in a fluoridated water supply environment. (Fig. 2 and 3) A comparison of teeth that developed in either a fluoridated or non-fluoridated environment showed that the non-fluoridated tooth enamel did bond more strongly. However, there was no difference in the dentine bond strengths. For the scenario where enamel is either uncut and retains the fluoride rich layer, or enamel is the major source of retention e.g., resin veneer, then phosphoric acid etching of the enamel should eliminate this problem. Clinical evidence is showing that the 2-step self etch systems are performing well and little different from the 3-step etch and rinse systems. The evidence for the 1-step self etch systems is still limited, although promising outcomes are slowly appearing for this group of adhesives. A point of note is that some of the new 1-step self etch systems are marketed as a single bottle solutions. These systems seem to dissociate more easily after being applied to the tooth surface. To avoid this, it is essential to follow exactly the application time recommended by the manufacturer and only dispense the adhesive immediately prior to application to the tooth surface to prevent evaporation of the solvent.

The bonding mechanism of most systems, either etch and rinse or self etch systems has been shown to be micro-mechanical with the bond enveloping collagen fibres and hydroxyapatite crystals to form a hybrid layer. However, recent evidence by Yoshida and his co-workers has shown that monomers such as 10-MDP and 4-META are able to form a salt with hydroxyapatite. The work has shown, in the case of 10-MDP, that a relatively insoluble salt can be formed with hydroxyapatite. However, in the case of 4-META, the salt is soluble. Nevertheless, this evidence is a clue as to why some of the self etch adhesive systems that contain these monomers show good bond strengths even though the hybrid is much thinner than the etch and rinse systems. These systems are also showing good clinical durability, again supposedly due to the chemical adhesion to tooth structure. The clinical study over 10 years using Clearfil SE Bond** by Akimoto has shown excellent outcomes. It is possible other monomers can also achieve a chemical bond, but evidence of this is still lacking.

When bonding to tooth structure it is not a ‘one method fits all’ situation, this is perhaps the greatest misconception by practitioners. The adhesion of different systems, be they etch and rinse or self etch will vary depending on the location of the tooth because the deeper the dentine in the cavity, the greater its surface wetness. The etching process removes smear plugs producing an inherently wetter surface, therefore those systems that do not bond well in a wetter environment should not be used. In this case, systems that do not disrupt the smear plugs are likely to be more reliable on deep dentine. When unsure of the bond reliability of a resin-based adhesive, then a glass ionomer lining is a sound alternative since these materials will adhere to ‘wet’ dentine.

Bonding to caries-affected dentine is a contentious issue (Fig. 4 and 5). It is known that the caries-affected dentine is less permeable to fluid movement along the dentinal tubules due to occlusion with whitlockite crystals. However, caries affected dentine is also inherently wetter and contains slightly less hydroxyapatite. Bonding to this substrate is

**Kuraray, Japan
possibly more of a problem for the etch and rinse systems as the etching process tends to remove a greater amount of hydroxyapatite crystals, and to a greater depth, than ‘normal’ dentine. This therefore makes adhesive resin infiltration more difficult to achieve. The alternatives are either a self etch system or glass ionomer cement.

In the case of restoring a carious proximal cavity, the next question that should be asked in the clinical decision process is where is the proximal margin located? A proximal cavity where the gingival margin of the proximal box approximates the gingival tissues or is as far down as root surface dentine, then bonding of resin based systems becomes much more unpredictable. The most reliable material of choice is a glass ionomer cement using the laminate method (sandwich technique). Ideally a conventional high strength glass ionomer cement should be placed to a thickness of approximately 2 mm along the gingival floor of the proximal box. Once set, the resin-based adhesive can be simply bonded to the GIC surface. The work by Zhang and others has shown that a good bond strength can be achieved with most self etch systems to conventional glass ionomer cements. The bond between the GIC and resin composite was marginally better for the self etch systems compared with the etch and rinse system. It is
believed the etching, washing and drying steps for the etch and rinse adhesive caused enough crazing of the GIC surface such that it was more likely to fail cohesively compared with the milder etching of the self etch systems tested. Should a GIC-resin laminate method be employed, it is essential to monitor the GIC base. If a patient’s oral hygiene is poor in this region there is the potential for dissolution of the GIC,19 which can be overcome by coating the GIC with either a proprietary coating or with the resin adhesive. Alternatively, a resin-modified glass ionomer cement adhesive could be used to bond to a deep proximal cavity. The only problem here is the potential problems with the light curing of the adhesive.

Finally, one of the difficult aspects of resin adhesion is to know when the adhesive is working properly. Apart from following the application instructions, it is important to look for a change in appearance of the bonded surface. Usually a well bonded surface will have an ‘oily/glossy’ appearance on the dentine (Fig. 6). The only systems where this tends to vary are the single step self-etch systems that require very strong air blasting after application. The dentine surface after application of these systems tends to have a matt and occasionally tacky appearance. It is important to use magnification to view the bonded surface. If the surface change is not apparent, then reaplication of the either the self-etching primer in the 2-step or adhesive in the 1-step self etch systems should occur. Similarly for the etch and rinse systems, reapplication of the bond is possible before curing. This should improve the reliability of the bond.

Adhesive dentistry allows us to conserve tooth structure in a way never before possible. This will allow patients to retain teeth for longer. But, adhesive dentistry has brought with it a new level of complexity that means practitioners must consider the benefits and disadvantages of the restoration placement process and be willing to modify techniques as necessary. This is quite different from the almost ‘universal’ method that has been used for amalgam when restoring posterior teeth based around the outdated Black’s cavity form.

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In the later part of the 19th century, there was no clear distinction between carious process and the lesion, so the term caries was used to refer to the cavity which can be found on tooth surfaces. It was in this setting that Dr Miller (1890) introduced the chemo-parasitic theory of caries, which stated that caries only develops in the presence of acids which are produced by bacteria living mainly in saliva. It was one of his contemporary colleagues, Dr Black, who observed the association between the accumulation of plaque and the development of cavities, this is the first association between dental biofilm and caries. This observation led to the universal acceptance of the extension for prevention principle, which required the extension of the boundaries of a cavity preparation out to self cleansing areas. Until recently, there was no real appreciation of the evolutionary nature of dental biofilm, its sophisticated structure and physiology and its important role in maintaining oral and general health.

It was not until Dr Keyes (1960) had completed his series of experiments on germ free rodents that the role of fermentable carbohydrate was fully understood, the mutans streptococci was identified as the most cariogenic group of bacteria and the transmissibility of caries from animal to animal was established. This work led to the specific plaque hypothesis which was proposed by Dr Loesche (1986) and it was then that the mutans streptococci and a very small number of other species were identified as the main pathogens. The attempts to develop vaccine and gene therapy were based on the belief that caries can be controlled by targeting those species. This concept is universally accepted and is still taught in many dental schools, even though there is now considerable doubt about its validity. It is now accepted that the relationship between mutans streptococci and the caries process is weak. There are individuals who have a high count of mutans streptococci who do not go on to develop caries lesions but more importantly, the reverse is also true, where caries lesions can form in individuals who do not have detectable levels of mutans streptococci. A high level of mutans streptococci only reflects the breaking down of the ecological balance of the biofilm. Its validity as a diagnostic tool is being questioned so it should only be used to monitor the results of the prescribed treatment.

The understanding of the caries process has changed a great deal in recent years so this led to the development of the ecological plaque hypothesis, which was proposed by Professor Marsh in 1994. It states that changes in the oral environment can drive the balance of the resident microflora, creating a shift from its original healthy state to a pathogenic state. The microbial metabolic activity in a biofilm is continuous and result in pH fluctuations. The earliest clinically visible outcome of this process is a white spot lesion, which is formed on a tooth surface where a biofilm is allowed to stagnate over time and the pH fluctuation leads to a cumulative net loss of calcium and phosphate.

When this is not rectified over a long period of time, the biofilm is transformed and its composition and activity will assume the pathological level as its new natural state. Therefore the ultimate clinical outcome, in the control of caries, is changing the ecological balance to bring the dental biofilm back to its natural and healthy state.

This latest theory combined the key elements of the earlier two and it adds the patient to the caries equation. It is the patient who has control over the oral environment, which in turn has great influence on the biofilm. This theory can be used to explain the clinical case of a patient who has a high number of mutans streptococci but does not develop caries lesions. Some of the possible reasons are:

- The structure of the dental biofilm is such that saliva and fluoride can easily penetrate and reach the tooth biofilm fluid interface.
- The enamel chemistry makes it more acid resistance.
- There is also an abundance of lactate consuming species.
- There are ammonia producing bacteria to neutralize acidity in biofilm fluid.

Caries is a chronic, life style and biofilm associated disease. Biofilms that colonize the oral cavity are highly complex and their role in health and disease is now much better understood. It can be argued that a biofilm, in adults, is unique to the individual because its composition and activity are heavily influenced by nutritional and physical conditions of the oral cavity and of different sites in the mouth.

Saliva plays a vital role in maintaining homeostasis in dental biofilms. Demineralization and remineralization take place at the tooth-biofilm interface and can be heavily influence when healthy saliva gains access to this interface. Healthy saliva is supersaturated with respect to hydroxyapatite so it has a general protective effect; it is also a very effective buffer and can neutralize acidity in the biofilm fluid. When the biofilm is allowed to grow too thick then the protective effect of saliva is diminished as it can’t reach the interface.

As the understanding of the caries process has changed substantially, it is important to move from the simple Venn diagram (Fig. 1), which only illustrates the multi-factorial nature of the caries process, to a more clinically relevant model (Fig. 2).
The success of a treatment plan relies on patient cooperation and that depends on the development of a good understanding of the interaction among the contributing factors that lead to the acceleration of the carious process.

This model illustrates clearly the primary factors which can significantly modify the metabolic cycle in the dental biofilm:

- Diet.
- Fluoride in the dental biofilm fluid.
- Fluoride strengthening effect on dental hard tissues.
- Saliva.

It clearly identifies the three areas which dentists need to work on in attempting to control the caries process:

- Tooth: manage and repair any defects.
- Oral environment: changing the primary factors with the ultimate aim of reversing a cariogenic biofilm back to its healthy natural state.
- Educate and motivate the patient to gain cooperation and compliance in making changes to the primary factors.

The dentist, therefore has three distinct roles to play. First, as a physician to diagnose and prescribe treatment. Second, as a counsellor to educate, motivate the patient and assist the patient in understanding and managing the caries process. Third, as a surgeon to manage and repair defects on tooth surfaces.

Recognizing that the caries process had many similar features with a chronic and lifestyle associated disease like diabetes, To conclude this article here is a quote from Sir William Osler (1849-1919) “a good physician treats the disease while a great physician treats the patient who has the disease”.

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OSSEOINTEGRATION – THE INFLUENCE OF IMPLANT SURFACE
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ABSTRACT
The modification of implant surfaces from the original machined to ‘micro-rough’, and more recently ‘bioactive’, surfaces has been proposed to improve clinical outcomes. This review outlines the evidence for the superior performance of modified implant surfaces. Pre-clinical trials consistently show that modified implant surfaces are more osteogenic and improve the degree of osseointegration. Clinically, there is a clear trend for improved clinical success with ‘micro-rough’ compared with machined implants. This is particularly the case in compromised sites, such as the posterior maxilla, and compromised patients, such as smokers. Furthermore, ‘micro-rough’ implant surfaces perform better in augmented sites, and facilitate the more predictable use of short implants, thus reducing the need for more invasive augmentation procedures. ‘Micro-rough’ implants have been associated with an increased susceptibility to peri-implantitis, but these findings relate to a surface that is no longer manufactured. Newly developed ‘bioactive’ surfaces have only been evaluated in a limited number of clinical studies.

INTRODUCTION
Dental implants manufactured from titanium have become a well established treatment modality for the replacement of missing teeth. The clinical procedures using dental implants are well documented, with good long term success rates reported in healthy patients and in favourable anatomical positions.† However, with increased clinical use and greater acceptance and popularity of implants, there are greater demands placed on implant systems from both clinicians and patients. In particular, there is demand for implant placement in sites where the quality and/or quantity of bone is less than ideal due to either local or systemic factors. Furthermore, there is a demand for accelerating the treatment process in order to obtain restoration in the quickest possible time.

Due to these increasing demands, there are continuing efforts to enhance the rate and amount of osseointegration. One parameter which could influence the success rate of implants is the alteration of the surface topography by increasing the roughness of the implant surface. Indeed, the use of microscale, and more recently nanoscale, modifications of implant surfaces has been proposed as one of the key factors in increasing the clinical success rate of implants, especially in areas of compromised bone quantity and quality. This review will explore the evidence that surface modification affects osseointegration. Emphasis will be placed on studies utilizing common commercially available implant surfaces.

COMMERCIALY AVAILABLE IMPLANT SURFACES:
Commercially available implant surfaces can broadly be divided into three categories:
1. First generation machined titanium surface representing the original dental implant surface developed in the 1960s by Professor P-I Brånemark. These implants are also known as turned or smooth surface implants, although in reality they have a small degree of roughness which is essential for osseointegration.
2. Second generation ‘micro-rough’ surfaces with increased microscale roughness developed in the 1990s. These surfaces are commonly referred to as being ‘rough’, although they vary in the degree of roughness between manufacturers. Common clinically utilized ‘micro-rough’ implants include:
   a. SLA (sand blasted, large grit, acid etched) surface.†
   b. Double acid etched (DAE) surface.‡
   c. Titanium oxide (TiO₂) blasted surface.§
   d. Anodic oxidation of machined surface.¶
3. Third generation ‘bioactive’ surfaces which aim to actively promote bone deposition on the implant surface and hence further enhance osseointegration via nanoscale or chemical modification of existing ‘micro-rough’ implants. These surfaces have identical microscale topography as their predecessors and commonly used examples include:
   a. Modified SLA surface. (SLAactive). Chemical modification of the SLA surface manufactured with the aim of minimizing surface contamination and transported in saline in order to maintain the contaminant-free surface.
   b. TiO₂ blasted surface modified by the incorporation of fluoride ions.¶
   c. Nanometer scale discrete crystalline deposition (DCD) CaP surface. DAE surface modified by precipitation of CaP molecules aimed to achieve roughness at the nanoscale level.

PRE-CLINICAL STUDIES
In Vitro Cell Culture Studies
In vitro studies utilizing cell culture models have been useful in determining the effect of different implant...

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* Presented at the Twentieth Convocation of the Royal Australasian College of Dental Surgeons, Perth, Western Australia. March 2010

† Straumann, Switzerland.
‡ Osseotite, Biomet 3i, USA.
§ TiOblast, AstraTech, Sweden.
¶ TiUnite, Nobel Biocare, Sweden.
¶ Osseospeed, AstraTech, Sweden.
** Nanotite, 3i Biomet, USA.
surfaces on cell function. In particular, the effect of surface modification on osteoblast function has been extensively studied. It has been demonstrated that micro-roughness can enhance osteoblast function when compared with machined implant surfaces.\(^2\) In response to smooth surfaces, osteoblasts attach and proliferate, but exhibit relatively low expression of differentiation markers, whereas, when grown on rough surfaces, osteoblast proliferation is reduced and differentiation is enhanced, leading to a microenvironment conducive to bone formation.\(^2\)

New generation ‘bioactive’ implant surfaces have also been shown to further enhance osteoblast function compared with ‘micro-rough’ surfaces. It has been shown that both the modified SLA and titanium oxide blasted surfaces can enhance osteoblast differentiation.\(^3\)

**In Vivo Pre-clinical Trials**

Animal studies have shown that ‘micro-rough’ surface titanium implants result in superior bone to implant contact compared with machined implants,\(^4\) as well as superior torque removal values.\(^5\) Histological analysis of the sequential healing events associated with ‘micro-rough’ surface titanium implants has shown that initial bone formation around these implants occurs not only at the exposed bone wall of the surgically created implant recipient site, as is the case with machined surface implants, but also along the ‘osteophytic’ implant surface.\(^6\) Furthermore, it has been demonstrated that there is a higher level of organization in the wound and greater bone-implant contact during the early healing associated with ‘micro-rough’ compared with machined surfaces.\(^7\)

More recently, it has been demonstrated that nanoscale and chemical modifications of implant surfaces provide additional benefits in terms of osseointegration, compared with ‘micro-rough’ surfaces. Indeed, surfaces with the same ‘micro-scale’ topography, but with additional nanoscale modifications have been shown to promote superior osseointegration in vivo, as measured by increased bone-implant contact, especially during the early stages of healing. More specifically, it has been demonstrated that the chemically modified SLA surface promoted enhanced bone apposition during the early stages of osseointegration compared with the SLA surface.\(^8\) Fluoride ion incorporation into the TiO\(_2\) blasted surface has also been shown to improve bone-implant contact during the early phases of osseointegration,\(^9\) and result in enhanced removal torque values.\(^10\) Similarly, the nanoscale modified DAE surface has also been shown to result in improved bone-implant contact in human studies,\(^11\) and superior removal torque values in animal studies.\(^10\)

In general, second and third generation implant surfaces appear to promote increased bone-implant contact, especially during the early stages of wound healing, thus suggesting that these implants would perform better than machined implants, especially in compromised sites and patients.

**CLINICAL TRIALS**

It is important to note that excellent long term results have been reported with the original first generation machined implants, with implant success of up to 99% reported at 15 years follow up.\(^1\) However, poorer results were obtained in compromised sites (e.g., posterior maxilla) and patients (e.g., smokers). Anecdotal evidence suggests that the development of modified implant surfaces has coincided with several significant developments in implant dentistry which may be related to enhanced osseointegration, such as decreased healing times, improved success of augmentation procedures, and increased success in compromised sites and patients. It is noteworthy that there are a large number of studies which document the clinical performance of first generation machined and the various second generation ‘micro-rough’ implants, but there are relatively few studies which report on the newly developed third generation ‘bioactive’ implants.

Most clinical trials are either retrospective or prospective cohort studies, and there are few randomized controlled clinical trials that directly compare the relative performance of different implant surfaces. In a systematic review of the few available controlled randomized clinical trials, most of which involve a small numbers of patients, it has been shown that there is a clear trend towards a higher risk for implant failure in implants with machined surfaces compared with ‘micro-rough’ surface implants.\(^12\)

In the absence of large randomized controlled clinical trials, a review of cohort studies incorporating large numbers of cases is necessary in order to ascertain the relative performance of ‘micro-rough’ and machined implants. A recent review\(^13\) undertook a comprehensive assessment of 1- to 15-year survival rates of fixed implant rehabilitations in the edentulous maxilla incorporating 32 studies, including 1,320 patients and 8,376 implants. Implants with micro-rough surfaces showed a statistically higher survival rate than machined implants at all intervals (1, 3, 5, 10 and 15 year time points).

**Short Implants**

It is well established that tooth loss leads to resorption of the associated alveolar bone. This presents a clinical challenge, especially in the posterior regions where anatomical constraints in the form of the maxillary sinus and the inferior alveolar canal limit the height of bone available for implant placement. Although augmentation procedures are available, it has been shown that vertical augmentation is unpredictable, and that implant survival is higher when short implants are used then when vertical augmentation is utilized.\(^14\) Furthermore, the use of short implants also has the advantage of lower patient morbidity and less technical sensitivity than augmentation procedures.

Therefore, the relative clinical success of short implants with machined and ‘micro-rough’ surfaces is an important clinical consideration which has been studied in several clinical trials. Feldman et al.\(^15\) compared a large number of machined (2294) and ‘micro-rough’ DAE (2597) short (10 mm or less) implants and found that the difference in cumulative survival rates between short- and standard-length implants was greater for machined-surfacd implants than for DAE implants. For DAE implants the overall difference in survival rates between standard and short implants was 0.7%, which was not statistically significant. However, there
was a 2.2% difference in 5-year survival rates between the machined-surfaced short- and the standard-length implants. For these implants, a 7.1% difference was observed in the posterior maxilla and an 8.5% difference in the anterior maxilla. These findings were supported by another study which investigated 96 short (6-8.5 mm) implants placed in the posterior maxillas of 85 patients. The implants had a machined (54) or a 'micro-rough' oxidized (42) surface and were followed for two years. Of the five implants that failed, four had a machined surface, and one had an oxidized surface. Therefore, there is clear evidence that short implants with a 'micro-rough' surface perform better than their machined counterparts, especially in compromised sites, such as the posterior maxilla.

**Smoking**

Smoking is recognized as a potential risk factor for implant failure. Balshe et al. compared the long-term survival rates of machined (2182 implants in 593 patients) and 'micro-rough' (2425 implants in 905 patients) surface implants among smokers and non-smokers. Among the 'micro-rough' surface implants, smoking was not identified as being associated with implant failure. In contrast, smoking was associated with implant failure among the group with machined surface implants (HR = 3.1; 95% CI = 1.6 to 5.9; P < .001). Furthermore, implant anatomic location was not associated with implant survival among patients with 'micro-rough' surface implants and among non-smokers with machined surface implants. However, anatomic location affected the implant survival among smokers with machined surface implants (P = .004). In particular, implant survival was the poorest for machined implants placed in posterior maxillary sites of smokers.

**Augmented sites**

In their review of studies involving fixed implant reconstructions of the maxilla, Lambert et al. found that machined implants placed in augmented bone had a statistically significant lower survival rate, unlike 'micro-rough' surface implants, for which no statistical difference between augmented and non-augmented bone survival rates was found. Machined implants showed a stable survival rate only when placed in native bone. When machined implants were placed in augmented bone, the survival rate decreased significantly at each study endpoint (1, 3, 5, 10 and 15 years).

In relation to sinus augmentation procedures, superior performance has been associated with 'micro-rough' compared with machined implants in a recent systematic review. A meta-analysis showed that the mean survival rate of 'micro-rough' implants was 96.7% (for 2,544 patients and 8,303 implants placed) compared with 86.3% machined surface implants (for 950 patients and 3,346 implants placed).

**Peri-implantitis**

Peri-implantitis is an inflammatory disease leading to bone loss around implants, which has a similar aetiology and pathogenesis to periodontitis. A meta-analysis has found a greater incidence of peri-implantitis around implants with 'micro-rough' surfaces when compared with implants with machined surfaces over a 3-year period. However, it should be noted that this meta-analysis was carried out on studies with relatively low numbers of participants and implants. Of particular note is a split-mouth study including 26 patients in which peri-implantitis affected seven implants in five patients, all having a rough titanium plasma sprayed (TPS) surface and none of the contralateral implants with a machined surface. The implants with the TPS surface are no longer commercially available, and an increased risk for peri-implantitis has not been reported for currently available 'micro-rough' implants.

In terms of treating peri-implantitis, the ultimate goal is to regenerate the lost bone and achieve re-osseointegration to the previously contaminated implant surface. In this regard, better outcomes have been reported with 'micro-rough' compared with machined implant surfaces, although there is variability in the performance of different 'micro-rough' implants.

**Third generation 'bioactive' surfaces**

It is important to note that the vast majority of clinical data showing an improved clinical performance associated with modified implant surfaces relates to the comparison of second generation 'micro-rough' and first generation machined implants, and there is little clinical evidence for additional clinical benefits of using third generation 'bioactive' surfaces, which have only recently been introduced. Since these 'bioactive' surfaces are largely modifications of well-documented 'micro-rough' surfaces and their superiority has been demonstrated in pre-clinical trials, it may be assumed that they will have superior clinical performance. However, such assumptions should be made with caution, and considering that 'micro-rough' surfaces perform well in most clinical scenarios, the use of new generation 'bio-active' implants should be evidence-based and take into account cost-benefit considerations for individual patients.

**SUMMARY AND CONCLUSIONS**

Modifications of the original machined titanium implant surface have been carried out in order to enhance osseointegration and provide a clinical benefit for the patient. The following conclusions can be reached following assessment of the relative performance of modified implant surfaces:

1. Pre-clinical *in vitro* cell culture studies and *in vivo* histomorphometric analysis of bone to implant contact consistently show that modified implant surfaces are more osteogenic and improve the degree of osseointegration, especially in the early stages of bone wound healing.
2. The majority of clinical trials report on machined and 'micro-rough' implants, with relatively few studies evaluating the use of newly developed 'bioactive' implant surfaces.
3. There is a clear trend for improved clinical success when using 'micro-rough' implants, particularly in compromised sites, such as the posterior maxilla, and compromised patients, such as smokers.
4. 'Micro-rough' implants perform better in augmented sites.
5. The use of short implants is more predictable with 'micro-rough' than machined surface implants.

6. There is evidence that 'micro-rough' implants are more susceptible to peri-implantitis, but these findings relate to a surface that is no longer manufactured, with no such susceptibility being found in relation to currently available surfaces.

7. In terms of osseointegration to a previously diseased implant surface, 'micro-rough' implants perform better than machined implants.

REFERENCES


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UNDERSTANDING RISK FOR PERIODONTAL DISEASE
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ABSTRACT
An ability to identify individuals at risk for progressive periodontal disease would enable targeted prevention and treatment, thus reducing the economic burden on society. The importance of the interplay between microbial, genetic and environmental factors in risk assessment is recognized and the relative contributions of various risk factors has been determined. However, newer technologies will enable more accurate individual risk profiling in the future.

INTRODUCTION
It is generally believed that risk for periodontal disease is the result of the interaction between bacterial, genetic and environmental factors. While genetics may place us at risk for certain diseases, whether we develop these diseases and at what age will be determined by our environment and behavioural choices.

Many years of research have increased our understanding of the pathogenesis of chronic periodontitis. Microbial, genetic and environmental risk factors have been identified yet the ability to identify individuals who are at risk of disease or disease progression has proven elusive.

MICROBIAL RISK FACTORS
Whilst a number of periodontal pathogens have been identified these same organisms can be found as part of the microbiota of periodontally healthy individuals. A longitudinal study of the natural history of periodontal pathogens demonstrated that they exhibit a high degree of volatility in terms of acquisition and loss over time suggesting that a dynamic relationship exists not only between constituents of the biofilm but also with the host. Porphyromonas gingivalis showed less volatility and was the only organism associated with progression of periodontal disease in this longitudinal study. However, newer molecular techniques such as high throughput sequencing are enabling the identification of uncultivable phytoplotes and the focus is shifting towards viewing the oral biofilm from a microbial ecological perspective. The complexity of microbial interactions and communication within the biofilm and with the host is now actively being researched. Indeed, combined genomic and proteomic analyses of host-biofilm interactions may ultimately be useful in disease prediction, prevention, diagnosis and treatment and lead to individualised risk profiling.

GENETIC RISK FACTORS
Specific polymorphisms in a large number of genes that may be associated with periodontal disease have been studied over the past decade with inconsistent findings.

Many of these studies have been cross-sectional and have looked at polymorphisms in isolation without taking into account other risk factors. A longitudinal study design enabled determination of the relative contributions of specific IL-1 and IL-10 gene polymorphisms, smoking, age and presence of Porphyromonas gingivalis. It was shown that IL-1 genotype alone had no significant effect on disease progression; however, it did have significant interactive effects with other risk factors. For example, IL-1 genotype positive (IL-1α+4845T/IL-1β+3954T) individuals who smoked could be expected to have 70% more disease than IL-1 genotype negative smokers. Likewise, IL-1 genotype positive individuals with Porphyromonas gingivalis in their plaque could be expected to have 80% more disease than IL-1 genotype negative individuals with Porphyromonas gingivalis. In this context, smoking and Porphyromonas gingivalis could be considered as primary risk factors and IL-1 genotype as a secondary risk factor. On the other hand, certain IL-10 genotypes (ATA/ACC or ACC/ACC) were associated with less disease progression and could be considered as protective genotypes. People with these protective genotypes could expect to have 25% less disease than those with other genotypes. Alternatively, those with non-protective genotypes could expect to have the same amount of disease as an individual 15 years older with a protective genotype. However, more importantly, this study showed that smoking can over-ride any protective genotype effect.

More recent research has focused on the peripheral blood and salivary transcriptomes rather than on alterations in the gene sequences themselves in order to identify susceptibility to periodontal disease. In these studies both whole genomic and focused gene arrays are being used to identify patterns of gene expression associated with periodontal disease and following treatment. However, at this stage it remains to be determined whether or not susceptible patients can be identified on the basis of differential gene expression.

ENVIRONMENTAL RISK FACTORS
The influence of environmental factors on disease progression is well recognized. For example, stress can lead to more rapid progression of periodontal disease and in this
context the influence of the hypothalamic-pituitary-adrenal axis on regulation of the local immune response is being investigated. The effect of smoking has been investigated over many years and studies have consistently shown that smokers have increased numbers of deep pockets and greater loss of attachment and alveolar bone, as well as a poorer response to treatment than non-smokers. It is now recognized that the healing capacity of smokers is impaired to such an extent that it is only 28% of that of non-smokers and this may be fundamental in explaining the increased disease expression observed in smokers.

It is increasingly recognized that environmental factors as well as microbial factors may exert an epigenetic effect, that is, cause a change in phenotype or gene expression without altering the underlying DNA sequence and it is this, which may be responsible for determining the nature of the host response.

CONCLUSION
Unravelling the complexities of gene-environmental interactions may lead to enhanced individual risk profiling and more targeted treatment in the future.

REFERENCES

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The temporo-mandibular joint (TMJ) and related pain/dysfunction is a common presenting complaint in dental and orofacial practice.

The limited value of the panoramic radiograph in the evaluation of the TMJ should be recognized. The bony structures can be examined with multidetector computed tomography (MCT) and cone beam (CB) 3D imaging systems. The relative weaknesses of CB imaging, notably in relation to scatter, low signal-to-noise ratio, beam hardening and potential motion artefacts must be recognized. Soft tissues are not well visualized in CB imaging, in contrast to MCT. The effective doses delivered vary dramatically between CB machines and only some are ultra low dose. MCT doses are more protocol dependent. The articular disc and other associated soft tissues of the TMJs are best evaluated with magnetic resonance imaging (MRI), although the bony structures are also visualized with this technique. The decision to employ MCT, CB or MRI in the examination of the TMJ is made on an individual case-by-case basis, requiring a thorough clinical examination and understanding of the strength and weaknesses of the available modalities. Other imaging techniques, such as nuclear medicine and ultrasound are occasionally employed.

The potential consequence of ruling out TMJ arthropathy as a result of the inappropriate prescription of an imaging modality is obvious. In addition, while degenerative disease and articular discal abnormalities are more common, other conditions ranging from erosive arthropathies to benign and malignant tumours also affect the TMJ. The radiologic interpretive skill set of those responsible for the radiologic examination must be considered. The consequence of mismanagement of TMJ pain/dysfunction related to undiagnosed or misdiagnosed pathology has been documented.

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ABSTRACTS OF PAPERS

WHERE ARE WE TODAY WITH PERIODONTAL REGENERATION?
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Lisa Heitz-Mayfield is currently Adjunct Professor at La Trobe University, Victoria, Honorary Professor at the University of Hong Kong, Associate Professor at The University of Sydney, NSW and Professor at the Centre for Rural and Remote Oral Health, The University of Western Australia and also maintains a specialist practice in West Perth.

The presentation outlined the clinical applications for the use of regenerative techniques in periodontology. Criteria for appropriate selection of patients, defect and surgical approach were addressed and an update on surgical techniques for the use of barrier membranes, biological agents and bone substitute materials were presented. The latest evidence for the predictability and expected outcomes of regenerative therapy and infrabony, furcation and recession defects were discussed.

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THE VERTICAL DIMENSION : THE MOST IMPORTANT FACTOR FOR ALL DENTISTS
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The functional properties and relationship is of the mandibular muscles are closely associated with growth and development of the dentofacial complex. Those muscles and the implications of differences in underlying vertical facial pattern affect day-to-day treatment decisions in all disciplines of dentistry -- not just orthodontics and oral and maxillofacial surgery. This presentation highlighted these implications. It was illustrated with 10 year follow-up clinical case material and references made to the author’s own research into clinical aspects of the mandibular muscles and the vertical dimension of the face.

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INFLUENCE OF ORTHODONTIC TOOTH MOVEMENT ON PERIODONTAL DEFECTS
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Periodontally susceptible patients who have experienced drifting, migration, extrusion, flaring and tooth loss may require adjunctive orthodontic treatment. Previous studies have shown that tooth movement can be performed in adults with reduced but healthy periodontium without further periodontal deterioration. Conversely, adults who did not have healthy periodontal tissue may experience further breakdown and tooth loss during orthodontic treatment. Animal studies showed orthodontic movement may enhance the rate of destruction of the connective tissue attachment of teeth with inflamed infrabony pockets, and the risk for additional attachment loss was particularly evident when the tooth was moved into the infrabony pocket. The paper described some of the available data relating to clinical results of orthodontic tooth movement on periodontal defects, including using intrusive movement for over-erupted but treated periodontally involved teeth.

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* Presented at the Twentieth Convocation of the Royal Australasian College of Dental Surgeons, Perth, Western Australia. March 2010
CORRELATION OF SERUM AND GCF ADIPOKINES IN OBESE SUBJECTS

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PURPOSE
Inflammatory cytokines (IL-6, TNF-α) released by adipose tissue in obese subjects may enhance the local immune response in the periodontal tissues. It is unclear whether the cytokines released by adipose tissue in serum are proportionately present in the gingival crevicular fluid (GCF).

The aim of this study was to correlate, in obese patients, the GCF levels of IL-6 and TNF-α with the levels found in serum.

MATERIALS AND METHODS
Thirty six obese patients were recruited from obesity clinics at Westmead Hospital. Obesity was defined using a body mass index \( \geq 30 \text{ kg/m}^2 \). Patients with conditions known to affect periodontal tissues, such as uncontrolled diabetes (HbA1c >8%) and smoking, were excluded.

Serum and GCF samples from 27 of the 36 subjects have been collected and analysed for IL-6 and TNF-α using commercially available ELISA kits. Within each subject GCF was collected from two healthy sites (n=27 subjects) and two sites with bleeding on probing (n=13 subjects). The GCF samples were collected using standardized filter paper† which was placed into the gingival crevice to a depth of \( \leq 1 \text{ mm} \) for 30 seconds. Blood contaminated strips were excluded. The levels of IL-6 and TNF-α in the GCF were compared and correlated with the levels found in serum.

RESULTS
TNF-α was detectable in 88% of serum samples but in only 60% of healthy GCF samples. In contrast, IL-6 was found in all serum and 78% of healthy GCF samples. There was no correlation between the levels of cytokines found in serum with those found in the GCF of healthy sites. A trend for a correlation was present in some subjects but not others. Detection of cytokines from gingivitis sites was variable. Similar to healthy sites, gingivitis sites display a trend for correlation in some but not all subjects. However, limited gingivitis sites were available for analysis.

CONCLUSION
Although statistical power is limited, preliminary results suggest a lack of correlation between the levels of IL-6 and TNF-α in serum and GCF from healthy sites. This is consistent with previous reports on other inflammatory mediators. These results also suggest that future studies examining the relationship between BMI and gingival cytokine levels should also examine serum samples. Overall, this suggests that the effect of obesity on periodontitis may not be dependent on the amount of cytokine released into circulation.

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* Young Lecturer presentation at the Twentieth Convocation of the Royal Australasian College of Dental Surgeons, Perth, Western Australia. March 2010

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ATHLETIC MOUTH GUARD DESIGN, FACIAL SKELETAL PROFILE
AND THEIR EFFECTS ON UPPER AIRWAY RESPIRATORY FUNCTION /
VENTILATION IN ATHLETES

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Many athletes refuse to wear mouth guards because of a belief that they make breathing difficult. Mouth guards provide protection from concussion, dento-alveolar injury, and fracture of the facial skeleton. This study aims to assess the respiratory function of a large number of athletes whilst they are wearing different types of custom mouth guards during various sporting scenarios.

The authors’ hypothesis is that a custom mouth guard will have no effect on respiration in athletes either at rest or whilst exercising.

Thirty one male subjects were recruited in the study
a. Patient’s skeletal measurements were then obtained by measurements of standard lateral cephalometric radiography.
b. Two mouth guards of different design were fabricated for each subject.
c. The subject was tested three times – wearing no mouth guard / mouth guard A and mouth guard B.
d. The respiratory data collected include ventilation (Ve), oxygen consumption (VO₂) at mild, moderate and maximum intensity of exercise.
e. A repeated measure ANOVA was used to assess whether there was any statistical difference between the three groups of data at minimal, moderate and maximal levels of exercise.
f. Logistic regression analysis will be used to determine whether there are any trends in the data that would suggest that craniofacial morphology have an effect on subjects who wear mouth guards.

The results show that there is no statistical difference in respiratory parameters between the three groups at minimal, moderate and maximum intensity levels of exercise.

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* Young Lecturer presentation at the Twentieth Convocation of the Royal Australasian College of Dental Surgeons, Perth, Western Australia. March 2010
CLINICAL AND RADIOGRAPHIC EVALUATION OF NOBELACTIVE™ DENTAL IMPLANTS: A PROSPECTIVE SPLIT-MOUTH COMPARATIVE STUDY

Danny Sai-Wah Ho, BDS(Hons) (Syd), FRACDS*

PURPOSE

Poor bone quality at a surgical site is a common problem in implant therapy due to the difficulty in achieving primary stability during implant insertion. The innovative design of the NobelActive™ implant† is specifically designed to be used in “soft” bone situations. The purpose of this study is to conduct a pilot randomized controlled trial to evaluate the clinical and radiographic efficacy of the NobelActive™ system.

MATERIALS AND METHODS

Using a split-mouth design, the NobelActive™ implant was compared with a contralaterally matched Brånemark implant.† Both implants were placed in a single surgical procedure using a one-stage protocol and reviewed at monthly intervals. NobelActive™ implants† were functionally loaded with provisional restorations at one month and all implants were restored with final crowns three months post-fixture placement. The implant was assessed using final rotation torque values, resonance frequency analysis, clinical parameters, digital subtraction radiography, and cone beam computed tomography.

RESULTS

Preliminary results have shown comparable healing responses between the test and control implants. Marginal bone level changes surrounding the implants during the initial healing period were also comparable when examined using subtraction digital radiography. Survival rates were lower with the test implants, though failures could be linked to other factors.

ACKNOWLEDGMENTS

The author would like to acknowledge the guidance and assistance provided by his supervisor, Associate Professor Stephen Yeung, and the clinical assistance of the surgeons. Implant fixtures and components were kindly donated by Nobel Biocare Australia.

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* Young Lecturer presentation at the Twentieth Convocation of the Royal Australasian College of Dental Surgeons, Perth, Western Australia. March 2010

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CORONECTOMY AS THE TREATMENT OF CHOICE IN WISDOM TEETH SHOWING RADIOGRAPHIC SIGNS OF CLOSE PROXIMITY TO INFERIOR DENTAL NERVE

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Dr Leung is a PhD(OMFS) candidate and Professor Leung is the Chair Professor of the discipline of Oral and Maxillofacial Surgery in the Faculty of Dentistry, The University of Hong Kong, Hong Kong.

ABSTRACT

The aim of the study is to compare the prevalence of post-operative inferior dental nerve (IDN) deficit after coronectomy with total removal of wisdom teeth showing specific radiographic signs of close proximity to IDN. A randomized clinical trial comparing total removal and coronectomy of wisdom tooth was conducted. Analyses of the correlations of IDN deficit and various radiographic signs of wisdom tooth roots showing close proximity to IDN were performed. Two radiographic signs were found to be positive predictors of intra-operative IDN exposure. Specific radiographic signs or the presence of two or more radiographic signs are positive predictors of post-operative IDN deficit. The study concluded that darkening of the wisdom tooth root and presence of two or more specific signs in radiographs significantly increased the risk of IDN deficit in lower wisdom tooth surgery. Coronectomy can significantly reduce the prevalence of an IDN deficit in patients with lower wisdom teeth showing radiographic signs of close proximity to IDN. It also carries less surgical morbidities when compared with total removal of lower wisdom tooth.

INTRODUCTION

Lower wisdom tooth impaction is a common phenomenon in the population. Many of the impacted lower wisdom teeth are indicated for removal due to recurrent pericoronitis and dental caries. Inferior dental nerve (IDN) injury is a rare yet significant complication in lower wisdom tooth surgery. It is because the anatomical course of the IDN within the inferior dental canal often runs in close proximity to the root of the lower wisdom tooth. Although the prevalence of IDN injury in lower wisdom tooth surgery has been low in recent studies,1 the risk of IDN injury remains high if there are specific radiographic signs showing close proximity of the wisdom tooth root to the IDN.2 A recent evidence-based review conducted by the authors’ centre has concluded that multiple factors including deep impaction, increased age, intra-operative IDN exposure and specific radiographic signs are associated with an increased risk of post-operative IDN deficit in lower wisdom tooth surgery.3 Yet, if a problematic lower wisdom tooth with a high risk of IDN injury needs to be removed, it becomes a difficult decision for both the surgeon as well as the patient.

Coronectomy literally means cutting off the crown from a tooth. It is a newer method of wisdom tooth surgery where the surgeon removes only the crown of the impacted lower wisdom tooth and leaves the root in place. The hypothesis is that the crown is the cause of pericoronitis and dental caries, so by its removal the problem can be solved, and by leaving the root behind IDN injury can be avoided. Previous studies on coronectomy have shown variable results, with significant morbidity like persistent root exposure and infection, which subsequently required re-operation to remove the retained root.1,2,3 Some of these studies were lacking a large sample size or a well-designed methodology, so that further evidence to justify its use is required.

The aims of this study are to identify the specific radiographic signs from panoramic radiographs that are positive predictors of post-operative IDN deficit in lower wisdom tooth surgery, and to compare the prevalence of post-operative IDN deficit and safety of coronectomy with total removal of wisdom teeth showing specific radiographic signs of close proximity to IDN.

METHODS

Patients presenting to the Discipline of Oral and Maxillofacial Surgery, Faculty of Dentistry, The University of Hong Kong, for the removal of impacted lower wisdom teeth between June 2006 and June 2008 were recruited into this randomized controlled trial if their lower wisdom teeth showed one or more of the radiographic signs on the panoramic radiograph: A. darkening of the root; B. abrupt narrowing of one or both of the canal white lines; C. interruption or loss of the ID canal white line; D. displacement of the ID canal by the root; E. abrupt narrowing of one or both of the canal white lines. Patients with systemic disease or local factors that may predispose to infection, or their wisdom teeth had pulpal caries or any related pathology were excluded. The patients were randomized to receive either total removal (control group) or coronectomy of the lower wisdom tooth (coronectomy group). For the coronectomy group, the root was further trimmed down 3-4 mm below the crestal bone. All

* Young Lecturer presentation at the Twentieth Convocation of the Royal Australasian College of Dental Surgeons, Perth, Western Australia. March 2010

wounds were closed primarily and no antibiotics were given post-operatively. In the Control Group, intra-operatively the operators inspected the extraction socket with copious irrigation and careful suction after surgical removal of the lower wisdom tooth to check on the presence of IDN exposure and this was recorded in the operation records. Exposure of IDN was defined as a tubular whitish soft tissue structure running in an antero-posterior direction at the level the wisdom tooth socket consistent with the radiograph as suggested by Tay and Go.6

The patients were reviewed post-operatively at 1 week, 1 month, 3 months, 6 months, 12 months and 24 months.

RESULTS
Three hundred and thirty three lower wisdom teeth (155 successful coronectomies, 178 controls) in 215 patients underwent surgery. Nine patients in the control group presented with IDN deficit, compared with one in the coronectomy group (p=0.023). IDN exposure was noted in 13.5% (24/178) of the subjects in the control group, among those 20.8% presented with IDN deficit. Among the five radiographic signs, darkening of root and displacement of IDN by the root were radiographic signs which were significantly related to IDN exposure (p = 0.001 and p = 0.019, respectively). Darkening of root was shown to be the only radiographic sign significantly related to post-operative IDN deficit in the control group (p=0.016). When two or more radiographic signs were present the risk of IDN deficit was significantly increased (p = 0.001). Coronectomy has shown to be significantly safer in terms of IDN deficit risk in the wisdom teeth where there is radiographic darkening of the root (p = 0.002) and those showing two or more radiographic signs (p = 0.005). Fewer subjects reported pain in the first post-operative week in the coronectomy group (p = 0.016). When two or more radiographic signs were present the risk of IDN deficit was significantly increased (p = 0.001). Coronectomy has shown to be significantly safer in terms of IDN deficit risk in the wisdom teeth where there is radiographic darkening of the root (p = 0.002) and those showing two or more radiographic signs (p = 0.005). Fewer subjects reported pain in the first post-operative week in the coronectomy group (p = 0.005). No dry sockets were noted in the coronectomy group, which was an advantage when compared with the control group with a 2.8% rate of dry socket. Infection rate was similar between the two groups at all time of review (p > 0.05). Coronal migration of the retained root after coronectomy was noted by serial radiographs. The rate of root migration was fastest in the first three postoperative months, with a mean movement of 1.90 mm (SD, 1.23 mm), and then the rate decreased gradually, reaching 2.97 mm (SD, 1.47 mm) in the 12th postoperative month. At 24 months, the mean total movement of the root was found to be 3.06 mm (SD, 1.67 mm).

CONCLUSION
The study concluded darkening of the wisdom tooth root and presence of two or more specific radiographic signs significantly increases the risk of IDN deficit in lower wisdom tooth surgery. Coronectomy can significantly reduce the prevalence of IDN deficit in patients with lower wisdom teeth showing radiographic signs of close proximity to IDN. It also carries less surgical morbidity when compared with total removal of lower wisdom teeth. Root migration after coronectomy tends to halt or slow down drastically after one year post-operatively. A phase IV clinical trial of coronectomy of lower wisdom tooth is indicated to investigate the long term safety and the fate of the retained root.

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INTRODUCTION

Post operative plaque control is a critical factor in the successful outcome of periodontal surgery and implant placement.1-3 Periodontal literature has consistently identified chlorhexidine as a chemical agent capable of adequately preventing biofilm formation when used appropriately.4,5 However, the optimum technique, frequency and duration of chlorhexidine use post-surgery is not known.

Full mouth rinsing with chlorhexidine has been associated with adverse effects, such as staining of the teeth and tongue, distortion of taste and mucosal irritation,6,7 and these adverse effects may detrimentally impact on the compliance of the patient with suggested cleansing protocols.

Recent evidence suggests a modified mechanical cleansing protocol with application of chlorhexidine.8 There is no literature to date assessing the effectiveness of a modified mechanical application of chlorhexidine on the early wound, without concomitant full mouth chlorhexidine rinsing. Thus it is currently not known whether such a method would provide the benefits of traditional post-surgical cleansing protocols without the adverse effects associated with full mouth chlorhexidine rinsing.

The aim of the present study was to evaluate the effectiveness on plaque control and clinical healing, of a specific mechanical cleansing protocol with application of chlorhexidine using a very soft toothbrush as an applicator, without full mouth rinsing after day 3.

MATERIALS AND METHODS

Following periodontal surgery or one-stage implant surgery, 52 patients were randomly assigned to one of two post-surgical protocols. Subjects smoking more than 10 cigarettes per day were excluded. Patients were recruited from the Periodontics Division of the Oral Restorative Sciences Department at Westmead Centre for Oral Health NSW, from a pool of patients requiring periodontal surgery or implant placement. The study was approved by the Ethics Committee from the Sydney West Area Health Service.

Patients following the control protocol rinsed twice daily for 1 min with 10 mL of 0.2% chlorhexidine for 28 days. Patients following the test protocol followed the control protocol for the first three days. From day 3 to 28 a soft toothbrush† was used to locally apply 10 mL of 0.2% chlorhexidine to the wound, twice daily. Patients were instructed to dip the toothbrush into the 10 mL of chlorhexidine and wipe the dento-gingival area with light vertical strokes. This was to be repeated until 10 mL had been applied to the surgical area.

Baseline measurements included probing depth, recession, presence of bleeding on probing and full mouth plaque scores. Follow up examinations at days 7 and 14 included presence of tooth staining, wound closure, full mouth plaque scores, adverse events and patient centred outcomes.

Tooth staining was measured visually. The most mesial tooth in the surgical field, and the four maxillary anterior teeth were assessed. Patient centred outcomes included the patient’s acceptance of the cleansing protocol, taste disturbance and postoperative pain. A 100 mm visual analogue scale (VAS) was used to evaluate patient centred outcomes. Tooth staining was evaluated using the staining index adapted from Cortellini et al.9 Baseline and follow up evaluations were repeated at day 28.

RESULTS

Forty-five patients completed the clinical trial. Statistical analysis indicated there were no significant differences between groups for baseline data (full mouth plaque score, sex, smoking, type of surgery). Both post-surgical protocols resulted in successful wound healing, measured by wound closure and absence of infection. Statistical analysis indicated there were no statistical differences between groups for patient centred outcomes, adverse events, or chlorhexidine staining at surgically treated teeth. Chlorhexidine staining increased in both groups over the 28 day trial. After 7 days of chlorhexidine use, 18% of distal surfaces and 13% of incisal tooth surfaces exhibited chlorhexidine staining, which had increased to 80% (distal) and 27% (incisal) following 28 days of use.

* Young Lecturer presentation at the Twentieth Convocation of the Royal Australasian College of Dental Surgeons, Perth, Western Australia. March 2010

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CONCLUSION

A specific mechanical post-surgical protocol involving a localised application of chlorhexidine, may be recommended in the early wound healing period as an alternate to full mouth chlorhexidine rinsing.

REFERENCES


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INCIDENCE AND MAGNITUDE OF VIRIDANS STREPTOCOCCAL BACTERAEMIA CAUSED BY FLOSSING OR SCALING AND ROOT PLANING IN PATIENTS WITH CHRONIC PERIODONTITIS

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BACKGROUND AND AIMS

Changes to antibiotic prophylaxis guidelines for the prevention of infective endocarditis (IE) have occurred in part due to similar incidences of bacteraemia caused by oral hygiene procedures as compared with dental treatments for which antibiotic prophylaxis has traditionally been provided. Viridans streptococci are important pathogens in IE. However, there is little evidence available comparing the magnitude of bacteraemia caused by oral hygiene activities with that caused by periodontal treatment. The aims of this study were to investigate the incidence and magnitude of viridans streptococcal bacteraemia (VSB) due to flossing as compared with scaling and root planing (SRP) in the same individual.

MATERIAL AND METHODS

Full-mouth flossing and single quadrant SRP were performed for 20 patients with moderate/severe chronic periodontitis at separate visits. Twenty millilitres of blood were collected as a baseline prior to the procedure and further samples obtained 30 seconds and 10 minutes after completion of flossing, at 5 minutes during SRP and 30 seconds and 10 minutes after completion of SRP. The magnitude of the bacteraemia was investigated with lysis centrifugation and expressed as CFU/mL. Bacteria were identified to species level.

RESULTS

No VSB was detected in any baseline samples. The incidence of VSB was 25% for flossing and 35% for SRP. In the flossing group, all VSB was detected 30 seconds after flossing (N=5/20). In the SRP group, VSB was detected at 5 minutes during SRP (N=5/20) and 30 seconds after SRP (N=2/20). The mean magnitudes of VSB were 1.61 CFU/mL for flossing and 0.28 CFU/mL for SRP.

CONCLUSIONS

It may be inconsistent to recommend prophylaxis for IE for periodontal procedures but not for flossing in patients with periodontitis.

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* Young Lecturer presentation at the Twentieth Convocation of the Royal Australasian College of Dental Surgeons, Perth, Western Australia. March 2010

ANNALS OF THE
ROYAL AUSTRALASIAN COLLEGE OF DENTAL SURGEONS
VOLUME 20 MARCH 2010

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Printed and published by the Proprietors, the Royal Australasian College of Dental Surgeons

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