Introduction

Group A
Plaque control: Home remedies practiced in developing countries

Initiator Paper
Dagmar E. Slot and Fridus A. Van der Weijden

Reactor Paper
Thomas E. Van Dyke

Consensus Paper
Sebastian Ciancio

Group B
Non-surgical periodontal therapy: mechanical debridement, antimicrobial agents and other modalities

Initiator Paper
Magda Feres, Marcelo Faveri, Luciene Cristina Figueiredo, Ricardo Teles, Thomas Flemmig, Ray Williams, Niklaus P. Lang

Reactor Paper
Niklaus P. Lang

Consensus Paper
Niklaus P. Lang

Group C
Periodontal regeneration - fact or fiction?

Initiator Paper
PM Bartold

Reactor Paper
Joerg Meyle

Consensus Paper
Shinya Murakami

Continued overleaf
Group D
Implants - Peri-implant (hard and soft tissue) interactions in health and disease: The impact of explosion of implant manufacturers

Initiator Paper
Saso Ivanovski 57

Reactor Paper
Young-Bum Park 69

Consensus Paper
Jamil Shibli 71

Group E
Interprofessional education and multidisciplinary teamwork for prevention and effective management of periodontal disease

Initiator Paper
Lijian Jin 74

Reactor Paper
Vincent J. Iacono 80

Consensus Paper
A. Kumarswamy 84
The 1st IAP “Conclave”  
11 – 13 April 2014  
Bangkok, Thailand

INTRODUCTION  
Ajay Kakar

On 11 – 13 April 2014, the International Academy of Periodontology (IAP) held a unique initiative by hosting a conclave meeting of leading periodontists from developing countries along with established leading luminaries as the invited faculty. The purpose of the conclave was to develop and report their conclusive findings on five different aspects of periodontal diseases and therapies. The theme for the conclave meeting was “Global strategies to address periodontal health and diseases, focusing on the emerging nations.” The goal was to address periodontal therapy on a global scale to achieve periodontal awareness and concomitant periodontal health improvements in developed, developing and underdeveloped countries. The key areas for discussion and recommendations were:

A. Plaque control - home remedies practiced in developing countries
B. Non-surgical periodontal therapy - mechanical debridement, antimicrobial agents and other modalities
C. Periodontal regeneration - fact or fiction?
D. Implants - peri-implant (hard and soft tissue) interactions in health and disease
E. Interprofessional education and multidisciplinary teamwork for prevention and effective management of periodontal disease

After establishing the five groups, a moderator, an initiator and a reactor was chosen for each of the five workgroups. The IAP board selected and invited experts in each of the areas. Subsequently invitations were sent out to periodontal/implant associations around the world to send representatives to take part in the deliberations. The Conclave was attended by representatives of close to 25 countries. The IAP set a maximum of 100 attendees split among the five groups.

Each workgroup was comprised of an initiator, a reactor and a moderator. The program was planned with a common opening session wherein the guidelines of the Conclave were established and then the moderators of each group led the discussions of each of the workgroup teams addressing a number of key questions.

Following the initial discussion, the groups reconvened and each group presented their initial findings. Comments and suggestions were taken from all the delegates and the groups again met for further deliberation to formulate their final conclusions.

This issue of the Journal of the International Academy of Periodontology contains the initial review papers and the final outcomes from the three days of discussions and deliberation by the delegates.

The IAP is extremely thankful to the supporting companies, without which this Conclave would not have been possible. We are grateful to Colgate Palmolive as the Principal Sponsor for the event, Proctor & Gamble – Oral B as the Gold Sponsors, and Giestlich, Johnson & Johnson and Sunstar as the Supporting Sponsors for the event.

The final publication of the papers presented herein was generously supported by additional funding from Colgate Palmolive.

GROUP LEADERS

**Workgroup A – Plaque Control**
Initiator: Ms. Dagmar Slot  
Reactor: Dr. Thomas Van Dyke  
Moderator: Dr. Sebastian Ciancio

**Workgroup B – Non-surgical Therapy**
Initiator: Dr. Magda Feres  
Reactor and Moderator: Dr. Nicklaus Lang

**Workgroup C – Periodontal Regeneration**
Initiator: Dr. Mark Bartold  
Reactor: Dr. Joerg Meyle  
Moderator: Dr. Shinya Murakami

**Workgroup D – Implants**
Initiator: Dr. Saso Ivanovski  
Reactor: Dr. Young Bum Park  
Moderator: Dr. Jamil Shibli

**Workgroup E – Interprofessional Education**
Initiator: Dr. Lijian Jin  
Reactor: Dr. Vincent Iacono  
Moderator: Dr. A. Kumarswamy
Participants

Agarwal, Ruchi, Private Practice, Melbourne, Australia
Alarcon, Marco, Universidad Peruana Cayetano Heredia, Peru
Al Bayaty, Foud, Universiti Teknologi MARA, Malaysia
Anagnostou, Fani, Paris Diderot University, France
Aswapati, Nawarat Wara, Khon Kaen University, Thailand
Bakalyan, Vardan, Yerevan State Medical University, Armenia
Bartold, Mark, University of Adelaide, Australia
Bunyaratavej, Pintippa, Mahidol University, Thailand
Byakod, Girish, Rangoonwaala Dental College, India
Cheung, KM, Private Practice, Singapore
Chitguppi, Rajeev, Terna Dental College-Navi Mumbai, India
Chiu, Gordon, Private Practice, Hong Kong
Ciancio, Sebastian, University of Buffalo, USA
Corbet, Esmonde, The University of Hong Kong, Hong Kong
Darby, Ivan, University of Melbourne, Australia
Ding, Yi, Sichuan University, PR China
Duncan, Warwick, University of Otago, New Zealand
Duygu, Ilhan, Private Practice, Turkey
Emingil, Gulnur, Ege University, Turkey
Ettiene, Daniel, Paris Diderot University, France
Faveri, Marcelo, Guarulhos University, Brazil
Feres, Magda, Guarulhos University, Brazil
Fernandes, Benette, Srinivas Institute of Dental Sciences, India
Gamal, Ahmed, Ain Shams University, Egypt
Giri, Dhirendra, College of Dental Surgery, Nepal
Halhal, Rita, Private Practice, France
Humagain, Manoj, Kathmandu University School of Medical Sciences, Nepal
Iacono, Vincent, Stony Brook Dental School, USA
Ilhan, Duygu, Private Practice, Turkey
Ivanovski, Saso, Griffith University, Australia
Izumi, Yuichi, Tokyo Medical and Dental University, Japan
Jacob, Shaiju, International Medical University, Malaysia
Jin, Lijian, Prince Philip Dental College, Hong Kong
Jin, Yan, Fourth Military Medical University, China
John, Janice, India (Transcriber)
Joshi, Vinayak, MMNGH Institute of Dental Sciences, India
Kakar, Ajay, Private Practice, India
Kakar, Mona, Private Practice, India
Kale, Rahul, M.A. Rangoonwaala College of Dental Sciences, India (Transcriber)
Kamil, Wisam, International Islamic University Malaysia, Malaysia
Kemal, Yulianti, Universitas Indonesia, Indonesia
Kendall, Kaye, Private Practice, Australia
Kim, Sung Tae, Seoul National University School of Dentistry, South Korea
Kim, Ti Sun, University Hospital of Heidelberg, Germany
Kumaraswamy, A, Yerla Medical Trust Dental College, India
Lang, Nikolaus, Universities of Zurich and Berne, Switzerland
Laorongsak, Srinakharinwirot University, Thailand
Leung, Keung, University of Hong Kong, China
Leechter, Jonathan, University of Otago, New Zealand
Loomer, Peter, New York University College of Dentistry, USA
Mahanonda, Rangsini, Chulalongkorn University, Thailand
Masud, Mahayunah, University Institute Technology Mara, Malaysia
Matheos, Nikos, Prince Philip Dental College, Hong Kong
Meylo, Joerg, University of Giessen, Germany
Minh, Nguyen Thi Hong, National Hospital of Odonto-Stomatology, Vietnam
Murakami, Shinya, Osaka University, Japan
Nagata, Toshihiko, University of Tokushima Graduate School, Japan
Narongsak, Laorisin, Srinakharinwirot University, Thailand
Nazareth, Bianca, India
Nishida, Mieko, Sunstar Inc., Japan
Ouyahoun, Jean Pierre, Paris 7 Denis Diderot University, France
Pack, Angela, University of Otago (Retired), New Zealand
Panikar, Arjun, Private Practice, India (Transcriber)
Park, Young Bum, Yonsei University, Korea
Patel, Nisha, Rishi Raj Dental College, India (Transcriber)
Patnaik, Samajj, India
Pillai, Nihar, Private Practice, India (Transcriber)
Pradhan, Shaili, National Academy of Medical Science, Nepal
Rajal, Jaisika, Subharti University, India (Transcriber)
Sakekari, Dimitra, Aristotle University of Thessaloniki, Greece
Senevirante, Cyanthi, Colgate, Singapore
Shibli, Jamil, University of Guarulhos, Brazil
Shibutani, Toshiaki, Asahi University, Japan
Shin, Seung Il, Kyunghee University, South Korea
Shorah, Mohammed, Fiji National University, Fiji
Singh, Preetinder, SDD Hospital & Dental College, India
Slot, Dagmar, Academic Centre for Dentistry Amsterdam, Netherlands
Soeroso, Yuniarti, Universitas Indonesia, Indonesia
Spahr, Axel, University of Sydney, Australia
Takashiba, Shogo, Okayama University Graduate School of Medicine, Japan
Tan, Benjamin, National University of Singapore
Tan, Wah Ching, National Dental Centre Singapore, Singapore
Thakur, Roshni, DY Patil Dental College, India (Transcriber)
Van Dyke, Thomas, Forsyth Institute, USA
Vidhale, Priya, Private Practice, India (Transcriber)
Wagh, Adivya, University of Texas, India (Transcriber)
Won, Jung Uk, College of Dentistry, Yonsei University, South Korea
Xuan, Dong-Ying, Southern Medical University, China
Yamazaki, Kazuhisa, Niigata University, Japan
Yang, Yueh Chao, Taiwan
Yeung, Stephen, University of Sydney, Australia
Zhang, Jin Cai, Southern Medical University, China
As a long-standing partner of the International Academy of Periodontology, Colgate® supports its mission to improve the oral health of patients. As a professional, you rely on evidence and science when deciding what products to recommend. That’s why we know you’ll appreciate the fact that Colgate Total® is one of the most tested and researched formulas in the world.

Thanks to its unique formula, Colgate Total is clinically proven to prevent, treat and reverse gingivitis. 20 years, 90 clinical studies and 20,000 subjects concur.

#1 TOOTHPASTE
RECOMMENDED AND USED BY DENTAL PROFESSIONALS

AND THE FIRST TOOTHPASTE AWARDED THE INTERNATIONAL ACADEMY OF PERIODONTOLOGY SEAL

The science behind this trust:

More than 20 years of validated safety and efficacy

Only FDA Approved toothpaste through the rigorous new drug application process

ADA Accepted as well as by over 40 dental associations worldwide

Over 90 clinical trials, 20,000 subjects

As a long-standing partner of the International Academy of Periodontology, Colgate® supports its mission to improve the oral health of patients. As a professional, you rely on evidence and science when deciding what products to recommend. That’s why we know you’ll appreciate the fact that Colgate Total® is one of the most tested and researched formulas in the world.

Thanks to its unique formula, Colgate Total is clinically proven to prevent, treat and reverse gingivitis. 20 years, 90 clinical studies and 20,000 subjects concur.

Know the Science. Get the Facts.
colgateprofessional.com/science
Introduction

The importance of plaque control measures to contribute to the oral health status of an individual has been emphasized in all workshops on periodontology (Claydon, 2008). Oral cleanliness is important for the preservation of oral health as it removes microbial plaque, thereby preventing its accumulation on teeth and gingivae (Choo et al., 2001). Self-care includes all self-supporting activities that an individual performs to prevent and treat personal ill health. Self-care or home-use activities include toothbrushing combined with interdental cleaning. People brush their teeth for a number of reasons: to feel fresh and confident, to have a nice smile, and to avoid bad breath and disease (Choo et al., 2001). But despite the widespread use of both toothbrushes and fluoride toothpastes, the majority of the population do not clean their teeth thoroughly enough to prevent plaque accumulation (Claydon, 2008).

There is, however, substantial evidence showing that toothbrushing and other mechanical cleansing procedures can reliably control plaque. The development of a variety of powered (electric) toothbrushes has been undertaken with the aim of enabling the user to achieve higher standards. Although power toothbrushes are sold worldwide and have been shown to be more effective than manual toothbrushes (Deacon et al., 2010), their significance in developing countries is limited because of costs. The minimum level of income deemed adequate in developing countries is limited because of costs. The minimum level of income deemed adequate in developing countries is limited because of costs. The minimum level of income deemed adequate in developing countries is limited because of costs. The minimum level of income deemed adequate in developing countries is limited because of costs. The minimum level of income deemed adequate in developing countries is limited because of costs. The minimum level of income deemed adequate in developing countries is limited because of costs. The minimum level of income deemed adequate in developing countries is limited because of costs. The minimum level of income deemed adequate in developing countries is limited because of costs. The minimum level of income deemed adequate in developing countries is limited because of costs. The minimum level of income deemed adequate in developing countries is limited because of costs. The minimum level of income deemed adequate in developing countries is limited because of costs. The minimum level of income deemed adequate in developing countries is limited because of costs. The minimum level of income deemed adequate in developing countries is limited because of costs. The minimum level of income deemed adequate in developing countries is limited because of costs. The minimum level of income deemed adequate in developing countries is limited because of costs. The minimum level of income deemed adequate in developing countries is limited because of costs. The minimum level of income deemed adequate in developing countries is limited because of costs. The minimum level of income deemed adequate in developing countries is limited because of costs. The minimum level of income deemed adequate in developing countries is limited because of costs. The minimum level of income deemed adequate in developing countries is limited because of costs. The minimum level of income deemed adequate in developing countries is limited because of costs. The minimum level of income deemed adequate in developing countries is limited because of costs. The minimum level of income deemed adequate in developing countries is limited because of costs. The minimum level of income deemed adequate in developing countries is limited because of costs. The minimum level of income deemed adequate in developing countries is limited because of costs. The minimum level of income deemed adequate in developing countries is limited because of costs. The minimum level of income deemed adequate in developing countries is limited because of costs. The minimum level of income deemed adequate in developing countries is limited because of costs. The minimum level of income deemed adequate in developing countries is limited because of costs. The minimum level of income deemed adequate in developing countries is limited because of costs. The minimum level of income deemed adequate in developing countries is limited because of costs. The minimum level of income deemed adequate in developing countries is limited because of costs.

Thus the purchase costs and the need for electricity for recharging or the cost of batteries restricts the potential use of power toothbrushes in developing countries. Additionally, the use of interdental brushes on a daily basis would be far beyond what the average consumer in developing countries could afford. Subsequently for this paper, manual toothbrushing, flossing and the use of wood sticks were considered to be suitable methods for mechanical plaque control by oral self-care in developing countries.

With respect to toothbrushing, a PubMed search at the time of preparation of this manuscript revealed that over 6500 relevant papers are indexed in this database. Consequently it was decided to consider the totality of the evidence as presented in systematic reviews. Such a synthesis is a comprehensive summary of all the research evidence related to a focused clinical question that integrates the best available evidence from original single studies. The present synopses of syntheses (Dicensio et al., 2009), summarizes the findings of a systematic review on various methods of mechanical plaque removal which are affordable in developing countries, with the aim to assess the effect on plaque scores and oral health.

Materials and methods

This synopsis of synthesis was conducted in accordance with the Cochrane handbook (Higgins and Green, 2011) for systematic reviews of interventions, which provides guidance for the preparations and the guidelines of Transparent Reporting of Systematic Reviews and Meta-analyses (PRISMA-statement; Moher et al., 2009; Dicensio et al., 2009).

Focused question

Based on evidence as presented in systematic reviews, what is the effect on plaque scores and oral health of self-care manual plaque control measures appropriate for developing countries?
Search strategy

Three internet sources were used to search for appropriate papers that satisfied the study purpose. These sources included the National Library of Medicine, Washington, D. C. (MEDLINE-PubMed) and the Cochrane Central Register of Controlled Trials. For this comprehensive search, both databases were searched for eligible studies up to 1 January 2015. The structured search strategy was designed to include any systematic review published that evaluated the effect of self-care regarding plaque control. For details regarding the search terms used, see Box 1.

Screening and selection

Two reviewers (DES and GAW) independently screened the titles and abstracts for eligible papers. If eligibility aspects were present in the title, the paper was selected for further reading. If none of the eligibility aspects were mentioned in the title, the abstract was read in detail to screen for suitability. After selection, the full-text papers were read in detail by two reviewers (DES and GAW). Any disagreement between the two reviewers was resolved after additional discussion. The papers that fulfilled all of the selection criteria were processed for data extraction. All of the reference lists of the selected studies were hand-searched by two reviewers (DES and GAW) for additional published work that could possibly meet the eligibility criteria of the study. Unpublished work was not sought.

• The eligibility criteria were as follows:
  • Systematic reviews
  • Papers written in the English or Dutch language
  • Evaluating studies conducted in humans
    ◦ ≥ 18 years old
    ◦ In good general health
  • Intervention: self-care products for controlling the dental biofilm.
  • Evaluation with one or more of the following clinical evaluation parameters: plaque scores (PS); gingival index (GI); and bleeding scores (BS).
  Exclusion criteria: rechargeable or battery powered devices.

Assessment of heterogeneity

The heterogeneity of the outcome parameters across studies was detailed according to the following factors:
• Databases searched
• Study and subject characteristics
• Manner of analysis of the obtained data

Quality assessment

Two reviewers (DES and GAW) scored the methodological qualities of the systematic reviews. Assessment of methodological study quality was performed by combining the proposed criteria of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement Checklist, together with items of the systematic review reviewers checklist (Ades et al., 2013), Quality Assessment Scale for Systematic Reviews (Barton et al., 2008, modified by Haladay et al., 2013) and reporting items suggested by Zorzela et al. (2014). Criteria were designated for evaluating the methods. This comprehensive combination of quality criteria is presented in Table 2.

Box 1. Search terms used for PubMed-MEDLINE and Cochrane-CENTRAL.
The search strategy was customized according to the database being searched.

The following strategy was used in the search:
{ <intervention> AND <outcome> }
Filter used: systematic review OR meta-analysis

{ <Intervention: [MeSH terms] Toothbrushing OR (Home Care Dental Devices) OR [text words] toothbrush OR toothbrushing OR toothbrush* OR toothpick* OR wood stick* OR (wooden interdental cleaner) OR (wedge stimulator*) OR (wooden stimulator*) OR miswak OR miswaak OR arak OR swak OR sewak, (Kayu Sag) OR (chewing stick) OR Floss OR (Dental floss) OR Flossing OR Tape OR (Dental tape) OR Superfloss OR Ultrafloss OR (Interdental cleaning devices) OR (Interproximal cleaning devices) OR (Interspace cleaning devices)> }
AND

<(Outcome: <[MeSH terms] (Dental Plaque) OR (Dental Plaque Index) OR (Dental Deposits) OR [text words] (dental deposit*) OR (dental deposits) OR (dental deposit) OR plaque OR (plaque removal) OR (plaque index) OR (dental plaque))>

The asterisk (*) was used as a truncation symbol.
Figure 1. Search and selection results.
### Table 1. Overview of the characteristics of the included systematic reviews processed for data extraction.

<table>
<thead>
<tr>
<th>ID Author (year)</th>
<th>Databases searched Data</th>
<th>Number of included studies/trials # participants</th>
<th>Mode of analysis (methodology, meta-analysis, vote counting)</th>
<th>Original review authors’ conclusions</th>
<th>COMMENTS of the synopsis authors</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Brushing</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slot et al., 2012</td>
<td>PubMed-Medline Cochrane CENTRAL</td>
<td>212 experiments 10,806 participants</td>
<td>Meta-analysis Weighted mean and 95% confidence interval</td>
<td>The efficacy in plaque removal following a brushing exercise is a reduction from baseline plaque scores of 42% on average, with a variation of 30 – 53% dependent on the plaque index used. The available evidence indicates that bristle tuft arrangement (flat trim, multilevel, angled) and brushing duration are factors that contribute to the variation in observed efficacy.</td>
<td>Lacks a comparison intervention</td>
</tr>
<tr>
<td><strong>Interdental cleaning</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Berchier et al., 2008</td>
<td>PubMed-Medline Cochrane CENTRAL</td>
<td>11 studies 559◊ participants</td>
<td>Meta-analysis Weighted mean difference Vote counting</td>
<td>The dental professional should determine, on an individual patient basis, whether high-quality flossing is an achievable goal. In light of the results of this comprehensive literature search and critical analysis, it is concluded that a routine instruction to use floss is not supported by scientific evidence.</td>
<td>Two included studies reported the same experiment; however, they were of different durations.</td>
</tr>
<tr>
<td>Sambunjak et al. 2011</td>
<td>Ovid-Medline OVID-EMBASE Cochrane CENTRAL Cochrane OHG trials LILAC-BIREME CINAHL-EBSCO ZETOC Web of science mRCT clinicaltrials.gov</td>
<td>12 trials 1083 participants</td>
<td>Meta analysis Standardized Mean Difference</td>
<td>There is some evidence from 12 studies that flossing in addition to toothbrushing reduces gingivitis compared to toothbrushing alone. There is weak, very unreliable evidence from 10 studies that flossing plus toothbrushing may be associated with a small reduction in plaque at 1 and 3 months. No studies reported the effectiveness of flossing plus toothbrushing for preventing dental caries.</td>
<td>Two studies included a control group using a 5% hydro alcohol. One study included an intervention group using a hummingbird power flosser which is not dental floss but a rubber stimulator.</td>
</tr>
<tr>
<td>Hoenderdos et al. 2008</td>
<td>PubMed-Medline Cochrane CENTRAL</td>
<td>8 experiments 438◊ participants</td>
<td>Vote counting</td>
<td>Evidence from controlled trials, most of which were also randomized, shows that wood sticks do not have an additional effect on visible interdental plaque or gingival index, but do, however, provide an improvement in interdental gingival inflammation by reducing the bleeding tendency.</td>
<td>No statistical analysis could be performed. Only triangular wood sticks were evaluated.</td>
</tr>
</tbody>
</table>

◊ = Calculated by the review authors
### Table 2. Methodological quality scores and estimated risk of bias of the included systematic reviews.

<table>
<thead>
<tr>
<th>Quality criteria:</th>
<th>Study:</th>
<th>Slot et al., 2012</th>
<th>Berchier et al., 2008</th>
<th>Sambunjak et al., 2011</th>
<th>Hoenderdos et al., 2008</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Oral hygiene device evaluated</td>
<td>Brush</td>
<td>Floss</td>
<td>Floss</td>
<td>Wood sticks</td>
</tr>
<tr>
<td></td>
<td>Defined outcome criteria of interest</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Target population in developing countries</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Describes the rationale</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Describes the focused (PICO)[S] question/hypothesis</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Describes if a protocol was developed ‘a priori.’</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Protocol registration/publication</td>
<td>NA</td>
<td>NA</td>
<td>+</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>Presented eligibility criteria (inclusion/exclusion criteria)</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Presents the full search strategy</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Various databases searched</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Performed (manual) search in additional sources (e.g. grey literature or trial registers)</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Stated if selected studies were screened by more than one reviewer</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Non-English language papers included</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Provided details on the performed study selection process/flow chart</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Reports study characteristics, such as patient demographics or length of follow-up</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Provide data of the selected studies on the outcome measures of interest</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Data were extracted by more than one reviewer</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Report heterogeneity of the included studies</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Estimated risk of bias in individual studies</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Performed a meta-analysis</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Performed a descriptive analysis</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Performed an analysis based on vote counting</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Describes additional/sub-analyses</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Grading of the obtained evidence</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Present limitations of the systematic review</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Provide a conclusion that responds to the objective</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Funding source</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

| Authors estimated quality score | 71% | 63% | 88% | 71% |

| Authors estimated quality     | substantial | substantial | high   | substantial |

Each aspect of the score list was given a rating of ‘+’ for an informative description of the item at issue and a study design meeting the quality standard, ‘-’ for an informative description without a study design that met the quality standard, and ‘?’ for insufficient information. NA, not applicable.
Disagreements in scoring for the final quality assessment scores were resolved by consensus. The consensus quality assessment scores and percent agreement were calculated. Each aspect of the item score list was given a rating of ‘+’ for informative description of the item at issue and a study design meeting the quality standard, ‘-’ for an informative description without a study design that met the quality standard and ‘?’ for insufficient information. If all quality items were given a positive rating a 100% quality score was obtained. The percentage estimated quality was interpreted as follows: 0% to 40% - low quality, 40% to 60% - moderate quality, 60% to 80% - substantial quality, 80% to 100% - high quality.

Data analyses
Plaque scores were considered to be the primary parameter of interest and formed the basis for selection of publications for this review. The data from those papers that met the selection criteria were extracted and processed for further analysis by two reviewers (DES and GAW). As a measure of oral health also bleeding scores (BS) and the gingival index (GI) scores were considered from those studies in which these outcomes were presented in conjunction with plaque score data. Data and conclusions as presented in the selected papers were extracted. Statistical heterogeneity and potential publication bias were evaluated. Disagreements between the reviewers were resolved by discussion.

Grading the ‘body of evidence’
The Grading of Recommendations Assessment, Development and Evaluation (GRADE) system, as proposed by the GRADE working group, was used to grade the evidence emerging from this synopsis of synthesis (GRADE, Guyatt et al., 2008). Two reviewers (DES and GAW) rated the quality of the evidence as well as the strength of the recommendations according to the following aspects: risk of bias, consistency and precision among outcomes, directness of results, and detection of publication bias.

Results
Search and selection results
The searches resulted in 78 unique papers (Figure 1). The screening of titles and abstracts initially resulted in six papers. Based on detailed reading of full texts two papers were excluded. Hand searching of the reference lists did not reveal any additional suitable systematic reviews. As a result, four studies were identified as eligible for inclusion in this synopsis according to intervention and outcome parameters.

Assessment of heterogeneity
Considerable heterogeneity was observed in the four systematic reviews with respect to the databases searched, study and subject characteristics of the original individual papers, description of inclusion and exclusion criteria, quality assessment scale used, report of effect scores, presence of meta-analysis, and conclusions made. Information regarding the included papers is displayed in detail in Table 1. Various clinical indices and their modifications have been evaluated.

Quality assessment
Quality assessment values, including details, are presented in Table 2. Based on a summary of these criteria, the estimated quality is substantial in three studies (Slot et al., 2012; Berchier et al., 2008; Hoenderdos et al., 2008) based on quality scores of 71%, 63% and 71% respectively. A high estimated quality based on a score of 88% was given to the Cochrane paper of Sambunjak et al., 2011.

Study outcomes results
Table 1 shows the results from the data extraction. The conclusion of the original review authors and the comments of the authors of this synopsis and a descriptive summary are presented per oral hygiene device.

Manual toothbrushes
The effect of a single brushing exercise using a manual toothbrush was assessed by Slot and coworkers (2012). In total, 212 individual brushing exercises as separate legs of experiments, including 10,806 participants, were used to calculate a weighted mean overall plaque score reduction in percentage. Based on the baseline and end scores, a plaque reduction percentage was calculated for each of the eligible brushing exercises taken from the selected studies. Using these data, a weighted mean difference (WMD) in plaque index scores reduction from baseline was calculated to be 42% including all methods of scoring plaque. Taking plaque index scores used into account, plaque scores dropped from 30% to 53% on average. Sub-analysis of the efficacy in relation to brush head configurations and brushing duration shows a numerical advantage of multilevel and angled designs relative to flat trim. In addition, the effect of a single brushing exercise with regard to toothbrushing time was evaluated. From this sub-analysis, based on Quigley and Hein plaque index scores, the estimated weighted mean efficacy was 27% after 1 minute and 41% after 2 minutes.

Floss
Berchier and coworkers (2008) evaluated the effect of flossing as adjunct to toothbrushing. Independent screening of titles and abstracts resulted in 11 publications that met the eligibility criteria. The majority of these studies showed that there was no benefit from flossing on plaque or clinical parameters of gingivitis.
From the collective data of the studies, it appeared possible to perform a meta-analysis of plaque and gingival index scores. In both instances, baseline scores were not statistically different. Comparing brushing and flossing against brushing only, the Quigley and Hein plaque index WMD was -0.04 (95% CI: -0.12; 0.04, \( p = 0.39 \)) and the Löe and Sillness gingival index WMD was -0.08 (95% CI: -0.16; 0.00, \( p = 0.06 \)). End scores also showed no significant differences between those groups that flossed in comparison to those that did not floss for the Quigley and Hein plaque (WMD: -0.24, 95% CI: -0.53; 0.04, \( p = 0.09 \)) or Löe and Silness gingival index (WMD: -0.04, 95% CI: -0.08; 0.00, \( p = 0.06 \)).

In a Cochrane review, the effects of flossing in combination with toothbrushing were compared with toothbrushing alone in the management of periodontal diseases and dental caries in adults (Sambunjak et al., 2011). Twelve trials were included in this review, with a total of 582 participants in flossing plus toothbrushing (intervention) groups and 501 participants in toothbrushing (control) groups. All included trials reported the outcomes of plaque and gingivitis. Seven of the included trials were assessed as at unclear risk of bias and five were at high risk of bias. Flossing plus toothbrushing showed a statistically significant benefit compared to toothbrushing in reducing gingivitis at the three time points studied, the standardized mean difference (SMD) being -0.36 (95% CI -0.66 to -0.05) at 1 month, SMD -0.41 (95% CI -0.68 to -0.14) at 3 months and SMD -0.72 (95% CI -1.09 to -0.35) at 6 months.

Wood sticks

Hoenderdos and coworkers (2008) presented a qualitative summary of the effect of wood sticks in combination with toothbrushing. Seven publications describing eight clinical experiments met the inclusion criteria. None of the studies that scored plaque demonstrated any significant advantage of the use of wood sticks. The improvement in gingival health observed in the studies represented a significant reduction of bleeding realized by the use of triangular wood sticks.

Evidence profile

Table 3 shows a summary of the various factors used to rate the quality of evidence and strength of recommendations according to GRADE (Guyatt et al., 2008). Because the data are fairly consistent, indirect and moderately precise, the strength of the recommendation is considered to be ‘moderate to strong’ for the self-care mechanical plaque removal devices.

Discussion

The model to guide clinical decision begins with original single studies as the foundation, and builds up from these to syntheses (systematic reviews), followed by synopses of the syntheses. Such synopses intend to describe the current best evidence that matches the patients’ specific circumstances. The advantages of a relevant synopsis of a synthesis are 2-fold: first, the synopsis provides a convenient summary of the corresponding synthesis (systematic reviews), and second, it is often accompanied by a commentary that addresses the methodological quality of the synthesis and the clinical applicability of its findings (Dicenso et al., 2009). The current synopsis intended to evaluate oral hygiene measures suitable for developing countries. For these specific patients with limited financial resources no evidence could be retrieved. The papers selected summarized research performed in Western societies.

Based on the observations by Slot et al. (2012) the efficacy of plaque removal following a toothbrushing exercise is a reduction from baseline in plaque scores of 42% on average, with a range of 30–53% dependent on the plaque index used. It appears that there is room for improvement in the efficacy of manual toothbrushes in their capability for reducing plaque score during a brushing exercise. The duration of toothbrushing is likely to be an important determinant of plaque removal in the general population; therefore, it should be stressed during toothbrushing instruction sessions. As plaque removal is strongly correlated with brushing time for any given toothbrush, brushing for 2 minutes or longer should be encouraged, regardless of the brush used. Brushing time is also likely the most easily controlled parameter of effective everyday brushing (Slot et al., 2012).

### Table 3. GRADE evidence profile for the effect of various methods of mechanical plaque removal suitable for developing countries based on the selected systematic reviews.

<table>
<thead>
<tr>
<th>GRADE</th>
<th>Toothbrush</th>
<th>Floss</th>
<th>Wood stick</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimated quality</td>
<td>Substantial</td>
<td>Substantial to high</td>
<td>Substantial</td>
</tr>
<tr>
<td>Consistency</td>
<td>Fairly consistent</td>
<td>Fairly consistent</td>
<td>Inconsistent</td>
</tr>
<tr>
<td>Directness</td>
<td>Indirect</td>
<td>Indirect</td>
<td>Indirect</td>
</tr>
<tr>
<td>Precision</td>
<td>Moderate</td>
<td>Moderate</td>
<td>Moderate</td>
</tr>
<tr>
<td>Publication bias</td>
<td>Possible</td>
<td>Possible</td>
<td>Possible</td>
</tr>
<tr>
<td>Body of evidence</td>
<td>Moderate</td>
<td>Strong</td>
<td>Moderate</td>
</tr>
</tbody>
</table>
Based on the individual papers in the review by Berchier et al. (2008), a trend was observed that indicated a beneficial adjunctive effect of floss on plaque levels. However, this could only be substantiated as a non-significant trend in the meta-analyses. Routine recommendation to use floss is thus not supported by scientific evidence. The dental professional should therefore determine, on an individual patient basis, whether high-quality flossing is an achievable goal. One may critically ask why the review by Berchier et al. (2008) does not substantially show dental floss as a co-operative adjunct to toothbrushing? The advocacy of floss as an interdental cleaning device hinges, in large part, on common sense. However, common sense arguments are the lowest level of scientific evidence (Sackett et al., 2000). A possible explanation is that the previous narrative reviews have not been conducted systematically. The fact that dental floss has no additional effect on toothbrushing is apparent from more than one review. Sambunjak et al. (2011) in their Cochrane review concluded that overall there is weak, very unreliable evidence that suggests that flossing plus toothbrushing may be associated with a small reduction in plaque. Hujoel et al. (2006) found that flossing was only effective in reducing the risk of interproximal caries when applied professionally. High-quality professional flossing performed in first-grade children on school days reduced the risk of caries by 40%. In contrast, self-performed flossing failed to show a beneficial effect. The lack of an effect on caries is most likely the consequence of plaque not being removed efficiently, as established by Berchier et al. (2008). Flossing also does not effectively clean wide interdental spaces, root surfaces or concavities. Such periodontally involved dentitions are more common in advancing age, when reduced dexterity and visual acuity further impede flossing.

Wood sticks can be used effectively where sufficient interdental space is available. Wood sticks fabricated from soft wood are designed to allow the mechanical removal of plaque from these interdental surfaces. When used on healthy dentition, wood sticks depress the gingivae by up to 2 mm and therefore clean part of the subgingival area. Thus, wood sticks may specifically remove subgingivally located interdental plaque that is not visible and therefore not evaluated by the plaque index. This physical action of wood sticks in the interdental area may produce a clear beneficial effect on interdental gingival inflammation (Finkelstein et al., 1990). Evidence from controlled trials (Hoenderdos et al., 2008), shows that hand-held triangular wood sticks do provide an improvement in interdental gingival inflammation by reducing the bleeding tendency. However, no concomitant effect on visible interdental plaque could be established. As explanation for this inconsistency one may consider a series of histological investigations in patients with periodontitis (Walsh and Heckman, 1985) which has shown that the papillary area with the greatest inflammation corresponds to the middle of the interdental tissue. It is difficult to clinically assess the mid-interdental area for plaque, as it is usually not available for direct visualization.

**Toothbrushes**

In normal use it must be concluded that the benefits of toothbrushing far outweigh the potential harm (Addy and Hunter, 2003). Although toothbrushing is known to cause gingival abrasions, data regarding the effect of toothbrushing on the initiation and progression of non-inflammatory gingival recession are inconclusive (Rajapakse et al., 2007).

The exact moment at which a toothbrush should be replaced is difficult to determine. The American Dental Association advocates toothbrush replacement every 3 to 4 months or sooner if the bristles become frayed (American Dental Association, Statement on Toothbrush Care: Cleaning, Storage and Replacement, available at http://www.ada.org/1887.aspx). Common sense dictates that toothbrushes should be replaced because the filaments and tufts do not retain their shape forever. Completely worn brushes lose the capacity to remove plaque effectively. This most likely occurs because of a loss of shear force, as the tips of the filaments can no longer disrupt the plaque adequately. Rosema et al. (2013) evaluated 3-month-old used and new manual toothbrushes and did not observe a clinically relevant difference in plaque score reductions following a 2-minute brushing exercise. However, the wear rate of the brushes seems to be the determining factor in loss of efficacy, rather than the age of the toothbrush.

When old brushes showed more wear new brushes had greater benefits over old brushes. Therefore, it seems appropriate to replace a brush when it shows wear up to a point where ‘the outer tufts are splayed and have lost tuft definition,’ the ‘inner tufts are splayed and become less distinct’ and ‘the definition between inner and outer tufts is lost.’ Individuals show great variation in the progression of toothbrush wear so the age of a toothbrush should not be the guiding factor for replacement (Rosema et al., 2013). The finding that heavily worn 14-month-old toothbrushes with severe bristle matting in the hands of 7- and 8-year-olds are not less effective than new toothbrushes with regard to plaque-removal capacity has important consequences for school brushing programs. If the old toothbrush can be maintained far beyond the generally recommended three-month period, school-based toothbrushing programs in underserved communities have a better chance to be sustained (Van Palenstein Helderman et al., 2006).
**Toothpaste**

The use of fluoride toothpaste is the primary intervention for the prevention of caries. A Cochrane systematic review (Walsh et al., 2010) confirmed the benefits of using fluoride toothpaste in preventing caries in children and adolescents when compared to placebo, but was significant only for fluoride concentrations of 1000 ppm and above. The relative caries preventive effects of fluoride toothpastes of different concentrations increase with higher fluoride concentration. The decision of what fluoride levels to use for children under 6 years should be balanced with the risk of fluorosis (Walsh et al., 2010). There is no evidence to support the use of low fluoride toothpastes by preschoolers regarding caries and fluorosis prevention. A more recent systematic review (Santos et al., 2013) showed that low fluoride toothpastes significantly increased the risk of caries in primary teeth \( RR = 1.13 \) (1.07 - 1.20); 4,634 participants in three studies and did not significantly decrease the risk of aesthetically objectionable fluorosis in the upper anterior permanent teeth \( RR = 0.32 \) (0.03 - 2.97); 1,968 participants in two studies.

The intra-oral retention or substantivity of active ingredients in toothpastes is important for their effectiveness, and this is influenced by user-related factors, among others. User-related factors include biological aspects such as salivary flow and salivary clearance, and behavioral aspects, such as frequency and duration of brushing, amount of toothpaste used and post-brushing rinsing behavior (Parnell and Mullane, 2013). An earlier study by Sjögren and Birkhed (1994) also showed that eating or drinking immediately after brushing reduced the salivary fluoride level by 12 to 15 times.

There is a lack of high-quality evidence to support definitive guidance in this area. However, the currently available international guidelines provide consistent recommendations despite the limited evidence (Pitts et al., 2012). A modified toothpaste technique has been suggested as a way to increase intra-oral fluoride and to prolong fluoride retention in order to maximize the anti-caries effect of toothpaste (Sjögren et al., 1995). The technique involves four steps as follows: 1) apply 1 g (1 cm) of toothpaste to a wet toothbrush, spread evenly on the teeth and brush for approximately 2 minutes using the Bass technique, 2) spit out no more than necessary during brushing, 3) take a sip of water (approximately 10 ml) and with the remaining toothpaste foam in the mouth, use the toothpaste slurry as a mouthrinse and filter it between the teeth by active cheek movements for 1 minute before carefully spitting out, and 4) no further rinsing afterwards, and no eating or drinking for 2 hours after brushing.

**Miswak**

Methods for oral hygiene vary from country to country and from culture to culture (Khan et al., 2009). Today, chewing sticks are being widely used in Asia, Africa, South America, and throughout the Islamic countries. They are known by different names in different cultures, such as miswak, siwak or arak. They were initially used by Babylonians around 7000 years ago, followed by the Greek and Roman empires. There are several shrubs and local trees being used as chewing sticks in different parts of the world, which are selected due to good taste and a texture like long bristles. The stick is chewed or tapered at one end until it becomes frayed into a brush. When the brushy edge is shredded after being frequently used, the stick becomes ineffective and it is then cut and further chewed to form a fresh edge. In this way, it can be used for a few more weeks (Sukkarwalla et al., 2013). Miswak has been documented as a potent antibacterial aid and its use is encouraged in different countries because of its good taste, texture, availability, cost and beneficial effect on teeth and supporting tissues.

No systematic review could be retrieved with respect to miswak but a single, blind, randomized crossover study compared it against regular toothbrushing. Image analysis of the plaque distribution showed a significant difference in reduction of plaque between the miswak and toothbrush periods \( p < 0.05 \) and it was concluded that the miswak is more effective than toothbrushing for reducing plaque and gingivitis. Miswak also appeared to be more effective than toothbrushing for removing plaque from the embrasures, thus enhancing interproximal health (Al Otaibi et al., 2003). The World Health Organization has, based on consensus, also recommended and encouraged the use of these chewing sticks as an affordable and effective alternative tool for oral hygiene (Sukkarwalla et al., 2013).

**Interdental cleaning**

Alternatives for commercially available products are scarce. During the International Symposium on Dental Hygiene in 2013, a presentation was given regarding the evaluation of substitutes for dental floss for lower socioeconomic groups. The fibers of fruit or vegetable bags were considered as a potential alternative to dental floss. Based on the results of a randomized controlled clinical trial there appears to be no difference on the plaque index scores when the teeth are cleaned with conventional floss or with the fibers of fruit or vegetable bags (Swart, International Journal of Dental Hygiene abstracts, p 167).
Behavior

Good oral health is dependent on the establishment of the key behaviors of toothbrushing with fluoride toothpaste. Primary schools provide a potential setting in which these behavioral interventions can support children to develop independent and habitual healthy behaviors. Currently, there is insufficient evidence for the efficacy of primary school-based behavioral interventions for reducing caries (Cooper et al., 2013). For example, 8- to 11-year-old school children who participated in a school-based toothbrushing program over 2 years did not reveal a statistically significant effect of this with respect to gingivitis and plaque scores (Rosema et al., 2012). There is a need for further high quality research to utilize theory in the design and evaluation of interventions for changing oral health-related behaviors in children and their parents (Cooper et al., 2013). Van der Weijden and Hioe (2005) systematically evaluated the quality of self-performed mechanical plaque removal in adults with gingivitis. Based on studies ≥ 6 months of duration, it appears that a single oral hygiene instruction, describing the use of a mechanical toothbrush, in addition to a single professional oral prophylaxis had a significant, albeit small, positive effect on the reduction of gingivitis.

In developing countries most patients receive in their lifetime only a single scaling, or if repeated scaling occurs they have large time intervals, at best accompanied with a single oral hygiene instruction. Because of a lack of dental manpower and resources, Lembariti et al. (1998) questioned whether an occasional scaling practice accompanied with limited professional attention for plaque control is effective in improving the periodontal condition. Scaling resulted in an approximately 20% reduction of the gingival bleeding score that remained during the 22-month follow-up period. Oral hygiene instruction had no significant effect on the calculus and bleeding scores. Formation of calculus still continued. The authors concluded that the effect of scaling alone on the gingival condition was small and the effect of a single oral hygiene instruction was negligible. Therefore, the practice of occasional scaling without repeated oral hygiene instruction, which is commonly employed in developing countries, should be considered as clinically irrelevant and of little use in improving the standard of periodontal health (Lembariti et al., 1998).

Integrated approach

The high prevalence of poverty-associated diseases such as diarrhea, respiratory tract infection, parasitic infections and dental caries among children in the developing world calls for a return to primary health care principles with a focus on prevention. The ‘Fit for School’ program in the Philippines is based on international recommendations and offers a feasible, low-cost and realistic strategy using the principles of health promotion outlined in the Ottawa Charter. The cornerstone of the program is the use of school structures for the implementation of preventive health strategies. ‘Fit for School’ consists of simple, evidence-based interventions such as hand washing with soap, toothbrushing with fluoride toothpaste and other high-impact interventions such as bi-annual de-worming as a routine school activity for all children visiting public elementary schools. The program has been successfully rolled-out in the Philippines, covering 630,000 children in 22 provinces, and it is planned to reach six million children in the next three years (Monsé et al., 2010). Child health in many low- and middle-income countries lags behind international goals and affects children’s education, well-being, and general development. Large-scale school health programs can be effective in reducing preventable diseases through cost-effective interventions. The paper outlining the baseline and 1-year results of a longitudinal health study assessing the impact of the ‘Fit for School’ program found a reduction in the prevalence of moderate to heavy soil-transmitted helminth infections, a rise in mean body mass index, and a trend towards reduction in dental caries and infections. The study design proved functional in actual field conditions (Monsé et al., 2013).

Limitations of this study

The available evidence as collected in the systematic review by Hoenerdos et al. (2008) with regard to wood sticks only refers to triangular shaped wood sticks. No data were gathered with respect to round or square toothpicks. None of the included systematic reviews included original studies that were carried out in developing countries. In particular, financial limitations should be considered in the evaluation of potential oral hygiene products.

Conclusion

No systematic reviews could be retrieved regarding the efficacy of mechanical plaque control as a measure of self-care in developing countries. Based on data of mechanical plaque control established in Western societies an affordable method should be to brush twice daily by means of a manual toothbrush and to use a fluoride-containing toothpaste. For interdental cleaning, wood sticks seem the most appropriate regarding costs effectiveness.
Acknowledgements

The authors acknowledge the International Academy of Periodontology Conclave 2014 Working Group A and Dr. Thomas Van Dyke and Dr. Sebastian Ciancio for their time and effort in improving this manuscript. Lastly, we are grateful for the efforts of Dr. Ajay Kakar in organizing the IAP conclave 2014 in Bangkok.

As this is a synopsis of earlier work, parts of this paper have been published before and therefore some duplication are inevitable. This paper contains summaries of:


References


Group A
Reactor Paper
Plaque control: Home remedies practiced in developing countries

Thomas E. Van Dyke, DDS, PhD

The Forsyth Institute, Boston, MA, USA

Introduction
The scholarly review by Slot and Van der Weijden (Journal of the International Academy of Periodontology 2015; 17/1 Supplement) of mechanical oral hygiene practices is well written and well organized. This is a difficult topic to address because of the lack of systematic reviews that have been performed in developing countries. Nonetheless, there are two major areas of interest that should be addressed at the conclave:

In consideration of the fact that the goal of removal of biofilm is the prevention of disease, it is also recommended that both anti-plaque and anti-gingivitis effects be considered as endpoints in the review of the literature.

Chemical plaque control
There is a single published systematic review of anti-plaque and anti-gingivitis agents that are incorporated into dentifrices and mouthrinses (Gunsolley, 2006). As this was performed in 2006, an update of the current literature should be undertaken at the conclave. In addition, a review of the current literature for papers not included in a systematic review should be undertaken to capture data related to new chemical agents that have been marketed since 2006. The chemical agents that should be considered include, but are not limited to:

- Triclosan
- Gantrez
- Stannous fluoride
- Other fluoride preparations
- Chlorhexidine
- Cetylpyridinium chloride
- Essential oils

Medicinal or herbal anti-plaque preparations
A number of herbal or traditional medicine preparations are marketed as anti-plaque or anti-gingivitis agents throughout the world. There are no systematic reviews of studies relating to any of these compounds. Nonetheless, these products and the compounds that they contain represent an important and growing segment of the products available to patients. A literature search is currently being performed to identify clinical reports pertaining to the safety and efficacy of an herbal or traditional medicine preparation currently available to the public.

While these reports are scarce and there is no systematic review, it is recommended that the reports be reviewed by the group and recommendations for use be made based on the current state of the art.

References
Slot D and Van der Weijden FA. Plaque control. Home remedies, practiced in developing countries - a synopsis of synthesis. Journal of the International Academy of Periodontology 2015; 17/1 (Supplement): 4-15
Group A
Consensus Paper
Plaque Control - Home remedies practiced in developing countries

Moderator: Ciancio, Sebastian, University of Buffalo, USA
Initiator: Slot, Dagmar Else, Academic Centre for Dentistry Amsterdam, Netherlands
Reactor: Van Dyke, Thomas, Forsyth Institute, USA

Working Group A:
Al Bayaty, Foud, Universiti Teknologi MARA, Malaysia
Aswapati, Nawarat Wara, Khon Kaen University, Thailand
Joshi, Vinayak, MMNGH Institute of Dental Sciences, India
Kendall, Kaye, Private Practice, Australia
Leung, Keung, University of Hong Kong, China
Patel, Nisha, Rishi Raj Dental College, India (Transcriber)
Pradhan, Shaili, National Academy of Medical Science, Nepal
Senevirante, Cyanthi, Colgate, Singapore
Takashiba, Shogo, Okayama University Graduate School of Medicine, Japan
Vidhale, Priya, Private Practice, India (Transcriber)

Introduction

Maintenance of effective plaque control is the cornerstone of any attempt to prevent and control periodontal disease. Complete natural cleaning of the dentition is virtually non-existent. To be controlled, plaque must be removed frequently by active self-care methods. Hence, the dental community continues to encourage proper oral hygiene and more effective use of mechanical cleaning. This group addressed the aspect of oral hygiene practices carried out at home by patients as well as the general population and a primary objective was to find out the scientific rationale and efficacy of the vast variety of alternatives available for “home remedies” for plaque control. Even though in the past few years more and more systematic reviews on this subject have been published, there is a definite lack of such studies and subsequent publications coming from the developing countries.

There were three key questions that were ultimately addressed by the Working Group.

1. What is the current status of mechanical methods for the removal of bacterial biofilms in developing countries?
2. What is the current status of anti-plaque and antimicrobial mouthwashes and toothpastes?
3. What is the current status of mouthwashes and dentifrices containing herbal ingredients

The background for discussion was presented in the Initiators’ document prepared by Slot and Van der Weijden (Journal of the International Academy of Periodontology 2015;17/1 Supplement). The fundamental question raised in the Initiators’ document, based on the data available in the systematic reviews was “What is the effect on plaque scores and oral health of self-care manual plaque control measures appropriate for developing countries?” As no systematic reviews for the same could be retrieved, a conclusion was drawn based on data on mechanical plaque control established in Western societies. The conclusion of the Initiators’ document, keeping in mind the lower economic status of the population, was that teeth should be brushed twice daily by means of a manual toothbrush in conjunction with a fluoride toothpaste. For interdental cleaning wood sticks seem the most appropriate regarding cost and effectiveness in this population.
Methods used during the deliberation

- Objective 1: “The current status of mechanical methods for the removal of bacterial biofilms in developing countries.” A synopsis of synthesis approach was used to quantify and assess all possible available published articles from the developing countries.
- Objective 3: “The current status of mouthwashes and toothpastes containing herbal ingredients.” The “Studies” approach was the only possible approach and hence a narrative review of available literature was carried out.

**Objective 1. What is the current status of mechanical methods for the removal of bacterial biofilms in developing countries?**

The objective was to carry out a “synopsis of synthesis” for arriving at the findings for this question. This synopsis was to be done from the literature available from the developing countries. However, a thorough search of the literature carried out by the Working Group could not find a single systematic review on mechanical plaque control from developing countries.

After extensive deliberation the group decided to use publications from Western countries and to extrapolate these findings to the developing nations. A total of four systematic reviews were identified as being eligible for this synopsis of synthesis. Of the four, one was on manual toothbrushes, one was on the usage of wood sticks and two were on dental floss.

These systematic reviews were evaluated for multiple parameters for each of the three groups. The aspects examined were the estimated quality, the consistency of the articles, the directness of the articles, the precision of reporting, publication bias, if any, and the entire body of evidence provided by the articles.

A summary of the findings is presented in Table 1. The studies selected for inclusion in the review were of a substantial quality, and for the review on floss the quality of papers selected was very high (a more than average standard and the data could be completely relied upon).

The data on the toothbrush and floss groups were very consistent and comparable, but the papers included in the wood sticks review were of poorer quality. This point was taken into very strong consideration when arriving at the conclusions of the efficacy and merits/demerits of wood sticks in plaque control.

Because brushes, floss and wood sticks are all commercial products it was essential to confirm if there was any commercial bias involved in the process. It was not possible to ascertain from any of the papers if there was a bias involved or not. Hence, it was concluded that the possibility of a commercial basis was possible in all of the three groups.

After a careful scrutiny of the papers included in the systematic review the Working Group concluded that the body of evidence available for the systematic review on floss was extremely strong. On the other hand the body of evidence available for wood sticks and tooth brushes could only be considered to be moderate, with the toothbrush reviews being marginally stronger than the wood stick review.

**Objective 2. What is the current status of anti-plaque and antimicrobial mouthwashes and toothpastes in developing countries?**

This question was also approached using the synopsis of synthesis model. The objective was again to obtain all the data from publications arising out of developing countries. The task was not to limit the papers to any specific countries and the major objective was to analyze data that provided information on plaque/biofilm inhibition as well as improvement of the gingival health. All papers based on products that had herbal and/or traditional chemicals were excluded in the literature search relevant to this question.

Twelve systematic reviews were identified and found to be eligible for the synopsis of synthesis for this question. These reviews were then subjected to a detailed analysis and discussion by the Working Group. A paradigm accepted while doing the analysis was that mouthwashes and dentrifices serve as carriers for chemical agents that would be plaque-inhibiting and could potentially control gingival inflammation and thereby improve and enhance gingival health.

<table>
<thead>
<tr>
<th>Table 1. Summary of findings from systematic reviews</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Toothbrush</strong></td>
</tr>
<tr>
<td><strong>Estimated quality</strong></td>
</tr>
<tr>
<td><strong>Consistency</strong></td>
</tr>
<tr>
<td><strong>Directness</strong></td>
</tr>
<tr>
<td><strong>Precision</strong></td>
</tr>
<tr>
<td><strong>Publication bias</strong></td>
</tr>
<tr>
<td><strong>Body of evidence</strong></td>
</tr>
</tbody>
</table>
The different chemical agents that were researched and analysed as potentially effective agents were as follows:

**Mouthwash ingredients**
- Chlorhexidine digluconate (CHX)
- Cetylperidium chloride (CPC)
- Essential oils (EO)
- Stannous fluoride (SnF₂)
- Hydrogen peroxide (H₂O₂)
- Hexitidine
- Delmopinol

**Dentrifice Ingredients**
- Chlorhexidine digluconate
- Stannous fluoride
- Triclosan

There was a total of 9 systematic reviews that were available for mouthwashes and four systematic reviews available for the dentrifice group. A further four reviews were identified and retrieved that could be subjected to a head-to-head comparison on combined use of mouthwash and dentrifice or as a comparison to a vehicle.

It was concluded that there is a benefit of adding chemical agents to a mouthwash or a dentifrice for plaque/biofilm control and thereby improving the health of the gingiva. The magnitude of the benefit was dependent on the specific active chemical ingredient available.

For dentifrices, chlorhexidine and stannous fluoride as well as triclosan all have a positive effect towards improved plaque/biofilm control. Of these three the triclosan- and stannous fluoride-based toothpastes seem to have the most potential for reducing plaque scores and improving gingival health.

A summary of the findings is presented in Table 2. The studies selected for inclusion in the review were of a mixed quality. For the dentrifice and mouthwash reviews the quality of papers selected was generally very good. For mouthwashes all of the additives (CHX, CPC, EO, H₂O₂, hexetidine, SnF₂, delmopinol) demonstrated efficacy towards improved plaque control. The most effective products regarding reducing plaque scores and improving gingival health contained CHX, EO or CPC as an active ingredient.

**Objective 3. Herbals – herbal dentrifices and mouthwashes**

The literature supporting the use of herbal-based anti-plaque and anti-gingivitis preparations is generally weak. No systematic reviews on this topic were identified. Only five products were directly assessed: green tea, neem, aloe vera, miswack and Paradontax™, because of their presence in the marketplace and available literature. Numerous other products, including cranberry extract preparations, triphala, juniper, salvia, chitosan and various other herbal combinations were not considered because of the lack of sufficient studies.

From the general scientific publications in this field, most of the products studied, with the notable exception of aloe vera, have some evidence of efficacy. However, most reports suffered from poor experimental design and lack of relevant controls and comparisons. It is important to note that head-to-head comparisons with existing products with known efficacy is not an adequate experimental design in the absence of a negative control.

Most of the studies also suffered from poor statistical analyses. For example, good statistical theory dictates that trials be designed to test the null hypothesis, i.e., equivalence of the test and control. Failure to reject the null hypothesis does NOT mean that the tested products are equivalent. Studies to test equivalence requires substantially more subjects than is practical in a clinical trial.

<table>
<thead>
<tr>
<th></th>
<th>Dentrifices</th>
<th>Mouthrinses</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Estimated quality</strong></td>
<td>Substantial</td>
<td>Substantial</td>
</tr>
<tr>
<td><strong>Consistency</strong></td>
<td>Fairly consistent</td>
<td>Fairy consistent</td>
</tr>
<tr>
<td><strong>Directness</strong></td>
<td>Indirect</td>
<td>Indirect</td>
</tr>
<tr>
<td><strong>Precision</strong></td>
<td>Moderate</td>
<td>Moderate</td>
</tr>
<tr>
<td><strong>Publication Bias</strong></td>
<td>Possible</td>
<td>Possible</td>
</tr>
<tr>
<td><strong>Body of Evidence</strong></td>
<td>Moderate</td>
<td>Moderate</td>
</tr>
</tbody>
</table>
Conclusions

Overall, for all three objectives more studies are required with better study designs. Nonetheless, the final conclusions were derived as the major outcomes from the deliberations of Working Group A:

Objective 1
- Based upon the available evidence, mechanical control of plaque (biofilm) is best achieved with (twice) daily toothbrushing using a manual toothbrush with a fluoride-based dentifrice.
- The body of evidence for this advice seems moderate.
- The World Health Organization (WHO) recommendation is based on consensus that chewing sticks such as miswaks are an affordable alternative.
- For interdental cleaning the wood sticks seem the most appropriate regarding cost effectiveness.
- Dental floss is a less effective tool that requires instructed skills for the user in order to be effective. There are weak scientific data to advocate flossing. It has to be a clinician's decision based on patient needs and dexterity.
- The body of evidence is moderate to strong.

Objective 2
While mechanical plaque removal should be considered the first priority, there is moderate evidence that dentifrices and mouthwashes are efficacious for prevention/reduction of plaque-related gingivitis. In addition, chemical agents added to dentifrices (triclosan or SnF₂) and mouthwashes (CHX, EO, CPC) can be of value and are recommended. It is recommended that mouthwashes and dentifrices be used as an adjunct to mechanical plaque removal.

Objective 3
Recommendations regarding the use of herbal medications in plaque and gingivitis are currently not possible due to a lack of sufficient evidence supporting their use. Further studies are required to determine the anti-plaque and anti-gingivitis properties of herbal additives to dentifrices and mouthwashes.

Reference
Slot DE and Van der Weijden FA. Plaque control. Home remedies practiced in developing countries - a synopsis of synthesis. Journal of the International Academy of Periodontology 2015; 17/1 (Supplement): 4-15
Introduction

The main goals of periodontal therapy are to achieve reductions in probing depth (PD), bleeding on probing and suppuration, to maintain or gain clinical attachment (CA) and to prevent future attachment loss (i.e., maintenance of the long-term stability of the periodontal tissues). These clinical improvements are accompanied by an ecological shift in the subgingival microbial composition, from a microbial profile related to disease to a profile compatible with health (Socransky and Haffajee, 2002; Teles et al., 2006; Feres, 2008). To achieve this microbiological goal, anti-infective treatments should reach not only deep periodontal pockets, but also shallow sites and other oral surfaces, which may harbor periodontal pathogens (Mager et al., 2003; Faveri et al., 2006a). However, to date periodontal treatment remains largely focused on deep pockets (Heitz-Mayfield and Lang, 2013). There is overall consensus that scaling and root planing (SRP), the gold-standard periodontal therapy, should be restricted to intermediate and deep pockets, and that instrumentation of shallow sites should be avoided in order to prevent trauma to both hard and soft tissues and possible consequent attachment loss (Ramfjord et al., 1987; Heitz-Mayfield et al., 2002). This mechanical therapy targets only the tooth surfaces and does not affect other areas of the mouth, such as the tongue and oral mucosae. In addition, SRP might not reach microbial reservoirs at the base of deep pockets, tooth furcations and within epithelial cells and the connective tissue. Consequently, SRP may fall short of inducing the changes in the subgingival microbial composition necessary to achieve and maintain the desired clinical improvements in all subjects, especially in cases of advanced disease where deep periodontal pockets are present (Loesche and Grossman, 2001; Sampaio et al., 2011). Therefore, other forms of therapy, such as different scaling modalities or the adjunctive use of local and systemic antimicrobials, lasers and photodynamic therapies have been proposed in order to potentiate the effects of non-surgical mechanical therapy. In all instances, however, SRP is accepted to be the basis for all periodontal therapy and the additional therapies proposed and scrutinized in this paper are always considered adjunctive and supplemental.

Lasers and photodynamic therapies (PDT)

Laser and photodynamic therapies emerged in the 1990s as promising treatments for periodontitis. The main appeal of the laser therapy was its selective calculus ablation, bactericidal effect and its potential to control bleeding (Ando et al., 1996; Fölwaczny et al., 2002; Aoki et al., 2004). Several types of lasers have
been proposed, either alone or adjunctive to SRP in the treatment of periodontitis, such as the erbium-doped yttrium-aluminum-garnet (Er:YAG), diode laser (DL) and neodymium-doped:yttrium-aluminum-garnet (Nd:YAG). Three recent systematic reviews have evaluated the overall efficacy of laser therapy in the treatment of chronic periodontitis (Sgolastra et al., 2012c; Sgolastra et al., 2013b; Sgolastra et al., 2014). Sgolastra et al. (2012c; 2013b) concluded that there were no statistically significant beneficial effects in the use of Er:YAG-only or DL as adjuncts to SRP, compared to results obtained with SRP only. On the other hand, a subsequent review (Sgolastra et al., 2014) suggested that the adjunctive use of Nd:YAG could potentially provide additional benefits to conventional nonsurgical periodontal therapy, especially in mean PD reduction (0.55 mm, 95% CI range: 0.34 to 0.76, p < 0.00001). However, only three studies, with 6 to 20 months of follow-up, were included in this meta-analysis (Qadri et al., 2010; Eltas and Orbak, 2012a; Eltas and Orgak, 2012b).

Photodynamic therapy (PDT) has been proposed as an adjunct to SRP in the treatment of periodontitis. The antimicrobial property of PDT involves a photoactivated dye (photosensitizer) that is absorbed preferentially by bacterial cells. When the photosensitizer is exposed to the light of a low power laser in the presence of oxygen it generates singlet oxygen and free radicals, which are extremely toxic to some microorganisms (Konopka and Goslinski, 2007; Maisch, 2007). Some of the clinical studies that have investigated the effect of adjunctive PDT associated with SRP in the treatment of chronic periodontitis have shown promising results (Andersen et al., 2007; Braun et al., 2008; Lulic et al., 2009; Giannelli et al., 2012), while other authors failed to show an additional benefit (Christodoulides et al., 2008; Chondros et al., 2009; Polansky et al., 2009; Ruhling et al., 2010; Theodoro et al., 2012). A recent systematic review indicated that SRP in combination with PDT provided better PD reduction (0.19 mm, 95% CI range: 0.07 to 0.31, p = 0.002) and CAL gain (0.37 mm, 95% CI range: 0.26 to 0.47, p < 0.0001) in comparison with SRP alone after 3 months of treatment. However, this benefit was no longer observed at 6 months (Sgolastra et al., 2013a).

Applying repeated (five times in two weeks) PDT in maintenance patients with residual PD ≥ 5 mm but previously treated for periodontitis, and comparing clinical outcomes to maintenance debridement in combination with a non-activated laser control in a randomized controlled trial (RCT; Lulic et al., 2009), clearly yielded improved clinical outcomes in residual pockets, while regular maintenance debridement failed to demonstrate improvements in both PD and CAL in the residual pockets. Hence, further RCTs are indicated to elucidate positive outcomes of PDT in combination with SRP in maintenance patients.

Four studies to date have assessed the microbiological effects of PDT (Sgolastra et al., 2013a), and only a modest benefit was observed in the composition of the subgingival microbiota. Two studies showed statistically significantly greater reductions in the prevalence of Treponema denticola, Eikenella corrudens, Capnocytophaga spp. (Chondros et al., 2009) and Porphyromonas gingivalis (Polansky et al., 2009) in subjects treated with SRP plus PDT than in those treated with SRP alone. However, no studies to date have thoroughly examined the effects of the PDT in changing the subgingival microbial profile.

In summary, evidence supporting the added benefits of lasers and PDT in periodontal therapy is still scarce. The most promising results were obtained with the adjunctive use of Nd:YAG to SRP. Therefore, additional RCTs examining the long-term microbiological and clinical effects of Nd:YAG, other laser therapies and PDT are needed before these treatments are incorporated into routine clinical practice.

**Full mouth scaling and root planing (FMSRP) and full mouth disinfection (FMD)**

In 1995, researchers from the University of Leuven suggested that quadrant-SRP would allow reinfection of already treated sites by a translocation of periodontal pathogens from untreated periodontal sites or other oral niches (e.g., tongue, mucosa and saliva) to recently instrumented pockets. Based on this hypothesis, the authors advocated a treatment protocol that consisted of SRP of all pockets within 24 hours combined with various forms of applications of chlorhexidine (CHX), such as subgingival irrigation, mouthrinsing and tonsil spraying (Quirynen et al., 1995). This protocol was named “full mouth disinfection (FMD).” As a consequence of studies demonstrating that CHX did not necessarily contribute to improved clinical outcomes after FMD (Quirynen et al., 2000), clinicians proposed to treat periodontitis by means of full-mouth SRP in 24 hours, but without the adjunctive use of CHX, a protocol that became known as full-mouth scaling and root planing (FMSRP) (Apatzidou and Kinane, 2004). Three systematic reviews comparing the clinical (Eberhard et al., 2008; Lang et al., 2008; Farman and Joshi, 2008) and microbiological (Lang et al., 2008) effects of FMD and/or FMSRP and conventional quadrant SRP for the treatment of chronic periodontitis were published in 2008. The reviews by Eberhard et al. (2008) and Farman and Joshi (2008) failed to show statistically significant differences between the FMSRP and conventional SRP. A discrete benefit for the FMD protocol in reducing PD (0.53 mm, 95% CI range: 0.28 to 0.77, p = 0.0001) and gaining CAL (0.33 mm, 95% CI range: 0.04 to 0.63, p = 0.03) in sites with PD ≥ 5 mm was reported by Eberhard et al. (2008). Lang et al. (2008) showed that FMD and FMSRP led to a slightly greater PD reduction in deep sites with PD ≥ 7 mm (0.50 mm, 95% CI range: -0.81 to 0.19, p = 0.001 and 0.43 mm, 95% CI range: -0.66 to 0.19, p < 0.0001, respectively) than...
quadrant-wise SRP. No additional reduction in levels and prevalence of specific periodontal pathogens was identified for any of the three treatment modalities (Lang et al., 2008).

Taken together, these systematic reviews have suggested that FMSRP or FMD protocols do not provide clinically relevant advantages over conventional quadrant-wise scaling. Nonetheless, the notion that SRP completed in 24 hours yields clinical improvements similar to those obtained with quadrant-wise SRP is relevant information and represents an important contribution to the periodontal field. Today, it is largely recognized that the FMD and FMSRP protocols are effective alternatives to the quadrant SRP and the choice between treatment modalities is generally based on patient preferences, professional skills, logistic settings and cost-effectiveness (Eberhard et al., 2008; Lang et al., 2008; Farman and Joshi, 2008).

Antiseptics: pocket irrigation and rinsing
Antiseptics have been used as adjuncts to non-surgical periodontal treatment for pocket irrigation (Rosling et al., 1983; Rosling et al., 1986; Rams and Slots, 1996; Guarnelli et al., 2008; Feng et al., 2011), as part of the FMD protocol (Quirynen et al., 1995) or to control supragingival plaque formation during the active phase of periodontal therapy and the healing phase (Faveri et al., 2006b; Feres et al., 2009).

The agents that have been most commonly used for pocket irrigation are Povidone-iodine (PVP-I), essential oils and chlorhexidine digluconate CHX (Rams and Slots, 1996). Overall, studies evaluating the effects of these antimicrobials in periodontal treatment have shown only short-term discrete clinical and microbiological benefits (Rosling et al., 1983; Rosling et al., 1986; Guarnelli et al., 2008; Feng et al., 2011), but these benefits do not seem to be maintained up to 6 months (Leonhardt et al., 2007) or one year post-therapy (Krück et al., 2012). Nonetheless, some studies have also suggested benefits in the use of CHX rinsing as an adjunct to SRP and during the healing phase of mechanical treatment (Quirynen et al., 2006; Faveri et al., 2006b; Feres et al., 2009). Feres et al. (2009) compared the clinical and microbiological effects of SRP alone or combined with professional plaque control or CHX rinsing twice a day for two months in the treatment of patients with chronic periodontitis. The two test treatments were more effective in improving PD and CAL than SRP alone, and the group rinsing with CHX exhibited the greatest reduction in PD in initially intermediate sites 6 months post-therapy. In addition, the most beneficial microbiological changes were observed in CHX-treated subjects, who showed a significant reduction in the proportions of red (P. gingivalis, T. denticola and Tannerella forsythia) and orange (mainly Fusobacterium spp.) microbial complexes, as well as an increase in the proportions of the host-compatible bacterial species. The authors concluded that strict plaque control performed during and after SRP, particularly by means of CHX rinsing, improved periodontal treatment outcomes. Subsequently, CHX rinsing was also shown to improve the clinical (Feres et al., 2012) and microbiological benefits of systemic antibiotics, especially in initially shallow sites (Soares et al., 2014).

Local antimicrobial delivery
Local application of antiseptics and antibiotics has been advocated for the treatment of localized periodontitis lesions, either as an adjunct to SRP in the active phase of treatment or to treat re-infected periodontal lesions in patients under maintenance therapy (Bonito et al., 2005). Local release of antimicrobial agents or antibiotics is normally performed by means of fibers, gels, chips or microspheres (Rams and Slots, 1996). Some examples are doxycycline hyclate gel (ATRIDOX®), minocycline hydrochloride microspheres (ARESTIN®), tetracycline hydrochloride fibers (PERIODONTAL PLUS AB, ACTISITE®), metronidazole (MTZ) gel (ELYZOL®) and chlorhexidine gluconate chip (PERIO-CHIP®). The greatest advantage of this type of local therapy is in avoiding the side effects of drugs used systemically and reducing the chances of developing bacterial tolerance to medications (Rams and Slots, 1996).

Previous systematic reviews have demonstrated a significant beneficial effect in the adjunctive use of local antimicrobials when compared with SRP alone; however, the clinical magnitude of this effect seems to be rather limited (Hanes and Purvis, 2003; Bonito et al., 2005; Matesanz-Perez et al., 2013). A recent systematic review and meta-analysis (Matesanz-Perez et al., 2013) indicated a statistically significant beneficial effect of the subgingival application of different antimicrobials with a weighted mean difference (WMD) of 0.40 mm in PD reduction and 0.31 mm in CAL gain. The main benefits were observed with the use of tetracycline fibers, sustained released doxycycline and minocycline microspheres. The adjunctive use of tetracycline fibers demonstrated a statistically significant benefit in PD reduction, with a WMD between 0.5 mm and 0.7 mm. Conversely, the benefit in CAL gain was smaller and did not provide a significant advantage over SRP alone. The local application of CHX and MTZ showed a minimal effect when compared to a placebo (WMD between 0.1 mm and 0.4 mm). Although this systematic review described some additional beneficial effect for most of the local antimicrobials evaluated, the clinical relevance of the data reported needs to be interpreted with caution. Most of these studies reported data for deep periodontal pockets, as these are the main targets for locally delivered antiseptics and antibiotics. This may skew the overall benefits of these adjunctive treatments, because these are the sites that respond less favorably to SRP and therefore any adjunctive treatment would lead to additional clinical benefits over those obtained with scaling alone. In addition, only two studies (Eickholz et al., 2002; Sakellari et al., 2010), out of the 52 included in this review showed low risk of bias. Thus, it seems necessary to conduct further clinical studies with strict methodological criteria and longer follow-up periods in order to justify the regular use of locally delivered antimicrobials during periodontal treatment.
Systemic antibiotics

The first clinical studies on the effects of systemic antibiotics on periodontal treatment were conducted at the end of the 1970s and during the 1980s, with the use of tetracycline in the treatment of localized aggressive periodontitis (Slots et al., 1979; Lindhe, 1981; Lindhe and Liljenberg, 1984). The treatment seemed promising, and hence, during the 1980s and 1990s almost all available antibiotics were tested for use in the treatment of chronic or aggressive periodontitis. At the beginning of the 2000s, the two first systematic reviews in the treatment of chronic or aggressive periodontitis were published (Herrera et al., 2002; Haffajee et al., 2003). Over 10 different antibiotics or combination of drugs were included in these meta-analyses, and both studies suggested that the use of systemically administered adjunctive antibiotics to SRP provided some additional benefit over SRP alone in terms of CAL gain and PD reduction. Herrera et al. (2002) reported that the treatments including systemic antibiotics yielded a statistically significantly greater reduction in PD (range 0.2-0.8 mm) and gain in CAL (range 0.2-0.6 mm) in sites with PD ≥ 7 mm in comparison with SRP only. The meta-analysis reported by Haffajee et al. (2003) indicated that antibiotics provided statistically significantly better full-mouth CAL gain of 0.3-0.4 mm. Neither study could assign superiority to any antibiotic due to insufficient numbers of studies, different treatment protocols (e.g., drugs, combination of drugs, doses, duration of therapies), small sample sizes and lack of longitudinal data beyond 6 months for the majority of the studies evaluated.

Although several different antibiotics were tested for their use in periodontal treatment up to 2002, certain protocols have been favored, and between 2002 and 2013 the literature converged on the use of three particular drugs: MTZ (Sigusch et al., 2001; Rooney et al., 2002; Carvalho et al., 2004; Xajigeorgiou et al., 2006; Matarazzo et al., 2008; Silva et al., 2011; Feres et al., 2012; Preus et al., 2013), MTZ + amoxicillin (AMX) (Cionca et al., 2009; Silva et al., 2011; Feres et al., 2012; Goodson et al., 2012) and azithromycin (AZT; Smith et al., 2002; Mascarrenhas et al., 2005; Dastoor et al., 2007; Haffajee et al., 2007; Haas et al., 2008; Oteo et al., 2010; Sampaio et al., 2011; Emingil et al., 2012; Han et al., 2012).

MTZ arose in the 1980s as a particularly effective drug for the treatment of chronic periodontitis patients mainly due to its efficacy against obligate anaerobes, including some important periodontal pathogens, such as the members of the red complex, P. gingivalis, T. forsythia and T. denticola (Proctor and Baker, 1971; Loesche et al., 1982; Feres et al., 2001). At that time, important clinical benefits with the adjunctive use of MTZ in periodontal treatment were demonstrated (Loesche et al., 1987; Loesche et al., 1992). These findings were corroborated by several additional studies (Sigusch et al., 2001; Rooney et al., 2002; Loesche et al., 2002; Carvalho et al., 2004; Xajigeorgiou et al., 2006; Feres et al., 2012; Preus et al., 2013).

AZT is a relatively new macrolide that emerged in medicine in the late 1980s (Girard et al., 1987) as a promising drug due to excellent pharmacological properties, which allow its administration only once a day (500 mg) for short periods of time (from 3 to 5 days; Henry et al., 2003). This simple dosage protocol and low incidence of side-effects associated with the use of AZT facilitated patient compliance, which represented a major advantage over other commonly used antibiotics in periodontics, including MTZ and AMX. Unfortunately, the results of the clinical studies evaluating the effects of AZT in association with SRP to treat subjects with advanced periodontitis demonstrated minimal or no additional effects of this antibiotic beyond that attained with mechanical debridement alone (Sampaio et al., 2011; Emingil et al., 2012; Han et al., 2012). In addition, the only clinical trial that directly compared the effect of AZT with another systemic antibiotic, MTZ, detected a statistically significant clinical advantage for MTZ+SRP in comparison with SRP-only, but not for AZT+SRP (Haffajee et al., 2011). The association of MTZ + AMX was suggested by van Winkelhoff and co-workers (1989) to treat Aggregatibacter actinomycetemcomitans-associated periodontitis, and in 2005, the first placebo-controlled RCT demonstrating the additional benefit of this combination of antibiotics in treating subjects with aggressive periodontitis, which were maintained up to 6 months post-treatment, was published (Guerrero et al., 2005). A few years later, the same benefits were suggested in subjects with chronic periodontitis (Cionca et al., 2009; Cionca et al., 2010). Thus, although various antibiotics have been used as adjuncts to periodontal therapy from the 1970s to 1990s, current literature appears to converge on the use of the combination of MTZ+AMX. This trend may clearly be observed in the literature. From 2002 to 2013, 70% of the published RCTs on the effect of systemic antibiotics in the treatment of periodontal diseases used MTZ+AMX. Moreover, three systematic reviews examining this antibiotic regimen were published (Sgolastra et al., 2012a; Sgolastra et al., 2012b; Zandbergen et al., 2012). Sgolastra et al., (2012a, 2012b) reported a significant reduction in mean PD (0.43 mm, 95% CI range: 0.24 to 0.63, p < 0.05 and 0.58 mm, 95% CI range: 0.39 to 0.77, p < 0.05) and mean CAL gain (0.21 mm, 95% CI range: 0.02 to 0.4, p < 0.05 and 0.42 mm, 95% CI range: 0.23 to 0.61, p < 0.05) in favor of SRP in association with MTZ+AMX in subjects with chronic and aggressive periodontitis, respectively. Although the data in these systematic reviews indicated an important benefit of the use of this antibiotic protocol, long-term data beyond 6 months of follow-up were sparse (Pavicic et al., 1994).

Three recently published RCTs presented the long-term effects (1 and 2 years of follow-up) of MTZ+AMX in the treatment of patients with chronic (Feres et al., 2012; Goodson et al., 2012) and aggressive (Mestnik et al.,
periodontitis and suggested a sustained benefit of this therapy. Feres et al. (2012) evaluated the effects of the adjunctive use of MTZ or MTZ+AMX in the treatment of generalized chronic periodontitis. The mean number of deep sites with PD ≥ 5 mm did not differ among the three groups at baseline (≈38), but there were clear differences at 1 year post-treatment. Subjects receiving only SRP still had a mean of 16.1 residual pockets, compared to 6.3 and 4.7 in the MTZ and MTZ+AMX groups, respectively. SRP was able to bring only 22% of the subjects to a “low risk” profile (≤ 4 sites with PD ≥ 5 mm) for further disease progression (Lang and Tonetti, 2003; Matulienė et al., 2008; Matulienė et al., 2010) at 1 year, as opposed to 61% and 66% reached by SRP+MTZ and SRP+MTZ+AMX, respectively. These findings have clinical implications because they suggest a reduced need for periodontal surgery in subjects receiving one of these antibiotic protocols. Although no statistically significant differences were detected between the two antibiotic groups for this parameter and for the other parameters evaluated by the authors, there was a constant trend towards better clinical outcomes when MTZ and AMX were combined, in agreement with two other studies (Matarazzo et al., 2008; Silva et al., 2011). These sustained long-term clinical benefits obtained with the combination of SRP and MTZ+AMX were corroborated by two other RCTs that evaluated the treatment of chronic (Goodson et al., 2012; Socransky et al., 2013) and aggressive periodontitis (Mestnik et al., 2012).

One question that could be raised is whether the combination of antibiotics and surgeries would provide any additional benefit. An answer to this question was given by the study of Goodson et al. (2012), which assessed eight different periodontal therapies and demonstrated that SRP+MTZ+AMX was the best of all treatments in terms of improving attachment levels. When the antibiotic and surgical groups were directly compared, a statistically significant higher mean CAL gain was observed in subjects receiving SRP+MTZ+AMX (1.53 ± 0.16 mm) compared to subjects treated by means of SRP and modified Widman flap (0.96 ± 0.21 mm). Interestingly, when all the eight treatments were compared, it was revealed that the inclusion of periodontal surgery did not significantly improve the clinical response in subjects with advanced chronic periodontitis (Goodson et al., 2012).

**Economic evaluation of adjunctive antimicrobials in the treatment of periodontitis**

When comparing alternative treatments for a given clinical condition, it is not only important to evaluate their effectiveness, but also their economic costs. If an alternative treatment is more effective and less costly, or less effective and more costly compared to the standard of care, it is quite obvious which treatment may be considered superior. However, for an alternative treatment that is more effective and more costly than the standard of care, it is less clear which treatment may be preferred. What treatment is considered superior will depend on the marginal costs in relation to the additional benefits and on how much payers are willing to pay for the incremental benefits (Higgins et al., 2012).

The costs that may be considered in analysis of cost-effectiveness include out-of-pocket payments by patients, reimbursements by third-party payers, travel costs, opportunity costs, and treatment costs averted (Vernazza et al., 2012). The societal perspective, which combines all relevant costs irrespective of who pays for them, provides the most comprehensive view on costs (Russel et al., 1996). As costs for dental services may vary considerably among countries (Pennington et al., 2011), and even among providers within the same country (Flemming and Beikler, 2013), they need to be assessed for each healthcare delivery system separately and outcomes cannot be generalized.

Using the perspective of a third-party payer in the United States, average per patient costs for the treatment of moderate to severe periodontitis have been evaluated over a 12-month period. Costs for SPR plus adjunctive local delivery of CHX using a disk device were US$1,568 and for SRP alone, US$1,393. The additional costs for the application of CHX disks were partly offset by a significant reduction in the frequency of periodontal surgery (9.2%) when compared to SRP alone (15.5%; Henke et al., 2001). If a third-party payer were willing to pay the additional cost of US$175 per patient in order to reduce the frequency of periodontal surgery by almost half, adjunctive local delivery of CHX with a disk device was cost-effective.

From the perspective of a self-paying patient, local delivery of MTZ gel as an adjunct to SRP was found to be less effective in providing average attachment gain at affected sites compared to adjunctive local delivery of CHX using a disk device. Adjunctive local delivery of CHX was extensively dominated by the adjunctive local delivery of minocycline gel. Adjunctive minocycline gel was cost-effective if patients were willing to pay £1,761 (in pound sterling) for an average of 1 mm attachment gain compared to no treatment. SPR alone was cost effective if the patients were willing to pay between £1,467 and £1,761 for an average of 1 mm attachment gain (Heasman et al., 2011). Comparing the use of systemic versus local antibiotics, Heasman et al. (2011) reported that the costs for an average of 1 mm attachment gain for SRP with adjunctive systemic administration of MTZ and AMX was only £837, suggesting that adjunctive systemic administration of antibiotics was more cost-effective compared to local delivery of antibiotics. Systemic antibiotics might also offer economic benefits if one considers treatment costs averted. Recent publications have indicated that the adjunctive use of systemic MTZ and AMX results in fewer residual deep pockets and, consequently, the need for surgical procedures (Gionca et al., 2009; Mestnik et al., 2012; Feres et al., 2012).
In conclusion, as patients’ willingness to pay depends on a number of factors including perceived health state, income, gender, and insurance coverage, cost-effectiveness of alternative treatments may vary considerably among patients (Grytten, 2002; van Steenberghhe et al., 2004; Tianivivat et al., 2008; Leung et al., 2010).

**Concluding remarks**

This review aimed to provide readers with an overview of the current literature on the effectiveness of adjunctive periodontal therapies. The data suggested that the use of adjunctive treatments to SRP might lead to additional clinical benefits to patients with chronic and aggressive periodontitis. Nonetheless, the practical question to be answered is: “Which of these therapies would lead to clinically relevant and long-lasting benefits that would justify its use in the daily clinic?” Apparently, the only adjunctive therapy with compelling data supported by RCTs with long-term evaluation and systematic reviews is the use of systemic MTZ alone or in combination with AMX. There is also some evidence of a clinical benefit for up to 6 months for the use of laser Nd:YAG, and a microbiological benefit up to 1 year for the use of CHX as a mouthwash in combination with SRP+MTZ+AMX during the active phase of therapy.

The data supporting the adjunctive use of MTZ+AMX for the treatment of generalized chronic and aggressive periodontitis are based on the results of numerous RCTs, including two trials with 1 or 2 years of follow-up (Feres et al., 2012; Goodson et al., 2012) and three systematic reviews (Sgolastra et al., 2012a, Sgolastra et al., 2012b, Zandbergen et al., 2012). It is important to mention that this treatment should be considered safe, as there seem to be no major side-effects associated with the intake of MTZ+AMX (Guererro et al., 2005; Cionca et al., 2009; Mestnik et al., 2010, Silva et al., 2011; Feres et al., 2012). The reduced need for additional treatment associated with the use of adjunctive systemic MTZ+AMX seems to be one of the greatest advantages for patients.

**References**


Introduction

The Initiator Paper for this discussion group by Feres et al. (2015), is a well balanced and objective review of most of the non-surgical treatment modalities suggested in the recent decade either as adjunct or supplemental measures to mechanical debridement.

Periodontal diseases are opportunistic infections caused by a proliferation of putative periodontal pathogens in a susceptible host and in an ecologic environment conducive to the colonization of periodontal niches with strict anaerobic bacteria. Consequently, the treatment of periodontitis must be anti-infective in nature and address both the composition of the bacterial colonization as well as the environmental factors that made it possible for pathogenic microorganisms to establish and proliferate. Hence, treatment of periodontitis is not only aimed at the eradication of the pathogenic microbiota, or at least the significant reduction of it, but also at influencing the environment to the extent that a health-associated instead of a strictly anaerobic microbiota may be established in periodontally diseased sites. This, in turn, means that physico-chemical conditions with a high partial pressure of oxygen (pO₂), a high redox potential (Rh) and a neutral or low pH are promoted through the therapeutic measures.

Probably the most effective therapy to achieve these goals is the mechanical debridement of the diseased sites by scaling and root planing. While the always improved clinical outcomes are undisputed, residual pocket environments may occasionally lead to conditions for re-infection or recolonization of the sites with residual pockets. Hence, it is imperative to treat the oral cavity as one ecological system rather than addressing only single sites for therapy.

The necessity of mechanical debridement as the gold standard of care has been clearly demonstrated (Feres et al., 2012). Moreover, it becomes clear that mechanical debridement is not only a treatment modality, but an essential treatment for all periodontitis sites, and, hence, the outcomes of additional or supplemental measures will have to be compared to this gold standard. Because mechanical debridement is associated with some loss of tooth substance and repeated instrumentations may, therefore, result in considerable damage to the hard structures, additional measures of non-surgically eliminating biofilm may help to minimize such undesired side-effects of the very effective mechanical debridement, especially in patients in periodontal supportive therapy.

Photodynamic therapy (PDT) and lasers

The use of photodynamic therapy (PDT) may provide welcome supplemental measures in order to reduce the loss of tooth substance usually encountered with conventional repeated mechanical debridement. Moreover, clearly improved clinical outcomes in residual pockets were demonstrated in a study of patients in supportive periodontal therapy (SPT) and multiple applications of PDT, while the regular maintenance debridement failed to demonstrate improvements in both pocket depth (PD) and clinical attachment level (CAL) in the residual pockets (Lulic et al. 2009). Therefore, further randomized clinical trials (RCTs) ought to elucidate positive outcomes of PDT in combination with scaling and root planing (SRP) in maintenance patients.

Regarding the use of other lasers, it may be stated that the investment in expensive machines neither facilitates the debridement procedure nor improves the clinical outcomes of debridement. Many more well-controlled studies have to be performed before lasers can be recommended to the clinician for routine periodontal therapy.
**Full mouth disinfection and full mouth scaling and root planing**

Commonly, non-surgical periodontal therapy is performed in stages in weekly to biweekly intervals. In order to avoid the hypothetical spread of bacteria from not yet treated sites to the freshly treated sites, the concept of full mouth disinfection or full mouth scaling and root planing within 24 to 36 hours has been advocated and promoted as being a superior way of delivering care than by the staged approach. Numerous studies and two systematic reviews have, indeed, revealed that differences in clinical outcomes, if admittedly present in certain locations and root configurations, are minimal and clinically of limited relevance. Consequently, it may be stated that all debridement protocols may be effective irrespective of their modality of delivery, and, hence, the clinician may choose the protocol most suitable for the practice and the patients’ needs.

**Use of antiseptics adjunctive to mechanical debridement**

Ever since the introduction of antiseptics as adjuncts for the prevention of biofilm formation and the development of gingivitis ( Löe and Schiött, 1970), the use of antiseptics has been advocated as an adjunct to mechanical biofilm control in various situations and indications. Antiseptics have to be recognized according to their substantivity as first and second generation antiseptics. While first generation antiseptics yield high substantivity, and, consequently, are released from the reservoirs within the oral cavity over longer periods of time (8-24 hours), second generation antiseptics may only be active for short periods owing to limited substantivity. Only the bis-biguanides (chlorhexidine) have been recognized as first generation antiseptics and result in optimal clinical outcomes, while all other antiseptics may have limited preventive effects even if they yield antibacterial activity in vitro. The biofilm preventive effect of antiseptics is most reliably tested by applying the experimental gingivitis model, in which during a three-week period of abolished oral hygiene procedures, a placebo control would result in a generalized gingivitis owing to biofilm accumulation. Test solutions of antiseptics may prevent biofilm formation to various degrees (usually 20-30%), while chlorhexidine has proven to reduce biofilm formation by 80-100% owing to its high substantivity. Consequently, gingivitis is prevented by applying this antiseptic drug. It has to be realized that the significant preventive effect of the antiseptics is aimed at the control of the supragingival plaque reservoir, and, hence, may affect the development of gingivitis. However, in periodontitis patients, the microbiota in the deep pockets is not effectively attacked. Rinsing or irrigating pockets is, therefore, a non-substantiated regime of limited clinical value. Nevertheless, when the supragingival plaque reservoir is to be depleted, first generation antiseptics are welcome adjuncts to mechanical debridement.

Unfortunately, effective antiseptics have side effects that affect their selection for long-term routine use. These are the development of discolorations, especially on teeth and prostheses, and a short lasting taste impairment for the salty taste modality. Recently, industry has promoted chlorhexidine rinsing with the addition of an anti-discoloration system (ADS). However, in testing the microbiological effects of these products using the Zurich biofilm in vitro model (Hofer et al., 2011), the test solution was able to reduce biofilm formation by 3 log steps compared with a negative (water) control. However, this was significantly less effective than the positive control (standard chlorhexidine solutions) which reduced viable counts by 6 log steps. Both the test and control solutions exhibited staining on all surfaces. A subsequent in vivo study applying the experimental gingivitis model (Li et al., 2014) clearly demonstrated that the combination of a chlorhexidine solution with an ADS was ineffective in preventing biofilm formation and was unable to prevent gingivitis from developing over the three weeks.

**Local antimicrobial delivery**

When using local antimicrobial agents for the treatment of residual pockets, it has to be realized that the release kinetics of the carrier system of the drug are extremely important. In order to be effective in attacking the microbiota in the pocket, the antimicrobial agent must be released over a long enough time (at least 7-10 days) in a high enough concentration that corresponds to at least 100x the minimal inhibitory concentration (MIC) of in vitro activity against the biofilm bacteria. Very few release systems present with such kinetics, and, hence, very few products can be recommended for controlled release of local antibiotics. However, with appropriate kinetics the application of controlled release local antibiotics has been demonstrated to be very effective, yielding good clinical outcomes. They are best used as adjuncts to a systematic mechanical debridement at single residual pockets or for the treatment of re-infected sites during supportive periodontal therapy. Moreover, they are welcome adjuncts in the treatment of peri-implant diseases.

**Systemic antibiotics as part of periodontal therapy**

The key question to be answered regarding the adjunctive use of systemic antibiotics is, indeed, what is the role and what are the priorities of the administration of antibiotics in the treatment concepts of chronic periodontitis. While there is clear evidence to incorporate an antibiotic regime in the treatment of aggressive
periodontitis, chronic periodontitis is generally successfully treated without the use of antibiotics. For aggressive periodontitis, the eradication of pathogens such as *Aggregatibacter actinomycetemcomitans* requires the use of a combination of amoxicillin and metronidazole, owing to the fact that *A. actinomycetemcomitans* is not strictly anaerobic, but rather a facultative anaerobic bacteria. This organism seems to penetrate into the tissues and should be eradicated to avoid re-infection. Obviously, mechanical debridement does not eradicate *A. actinomycetemcomitans*, while other major presumptive pathogens are usually present below detection levels following mechanical debridement.

For chronic periodontitis, however, there is no need for the use of antibiotics owing to the effectiveness of the mechanical debridement process. However, in recent years well conducted studies demonstrated that the administration of the amoxicillin/metronidazole regime for 7 to 14 days in addition to full mouth scaling and root planing may result in fewer residual pockets needing additional therapy when compared to a placebo group (Cionca et al., 2009; Silva et al., 2011; Feres et al., 2012, Goodson et al., 2012). These studies have opened the debate concerning the priority of the use of antibiotics in the treatment of chronic periodontitis. At present, there is not enough evidence to routinely recommend antibiotics as adjunct to mechanical debridement. Similar to the application of controlled release devices, systemic antibiotics should be reserved for specific indications. Never should they be given to compensate for poor biofilm control or in place of adequate mechanical debridement.

**Concluding remarks**

Even though various treatment regimes and protocols have been suggested in recent years, the undisputed concept of mechanical debridement has priority over all other modalities in the treatment of chronic periodontitis. The cost-benefit analysis is an often times neglected issue when new approaches are evaluated. Hence, patient-centered outcomes have to be studied in relation to the clinical benefits and in the light of environmental factors.

**References**


Introduction

Periodontal diseases are complex opportunistic infections modified by the host inflammatory response. Therefore, the current recommended treatment of periodontitis is primarily anti-infective in nature. Anti-infective approaches rely on adequate patient removal of plaque through good oral hygiene practices and mechanical debridement by an oral health professional. Scaling and root planing (SRP) is accepted to be the basis for all periodontal therapy, and any additional therapies should be considered adjunctive and supplemental.

What is the current status of laser and photodynamic therapy as adjunctive measures to mechanical debridement?

The benefits of laser and photodynamic therapy (PDT) have been proposed and documented over the past two decades. While laser therapy (Nd:YAG) used in conjunction with SRP yielded beneficial short-term clinical outcomes, especially in reducing probing depths (PD), the long-term clinical benefits of such therapy are questionable. Hence, from the current available evidence, as well as the associated high cost, laser therapy cannot be recommended for the treatment of periodontal disease.

Photodynamic therapy as an adjunct to SRP in the treatment of periodontal disease provides some additional benefits in terms of PD reductions and clinical attachment level (CAL) gains compared to SRP alone at 3 months. However, these benefits have not been observed at 6 months. For patients undergoing supportive periodontal care, the repeated use of adjunctive
PDT with SRP has shown improved clinical outcomes with regards to reducing the number of residual pockets (PD ≥ 5 mm). However, the long-term benefit for applying this approach to maintenance patients needs confirmation by well-planned randomized controlled clinical trials (RCTs).

What is the effect of various protocols for the delivery of mechanical debridement?

While various protocols for the delivery of mechanical subgingival debridement have been proposed, two systematic reviews have indicated slightly greater probing depth reductions in deep sites with PD ≥ 7 mm following full mouth disinfection (FMD) or full mouth scaling and root planing (FMSRP) compared to quadrant-wise scaling and root planing. These FMD or FMSRP protocols for the delivery of mechanical subgingival debridement may be chosen depending on patient availability and preferences, logistic settings and cost effectiveness. Irrespective of what protocol is used for subgingival debridement, it is recognized that the optimal clinical results can only be obtained if the patient is able to adequately perform oral hygiene.

What is the role of adjunctive antiseptics in non-surgical periodontal therapy?

A large number of antiseptics have been proposed for chemical plaque control. However, there is limited evidence demonstrating a significant, or clinically relevant, beneficial effect of these compounds used either in active periodontal therapy or during maintenance. The use of chlorhexidine digluconate (CHX) in a concentration of 0.12% as a mouth rinse during the healing phase of periodontal interventions has shown good clinical outcomes. In two RCTs, CHX mouth rinses have been tested as an adjunct to quadrant-wise routine SRP in the management of chronic periodontitis. Improved PD reductions and CAL gains have been documented with a two-month application of CHX adjunctive to SRP compared with SRP alone. Moreover, the CHX-SRP regime yielded greater reductions in the proportions of red and orange complex pathogens. It is recognized that only CHX results in adjunctive beneficial clinical outcomes due to its high substantivity. Furthermore, the effect of CHX results from modification of the supragingival plaque ecosystems. When CHX rinses are considered, the side-effects of such therapy (e.g., tooth staining) should be taken into consideration, and the additional clinical benefits to be expected have to be weighed against such side-effects. To date, there is no evidence of clinical efficacy of non-staining antiseptics used during the healing phase of periodontal interventions. With regards to FMD, there is no RCT that has tested the presumptive additional benefits of CHX administration.

What is the current status of local and systemic antimicrobials as adjuncts in subgingival biofilm control?

Local delivery antimicrobial agents may be useful as an adjunct in the treatment of periodontal disease. The release kinetics of the devices must allow for delivery of a sustained high dose of antimicrobials capable of entering the subgingival biofilm. Generally, at least 7 days of controlled release of the drugs is necessary to provide the desired clinical effects. Unfortunately, very few controlled release devices are available in the market today. Nevertheless, the concept of controlled local antimicrobial delivery deserves attention. Multiple RCTs and systematic reviews have documented significantly greater PD reductions and CAL gains in deep pockets treated with local delivery of antibiotics and SRP both for active periodontal therapy and for maintenance care of residual pockets. In the future the use of controlled release local devices for the treatment of peri-implant infections is recommended.

The value of systemic antibiotics in the management of periodontitis has been debated for decades. In two systematic reviews covering six and 27 studies (12 in aggressive periodontitis) that have investigated the administration of adjunctive systemic antibiotics for the treatment of periodontitis, additional clinical beneficial outcomes have been documented. In patients with aggressive periodontitis, the control of Aggregatibacter actinomycetemcomitans preferably requires the use of a combination of antibiotics such as amoxicillin (AMX) and metronidazole (MTZ). The efficacy of AMX/MTZ used as an adjunct to mechanical debridement for the treatment of aggressive periodontitis has been studied in eight RCTs lasting from 2 months to 1 year. All these studies have demonstrated significant and clinically meaningful benefits when this regime was used, compared to SRP alone. Consequently, the adjunctive use of AMX/MTZ is recommended in the treatment of aggressive periodontitis.

However, in the treatment of chronic periodontitis the use of systemic antibiotics as an adjunct to mechanical debridement is still under debate. In recent years, there have been at least 10 RCTs conducted evaluating the clinical efficacy of the adjunctive use of AMX/MTZ in the treatment of advanced chronic periodontitis. All of these studies demonstrated additional reductions in PD, gains of CAL and fewer residual pockets (PD ≥ 5 mm) when AMX/MTZ was used as an adjunct to therapy compared to mechanical debridement alone. In advanced periodontitis patients, as defined by a “Level 2 periodontitis case” (proximal attachment loss of ≥ 5 mm in ≥ 30% of the teeth present; Tonetti & Claffey, 2005), a benefit from additional AMX/MTZ administration has been demonstrated to various degrees depending on their risk profile (smoking, diabetes mellitus). The effect
has predominantly been documented over 3-6 months with three studies from 1 to 2 years. In all studies, the adjunctive systemic antibiotics were administered in conjunction with the initial mechanical debridement, i.e., prior to the healing of the periodontal intervention. It is unknown whether or not the additional benefits would be observed if the antibiotic regime is postponed to the healing phase, following the initial mechanical debridement. Hence, an RCT is needed to determine the proper timing for adjunctive systemic antibiotic administration. The potential additional clinical benefits obtained through other systemic antibiotics (e.g., azithromycin) has also been studied, but the results have not been as good as for AMX/MTZ. For instance, in eight RCTs of chronic and two RCTs of aggressive periodontitis the adjunctive administration of azithromycin (AZT) to SRP did not provide similar improved clinical outcomes as noted for AMX/MTZ.

As AMX/MTZ is a combination of antibiotics with high morbidity and substantial side-effects the potential benefits of this regime in the treatment of advanced periodontitis have to be weighed against such side-effects. Furthermore, the influence of additional systemic antibiotic administration on the environment should not be overlooked.

What is the current status of the effect of nonsurgical periodontal treatment on glycemic control in people with diabetes?

When considering the influence of periodontal therapy on glycemic control in periodontitis patients with type 2 diabetes mellitus, there are contradictory outcomes. While some studies have demonstrated a positive influence following effective periodontal therapy on glycosylated hemoglobin levels, other studies have failed to demonstrate such benefits. Since the evidence available on the influence of effective periodontal therapy on glycemic control is contradictory, no specific recommendations can be made at this time. However, effective periodontal therapy is beneficial for all patients by lowering the infective burden in the tissues. It should be noted that studies testing the effect of periodontal therapy on glycemic control should be performed with a quality assurance, i.e., ensuring that the outcome of the periodontal treatment has been successful.

What are the potential benefits of immobilization of teeth with moderate to extensive periodontal damage?

Potential benefits of immobilization of periodontally involved teeth have been suggested as part of periodontal therapy for decades. However, the evidence for this approach is completely lacking. Splinting of teeth has, at best, only a limited place in periodontal therapy that is aimed at infection control. However, there is some evidence that during regenerative procedures, immobilization of very mobile teeth may slightly improve the clinical outcome. Moreover, splinting may be performed to facilitate mechanical debridement or for improving the patient comfort.

Reference

Group C
Initiator Paper
Periodontal regeneration - fact or fiction?

PM Bartold

Colgate Australian Clinical Dental Research Centre
Department of Dentistry, University of Adelaide, Australia

Introduction
Periodontal disease is an all-encompassing term relating to inflammatory disorders of the periodontium, which range from the relatively benign form known as gingivitis to the more aggressive forms of early onset periodontitis and rapidly progressive periodontitis. All forms of inflammatory periodontal diseases are associated with bacterial deposits on the root surfaces (Offenbacher et al., 1996; Page et al., 1997). One of the most significant outcomes of periodontal inflammation is connective tissue damage. Because the gingival tissues have a remarkable capacity to regenerate to their original form and function, the tissue damage caused by gingivitis is reversible, provided the causative agent(s) are removed (Melcher, 1976). However, with long-term plaque deposition the disease may become more established and destructive. Depending upon host, genetic, environmental and other factors, there may be subsequent loss of connective tissue attachment to the root surface, bone resorption, and formation of a periodontal pocket. In contrast to gingivitis, with the establishment of periodontitis, many of the architectural changes to the hard and soft connective tissues are irreversible - even if the causative inflammation is controlled.

One of the goals of periodontal therapy is to restore periodontal tissues affected by disease to their original architectural form and function. This requires regeneration of the gingival connective tissues destroyed by inflammation, formation of cementum, restoration of lost bone, and re-establishment of connective tissue fiber attachment into previously diseased root surfaces. However, predictable and complete regeneration of the diseased periodontium has been difficult to achieve. Nonetheless, since the pioneering guided tissue regeneration experiments of just over 30 years ago (Nyman et al., 1982), studies have repeatedly demonstrated that periodontal regeneration is biologically possible and clinically feasible.

What is regeneration?
To understand the outcomes of periodontal therapy precisely, the following terms have been defined (The American Academy of Periodontology, 1992): Periodontal repair is the restoration of new tissue that does not replicate the structure and function of lost tissue and is analogous to scar tissue formation. Periodontal regeneration is defined histologically as regeneration of the tooth’s supporting tissues, including alveolar bone, periodontal ligament and cementum over a diseased root surface.

It should be noted that the full extent and success of periodontal regeneration must be assessed not only using clinical parameters (periodontal probing, radiographs), but also re-entry evaluations and, ideally, histological confirmation (Bosshardt and Sculean, 2009). Clearly such assessments are not always possible, and so there has been great reliance upon animal models and some rare human histology studies.

There are at least four criteria that must be met in order for periodontal regeneration to have occurred. These include all the features of the normal dentogingival complex that would equate to restoration of these tissues to their original form, function and consistency (Bartold et al., 2000):

1. A functional epithelial seal must be re-established at the most coronal portion of the tissues and be no more than 2 mm in length.
2. New connective tissue fibers (Sharpey’s fibers) must be inserted into the previously exposed root surface to reproduce both the periodontal ligament and the dentogingival fiber complex.
3. New acellular, extrinsic fiber cementum must be reformed on the previously exposed root surface.
4. Alveolar bone height must be restored to within 2 mm of the cemento-enamel junction.

Presented at the First IAP Conclave, Bangkok, Thailand, 11-13 April, 2014
Correspondence to: PM Bartold, Colgate Australian Clinical Dental Research Centre, Department of Dentistry, University of Adelaide, Adelaide, South Australia 5005, Australia E-mail: mark.bartold@adelaide.edu.au

© International Academy of Periodontology
Processes involved in periodontal regeneration

The processes involved in periodontal healing are largely the same as those for other organs and tissues. However, there are some significant differences. Inflammation is a major requirement: the formation of a blood clot at the site to be healed is needed to provide a provisional matrix, which subsequently becomes organized into granulation tissue. Formation of granulation tissue and fibroblast proliferation are features of chronic periodontitis associated with healing and repair. The granulation tissue is subsequently remodelled into scar tissue or regenerated tissue. Periodontal regeneration is unique because it involves both soft (gingival and periodontal ligament) and mineralized (bone and cementum) connective tissues. The healing of all periodontal components needs to be coordinated and integrated in order for regeneration to occur. Many molecules and cell types presumably participate in this process. The cellular events required are migration of cells by chemotaxis, their adhesion, proliferation, differentiation and production of matrix components. One of the crucial cellular events is recruitment of cells through which the selected cell type determines whether healing occurs by repair or regeneration. The mechanisms involved in cell selection are still largely unknown, although it is likely to involve selective chemotaxis, adhesion, and specific cell-molecular interactions.

Historical perspective of regenerative procedures

Root surface conditioning

Over the years many techniques have been used in an attempt to increase the amount of connective tissue reattachment to tooth roots following periodontal treatment. Most of these have focussed on trying to improve the biological compatibility of the root surface to new connective tissue attachment. These concepts were founded in the belief that the root surface must serve as a suitable site for cell attachment and fiber development during regeneration. Furthermore, it was considered that diseased root surfaces were contaminated by bacterial products, and were characterized by loss of collagen, alterations in mineral density, and composition of the surface. Accordingly it was proposed that these surfaces did not support the attachment or growth of fibroblasts but promoted epithelial migration along the surface. For these reasons, attempts were made to modify the diseased root surfaces to make them conducive for the attachment of connective tissue cells. A list of root surface conditioning agents investigated over the years is detailed in Table 1. Despite the apparent sense in trying to improve the biological compatibility of the root surfaces using such conditioning agents, clinical results were disappointing (Fuentes et al., 1993; Mariotti, 2003; Moore et al., 1987). Irrespective of the type of demineralizing agent used, it cannot be claimed that demineralization of the root surface per se is a regenerative procedure. It may, however, have a positive effect on wound healing and be used as a component of, or a step within, various regenerative procedures.

| Acid etching                  | Citric acid          |
| Detergents                   | Cetylpyridinium chloride          |
| Chelating agents            | Ethylenediaminetetraacetic acid |
|                          | Egtazic acid          |
| Attachment proteins         | Fibronectin          |
| Growth factors              |                        |

Graft materials used for periodontal regeneration

Regeneration of bone defects associated with periodontal disease and restoration of architectural form of the alveolar arch due to tooth loss remains a significant problem in dentistry. Ingrowth of soft connective tissue into such defects often occurs and this prevents the formation of new bone tissue, causing aberrations and functional disturbances. In an effort to stimulate osteogenesis, various grafting procedures and materials have been developed. However, the search for an ideal graft material continues to be a challenge. A list of some graft materials investigated is shown in Table 2.

There have been several philosophies developed regarding the importance of repair of bony defects caused by chronic periodontal diseases. The rationale behind the use of bone grafts in angular bony defects is that the presence of bone tissue close to a scaled and root planed surface would stimulate the formation of a connective tissue attachment. However, such concepts have been disputed because, on biological grounds, the use of bone transplants for the management of periodontal defects is highly questionable (Karring et al., 1984).

| Grafts             | Autogenous bone |
|                   | Allogeneic bone |
|                   | Xenogenic bone  |
| Biomaterials       | Beta tricalcium phosphate |
|                   | Hydroxyapatitie |
|                   | Calcium sulfate |
|                   | Calcium phosphate |
|                   | Bioactive glass |
Boyne (1973) stated that an ideal graft material should: (1) exist in an unlimited supply, without the need for violation of a distant donor site; (2) provide immediate osteogenesis for rapid consolidation; (3) elicit no adverse host responses such as immune reaction; (4) facilitate re-vascularization, which assists early healing and resistance to infection; (5) stimulate osteoinduction of recipient site cells; (6) be adaptable to a variety of physical requirements; (7) cause no impediment to growth or orthodontic tooth movement; (8) provide support and stability where discontinuity or mobility exists; (9) provide a framework for osteoconduction; and (10) be completely replaced by host bone of the same or superior quality and quantity as quickly as possible. In light of our current understanding of the contribution of specific components of the periodontium, for periodontal defects, an ideal graft material should also induce or enhance cementogenesis and the formation of a new attachment apparatus (new bone, cementum, and periodontal ligament). To date there is no such material that fulfills these requirements.

Many osseous grafting materials have been used to try to promote periodontal regeneration and have included autografts, allografts, xenografts and alloplastic materials.

The use of various grafting materials may produce radiographic evidence of bone fill and clinical evidence of improvement in probing depths and clinical attachment levels. However, several studies have shown that, even though there is some bone growth around the graft particles, there is substantial fibrous encapsulation of the graft (Becker et al., 1996; Xiao et al., 1996). In addition, there is an interposed layer of epithelial cells present on the root of the tooth, and consequently, no connective tissue reattachment (Yukna, 1976; Listgarten and Rosenberg, 1979; Caton et al., 1980). Consequently, the relevance of these materials to the regeneration the periodontium can be questioned.

**Evidence to date regarding grafting materials for periodontal regeneration**

Several systematic reviews have concluded that the use of grafting materials for the management of class II furcations may result in improved probing depth reduction and gains in clinical attachment levels compared with open flap debridement (Trombelli et al., 2002; Reynolds et al., 2003). However in terms of regeneration it is clear that bone fillers generally result in bone deposition adjacent to pre-existing bone. Further away from the pre-existing bone edge, simple bone fillers without the presence of any osteoinductive agents are usually engulfed by fibrous connective tissue. Interestingly, this response does vary among various bone filling agents. For example, BioOss® (Geistlich, Wolhusen, Switzerland) tends to show less fibrous encapsulation compared to bioactive glass and biphasic calcium phosphate (Sculean et al., 2004; Windisch et al., 2008). Furthermore, it must be noted that most of the responses noted to date are limited to bone regeneration with little regard for new cementum and new periodontal ligament formation. Indeed, histological evidence for new connective tissue attachment to root surfaces following the implantation of these graft materials is very limited. Similar findings have been noted for autogenous bone grafts (Wang et al., 2005). The outcomes following the use of allogeneic bone grafts in periodontal defects have also been extensively reviewed (Wang et al., 2005). There appears to be little good evidence that the use of allogeneic materials results in any significant periodontal regeneration (Dragoo and Kaldahl, 1983; Bowers et al., 1989a, Bowers et al., 1989b; Bowers et al., 1989c).

**Guided tissue regeneration**

**Principles**

By the early 1980’s a number of important observations had been made in relation to periodontal regeneration. These have been summarized by Card et al. (1987) and are presented here in a slightly modified form:

1. Regeneration is biologically possible but can only be verified by histological analysis.
2. Epithelial migration and formation of a long junctional epithelium is a fundamental healing process occurring after either surgical or non-surgical periodontal therapy.
3. Formation of a long junctional epithelium prevents root resorption by gingival connective tissue but also impedes new connective tissue attachment onto the root surface.
4. Periodontal ligament cells colonize root surfaces quicker than bone-derived cells, thus preventing ankylosis.
5. New attachment can be obtained onto a root surface that has been exposed to the oral environment.
6. Gingival connective tissue cells and bone cells do not appear to have the ability to form new connective tissue attachment onto a root surface.
7. Cells derived from the periodontal ligament appear to have the potential to form new connective tissue attachment onto a root surface.
8. In order for regeneration to occur, selective repopulation of the wound site must occur with cells possessing the potential to form new cementum, periodontal ligament, and alveolar bone.

From the above observations, a clinical procedure based on the principles of guided tissue regeneration was developed (Nyman et al., 1982b). This method relies on draping a barrier membrane from the root surface over the periodontal defect and onto adjacent alveolar bone prior to replacement of a full thickness mucoperiosteal
flap. In doing so, a space is provided into which cells from the periodontal ligament may migrate, and an effective barrier prevents either gingival connective tissue or epithelium from occupying this space during the healing (regenerative) phase. Apart from exclusion of gingival epithelium and connective tissue from the healing site, wound stability, adhesion of the blood clot to the tooth surface, and the provision of adequate space by the barrier membrane are also considered to be contributory to the successful outcome of guided tissue regeneration therapy (Scantlebury, 1993).

### Types of membranes

A wide range of materials, including methylcellulose acetate, expanded polytetrafluoroethylene (ePTFE; GORE-TEX®, Gore, Flagstaff, AZ, USA), collagen, polyglycoside synthetic polymers, and calcium sulfate have been tested for effectiveness and used as a physical barrier in guided tissue regeneration. These membranes are derived from a variety of sources, natural and synthetic, and are either bioabsorbable or nonresorbable (Villar and Cochran, 2010; Bottino et al., 2012).

### Non-resorbable membranes

Prior to commercialization of guided tissue regeneration membranes, the original experiments in this field used Millipore filters (type GS: Millipore A, 67 Mosheim, France; pore size 0.22 µm; Nyman et al., 1982b). However, these membranes were fragile and tended to tear, which limited their clinical use. Methylcellulose acetate barriers were later replaced by non-resorbable ePTFE membranes specifically designed for periodontal regeneration. A specific design feature of the ePTFE membranes was an open microstructure collar and a cell occlusive apron. The collar was designed to impede epithelial downgrowth and the occlusive apron was designed to inhibit gingival epithelium and connective tissue gaining access to the repairing periodontal defect. This material not only possesses adequate stiffness to allow creation and maintenance of a secluded space into which the new attachment will form, but also is supple enough to allow adequate adaptation over the defect (Villar and Cochran, 2010). Non-resorbable membranes are particularly prone to exposure to the oral environment. As a consequence, bacterial contamination and infection may result in delayed wound healing and poor regenerative outcomes. These membranes need to be removed after 6 to 8 weeks in a second surgical procedure.

### Resorbable membranes

Various bioabsorbable materials, including polyglycoside synthetic polymers (i.e., polymers of polylactic acid, polyglycolic acid, polylactate/poly-galactate), collagen, and calcium sulfate have been developed as membrane barriers. The clinical efficacy of bioabsorbable membranes depends on their ability to retain their structural physical integrity during the first 6 to 8 weeks of healing and to be gradually absorbed thereafter. Based on this concept, chemicals and structural modifications (i.e., polymerization, cross-linking) were incorporated into bioabsorbable membranes to extend their absorption time and increase the clinical effectiveness of these materials.

Biodegradable collagen membranes possess a lower risk of exposure and do not need a second surgical procedure for their removal. As collagen membranes possess fewer favorable mechanical properties than non-resorbable membranes, bone filler is needed to prevent their collapse into the defect area.

Chitosan, a deacetylated derivative of chitin, is another biomaterial used for guided tissue regeneration that is biodegradable. Its property of bacteriostasis may reduce the bacterial contamination and benefit periodontal tissue regeneration (Xu et al., 2012).

In the future there will be further developments in the rational design of biodegradable products for guided tissue regeneration. It is likely these developments will include enhanced mechanical properties with controlled degradation dynamics together with delivery systems for bioactive and antibacterial agents (Bottino et al., 2012).

### Does guided tissue regeneration work?

The guided tissue regeneration technique is sensitive and technically demanding. From the studies published to date it is apparent that gains in both probing and attachment levels can be expected following guided tissue regeneration procedures, although there is significant variability depending on numerous clinical parameters that affect periodontal regeneration outcomes (Demaloni et al., 1993; Tonetti et al., 1993; Mellonig et al., 1994; Machtet et al., 1994). Some of the major limiting factors include: defect size and location, type of furcation defect, degree of membrane exposure during healing period, and degree of microbial contamination. A more recent systematic review confirmed that the clinical outcomes of guided tissue regeneration on parameters such as attachment gain, reduced pocket depth and hard tissue gain at re-entry surgery are all greater than open flap debridement (Needleman et al., 2005). However, it was noted that there was marked variability among studies and the clinical relevance of these improvements was unclear.

Long-term studies and evaluations of guided tissue regeneration have indicated that the clinical improvements obtained by this procedure are of small magnitude and exhibit large variability (Brathall et al., 1998; Pontoriero and Lindhe, 1995; Wallace et al., 1994; Machtet et al., 1996). Two meta-analyses have concluded that guided tissue regeneration yields greater clinical attachment gain than open flap debridement alone for intrabony...
and furcation defects (Jepsen et al., 2002; Murphy and Gunsolley, 2003). In addition, quantitative analyses of clinical outcomes following guided tissue regeneration treatment suggests that this therapy is only a successful and predictable alternative in well-selected cases such as narrow intrabony defects and class II mandibular furcations (Villar and Cochran, 2010). Notwithstanding the generally modest gains in clinical attachment, 10-year follow-up studies demonstrate stable gains in clinical outcomes and thus support the use of guided tissue regeneration in treatment of intrabony periodontal defects and class II furcation defects (Eikholz et al., 2006; Pretzl et al., 2009; Nickles et al., 2009; Sculean et al., 2008a). However, for more advanced defects such as class III furcations and 1-wall intrabony defects guided tissue regeneration does not result in very predictable outcomes (Gottlow et al., 1992; Becker and Becker 1993).

While the histological outcomes of new attachment, new cementum and new bone formation are well documented in animals, the outcome is less well documented for humans. At the time of membrane removal (for non-resorbable membranes), the regenerating tissues forming underneath the membrane are of a soft, gelatinous consistency (Becker et al., 1988). With time, this tissue may mature into bone - although this appears to be a rather variable response. All of the human histological studies to date have been either case reports or case series on very low numbers of subjects under non-standardized experimental conditions (Nyman et al., 1982; Gottlow et al., 1986; Stahl et al., 1990; Sculean et al., 1999; Stoller et al., 2001; Windisch et al., 2002). These studies have indicated that the predominant healing process following guided tissue regeneration procedures is via new connective tissue attachment to the root surface with minor contributions of new cementum and bone formation. Therefore, by definition, regeneration has not occurred.

**Combinations of guided tissue regeneration and bone grafts**

One challenge of regenerative therapies has been to achieve alveolar bone replacement in furcation, dehiscence, and horizontal defects coronal to the existing bony crest level. Guided tissue regenerative techniques alone have failed to achieve this. More recently, a combination of grafting treatments and barrier membranes has been attempted to augment the technique of guided tissue regeneration. Often these were combined with root demineralization techniques. The combinations include resorbable or non-resorbable barrier membranes with bone graft or synthetic grafts placed under them, and coronally positioned flaps. Several studies have reported some improvement in the healing of furcation defects when a combination of guided tissue regeneration membranes and demineralized freeze-dried bone allografts or dura mater membrane were used (Anderegg et al., 1991; Schallhorn and McCain 1988; Zaner et al., 1989). However, these assessments were based solely on clinical criteria and no histological data were available. More recently, the effects of guided tissue regeneration, with and without demineralized freeze-dried bone allografts, in the treatment of furcation defects in dogs with naturally occurring periodontal disease, has been evaluated (Caffesse et al., 1993). In this histological study, adjunctive bone grafting did not appear to enhance regeneration. In a human study, comparing demineralized freeze-dried bone allografts with and without ePTFE membranes in periodontal defects and using allografts as controls, it was concluded that utilization of ePTFE membranes, in addition to demineralized freeze-dried bone allografts, did not lead to additional radiographic gains in the defect area (Guillemin et al., 1993). However, a relatively recent systematic review came to the conclusion that most preclinical studies have histologically demonstrated periodontal regeneration when grafting materials are combined with barrier membranes (Sculean et al., 2008b). Thus, the overall conclusion of these studies is that the results for combined guided tissue regeneration and grafting materials are variable and benefits, if any, are only marginal.

**Biological agents for periodontal regeneration**

With the limitations of the above agents and procedures in mind, more recent efforts in periodontal regeneration have been focused on the use of biological agents to assist in stimulating self-repair/regeneration mechanisms within the periodontium. This approach has been referred to as “endogenous regenerative therapy” (Chen et al., 2010), and is an important and exciting emerging area in periodontal regeneration. This field focuses on the use biological agents such as growth factors, matrix extracts, plasma concentrates and biologically active peptides to stimulate the host’s inherent capacity for periodontal regeneration.

**Enamel matrix proteins**

An important advancement in periodontal regeneration was the discovery of enamel matrix proteins, produced by Hertwig’s epithelial sheath (Lindskog, 1982; Slavkin et al., 1989). These proteins were shown to play an important role in cementogenesis, as well as in the development of the periodontal attachment apparatus (Ten Cate, 1996; Hammarström, 1997). This observation led to the development and utilization of the biologically active agent “enamel matrix derivative” (EMD, Emdogain; Straumann AG, Basel, Switzerland) as a local adjunct to periodontal surgery for stimulating regeneration of periodontal tissues (Hammarström et al., 1997; Wilson, 1999; Rathe et al., 2009; Sculean et al., 2007a; Sculean et al., 2007b; Venezia et al., 2004).
Numerous clinical and histological studies have demonstrated that treatment of periodontal defects with EMD results in periodontal regeneration (Esposito et al., 2005; Venezia et al., 2004; Kalpits and Ruben, 2002; Esposito et al., 2009; Rathe et al., 2009; Sculean et al., 2007c). In addition, several systematic reviews evaluating the results of randomized clinical trials have confirmed the positive clinical outcomes of using EMD for periodontal regeneration which appear to be stable over the long term (Kalpits and Ruben 2002; Venezia et al., 2004; Esposito et al., 2005; Tu et al., 2008; Esposito et al., 2009). Most recently it has been concluded that EMD is superior to control treatments for intrabony defects and as effective as resorbable membranes but superior to non-resorbable membranes for class II furcation defects (Koop et al., 2012).

**Combination treatments of guided tissue regeneration, EMD and bone grafts**

A number of studies have investigated whether there is any additive effect for the use of EMD when combined with bone grafts and or guided tissue membranes for the treatment of infrabony lesions (Zucchelli et al., 2003; Gurinsky et al., 2004; Sculean et al., 2005; Bokan et al., 2006; Kuru et al., 2006; Hoidal et al., 2008). Systematic reviews of the results of such studies have indicated that there is little evidence to support any significant additive effect of EMD in combination with other regenerative materials (Trombelli and Farina, 2008; Tu et al., 2010).

**Growth factors in periodontal regeneration**

Nearly all of the events associated with tissue repair and regeneration are regulated by polypeptide growth factors. Therefore it is logical to consider that these factors may be able to promote regeneration (Caffesse and Quinones, 2000; Giannobile et al., 2010; Murakami, 2011; Stavropoulos and Wikesjo, 2012). A number of growth factors, both alone and in combination, have been studied for treatment of natural and experimentally induced periodontal defects in animal models (Table 3). Although there has been little uniformity among these studies in terms of study design, animal and periodontal defect model, types of growth factors and carrier vehicles, the results in general indicate that the application of various growth factors for periodontal regeneration produces favorable results (Reynolds and Aichelmann-Reddy, 2012; Darby and Morris, 2013). Despite a large body of evidence arising from both pre-clinical trials and randomized clinical trials, with the exception of Gem-21S®, a β-TCP/rhPDGF-BB combination (Osteohealth-Luitpold Pharmaceuticals, Shirley, NY), few of these growth factors have been developed into an everyday clinical practice product. This is largely due to a number of critical issues that still impede progress and need to be resolved. These include: (1) the complexity of the periodontium, which consists of four different tissues; (2) restricted understanding of the differentiation repertoire of the periodontal cells; (3) the exact target cells that are to be modulated by these factors; (4) the stability of the tissues that are to be formed under the influence of these factors; (5) the use of very high doses of bone morphogenetic proteins; (6) the ideal carrier has still not been found; and (7) the high costs that are associated with production of recombinant growth factors (Ripamonti and Petit, 2009; Bartold et al., 2000). Thus, further investigation is needed to facilitate the clinical translation of the polypeptide growth factors and their delivery systems.

| Table 3. Growth factors used for periodontal regeneration |
|-----------------------------|---------------------|
| Platelet-derived growth factor |
| Bone morphogenetic proteins |
| Transforming growth factor beta |
| Insulin-like growth factor |
| Fibroblast growth factor |

**PepGen-15**

The cell binding peptide P-15® (Dentsply Friadent, Mannheim, Germany) is a short polypeptide of 15 amino acids which mimics the cell binding domain of type I collagen combined with anorganic bovine bone-derived hydroxyapatite matrix. Its principal biological action is to enhance cell attachment of fibroblasts and osteoblasts, which may promote osteogenesis (Bhatnagar et al., 1999). Several clinical studies (case series and a controlled monitored multicenter trial) investigating the efficacy of P-15® for periodontal regeneration have shown it to yield better clinical outcomes compared to the carrier alone (Yukna et al., 2000; Yukna et al., 2002). These clinical outcomes were found to be stable up to 3 years. However, no studies have made comparisons between P-15® and the gold standard of guided tissue regeneration or other regenerative procedures.

**Platelet-rich plasma**

Platelet-rich plasma (PRP) is an autologous blood preparation enriched in growth factors such as transforming growth factor beta (TGF-β), vascular endothelial growth factor (VEGF), and platelet-derived growth factor (PDGF). Platelet-rich plasma has been used in various surgical fields, including maxillofacial and periodontal surgery with the expectation of enhancing bone and soft-tissue healing (Mehta and Watson, 2008; Foster et al., 2009). To date the evidence for enhanced periodontal regenerative outcomes has been poor (Dori et al., 2008; Kotsovilis et al., 2010; Del Fabro et al., 2011).
Future technologies for periodontal regeneration

The emerging fields of personalized medicine and regenerative medicine are evolving quickly. Both are largely based on the concepts of tissue engineering, which is the science of reconstructing or mimicking natural processes through the use of synthetic polymer scaffolds with the expectation of tissue regeneration (Bartold et al., 2000). The vision is that suitable cells, produced in large enough quantities through cell culture methods, together with appropriate bioscaffolds will be implanted into tissues and organs to produce fresh replacement cells to take over from lost or damaged cells and result in tissue regeneration.

Stem cells and tissue engineering

An appealing approach to periodontal regeneration involves the use of cells, bioactive agents and biomaterials for therapeutics using tissue engineering principles (Bartold et al., 2000). The concept of tissue engineering, taking into account the need for regenerative treatment of periodontal defects with an agent or procedure, requires that each functional stage of reconstruction be grounded in a biologically directed process. This biological technology, together with the emerging field of nanotechnology (the science of bioengineering at the molecular level to produce materials with hitherto unknown and unthought-of properties) will pave the future of periodontal regeneration. To this end there is considerable work being carried out with regards to the rational use of biodegradable scaffolds, informed use of instructive molecular messengers and the selection of specific cell phenotypes or even stem cells for periodontal regeneration.

Key factors in attaining successful periodontal regeneration are the correct recruitment of cells to the site and the production of a suitable extracellular matrix consistent with the periodontal tissues. As cell seeding to enhance regeneration of other tissues (skin, cartilage, bone, cardiovascular components, pancreas, etc.) has been used successfully (Persidis, 1999), it is seems logical that autologous periodontal ligament stem cells cultured within a suitable delivery scaffold, in conjunction with the growth and differentiation factors present in an autologous blood clot, will lead to new periodontal tissue attachment via a tissue engineering approach (Bartold et al., 2006).

The discovery of periodontal ligament stem cells has opened a new vista for periodontal regeneration (Seo et al., 2004). Many studies have now confirmed the presence of mesenchymal stem cell (MSC)-like cells in the periodontal ligament (Trubiani et al., 2005; Nagatomo et al., 2006; Gronthos et al., 2006; Jo et al., 2007; Techawattanawisal et al., 2007). These cells have the characteristics of multipotency with an ability to differentiate into osteoblast, cementoblast or lipidogenic phenotypes. These cells are also able to survive cryo-freezing, which is of particular significance if these cells are to be “banked” for future use (Seo et al., 2005).

Successful cell transplantation into periodontal defects and subsequent regeneration was first described over 20 years ago (van Dijk, 1991). Since then, a new field of periodontal cell transplantation opened up with encouraging results being reported. While the early investigations met with some success, overall the treatment outcomes were limited because of the heterogeneous nature of the cells used for such studies. More recently, the use of periodontal ligament stem cells for tissue engineering approaches to facilitate periodontal regeneration has emerged. To date most of the studies have been restricted to experimental animals, with only one report involving transplantation of periodontal ligament stem cells into human periodontal defects being published (Feng et al., 2010; Hynes et al., 2012).

Thus periodontal ligament stem cells can be used for regeneration of the periodontium in surgically created defects in both small and large animal models, albeit with limited success and in only a narrow field of application. A significant issue with these studies is that surgically created periodontal defects are very different from defects arising from periodontitis and thus any extrapolation of findings for stem cell regeneration in surgically created defects and what may happen in periodontitis needs to be made with caution. Another problem encountered with this approach is that very few of these stem cells attach to the surface of the alveolar bone and teeth. This led to the application of using cell sheet technology in conjunction with regenerative principles to deliver the regenerative potential of the periodontal ligament stem cells to the appropriate location (Iwata et al., 2009; Washio et al., 2010). This requires the identification and isolation of the cells required for periodontal regeneration and then growing these cells on a temperature-sensitive sheet in culture. Cell sheet construction involves the use of a temperature-sensitive polymer biomaterial, poly N-isopropylacrylamide (PIMA Am), in the cell culturing process. Once a mature cell sheet is formed, it is harvested by decreasing the temperature, which leads to detachment from the temperature-sensitive substrate. This allows harvesting of a complete sheet of cellular material with an intact extracellular matrix and cell-cell junctions, in an attempt to optimize any regenerative attempts. Recently a clinical study of periodontal regeneration using cell sheet technology in humans has commenced in Japan (Yoshida et al., 2012). Following approval by the appropriate government regulatory bodies, autologous cell sheet transfers with autologous serum have been prepared using a standard operating procedure to ensure the quality of the transplant material. Following in vitro and in vivo testing, the cell sheets were prepared and approved for human clinical trials in January 2011. To date we still await the results of these trials, but on the basis of the preclinical trials the potential for this technology for periodontal regeneration is promising.
Gene and cell-based therapy

Despite the emerging evidence that local application of growth factors may encourage periodontal regeneration, a number of issues remain which limit their efficacy. These include containment of the factor at the local site, limited controlled release of the bioactive peptides, and inactivation of the growth factor via locally produced proteinases. As a result, more refined techniques have been employed to improve growth factor delivery and release for periodontal regeneration. One such method is gene transfer, whereby genes for regeneration-promoting growth factors using plasmid and adenovirus gene delivery methods are used (Giannobile et al., 1998; Zhu et al., 2003). Specifically, the use of adenoviral vectors encoding for growth factors such as platelet-derived growth factor and bone morphogenetic protein-7 has been investigated for use in periodontal regeneration (Anusaksathien et al., 2003; Jin et al., 2003; Jin et al., 2004). These studies have shown that using such an approach there is sustained transgene expression for up to 10 days and enhanced bone and cementum regeneration at treated sites beyond this time period compared to the sites treated with control vectors (Jin et al., 2003; Jin et al., 2004). However, there is still a considerable amount of further work required before such an approach becomes a clinical reality. In particular, in order to maximize the duration and extent of gene expression, and ultimately to determine the success of gene transfer techniques in periodontal regeneration, the number of cells that are virally transduced to express specific genes needs to be optimized. Issues remain regarding the overall control of the process and how to both “turn on” and “turn off” the genes. In addition, research is required to assess the potential risks of the immunogenicity of viral recombination, which could significantly alter the success of gene transfer therapies for periodontal regeneration (Imperiale and Kochanek, 2004; Rios et al., 2011).

Summary and conclusions

Numerous techniques have been tried and tested to regenerate tissues lost to periodontal disease. While there has been some success to date, more work is required to move this to a reliable and clinically predictable procedure. Much of the future success for such treatments will rely largely on our understanding of the biology of both developmental and regenerative processes. Nonetheless, despite the noble goal of periodontal regeneration, the relevance of re-creation of a connective tissue attachment has been questioned. Since formation of a long junctional epithelial attachment to the tooth following a variety of periodontal treatment procedures has been shown to be no more susceptible to further breakdown than a non-diseased site, the question arises as to what purpose do we seek the ultimate outcome of periodontal regeneration? The answer lies in the “fact and fiction” of periodontal regeneration. There is no doubt that the regenerative procedures that have been developed can be shown to be biologically successful at the histological level. Furthermore, the results of periodontal regeneration (particularly guided tissue regeneration) have been stable over the long term (at least up to 10 years). However, the techniques currently under use which show the greatest promise (guided tissue regeneration and growth factors) are still clinically unpredictable because of their highly technique-sensitive nature. In addition, whether the slight clinical improvements offered by these procedures over routine open flap debridement procedures are of cost or patient benefit with regards to improved periodontal health and retention of teeth remains to be established.

The next phase in regenerative technologies will undoubtedly involve a deeper understanding of the molecular signaling (both intra- and extra-cellular) and cellular differentiation processes involved in the regenerative processes. So in answer to the question of whether periodontal regeneration is fact or fiction, the answer clearly is that it is both. However, with more work it will become established fact with little fiction and the desired clinical endpoint of predictable regeneration of the periodontal tissues damaged by inflammation to their original form and function will be achieved.

References


Esposito M, Grusovin MG, Coulthard P and Worthington HV. Enamel matrix derivative (Emdogain) for periodontal tissue regeneration in intrabony defects. *Cochrane Database of Systematic Reviews* 2005; CD003875.

Esposito M, Grusovin MG, Papanikolaou N, Coulthard P and Worthington HV. Enamel matrix derivative (Emdogain®) for periodontal tissue regeneration in intrabony defects. *Cochrane Database of Systematic Reviews* 2009; CD003875.


Impertiale MJ and Kocahanek S. Adenovirus vectors: biology, design, and production. *Current Topics in Microbiology and Immunology* 2004; 273:335-357.


Murakami S. Periodontal tissue regeneration by signaling molecule(s): What role does basic fibroblast growth factor (FGF-2) have in periodontal therapy? *Periodontology 2000* 2011; 56:188-208.


Needleman IG, Worthington HV, Giedrys-Leeper E and Tucker RJ. Guided tissue regeneration for periodontal infra-bony defects. *Cochrane Database of Systematic Reviews* 2006; CD001724.


Reynolds MA and Aichelmann-Reidy ME. Protein and peptide-based therapeutics in periodontal regeneration. *Journal of Evidence Based Dental Practice* 2012; 12(3 Suppl):118-126.


Group C
Reactor Paper
Periodontal regeneration - fact or fiction?

Joerg Meyle

University of Giessen, Germany

Introduction
In the comprehensive and elegantly written review by Bartold et al. in Periodontology 2000, the authors have reviewed all different aspects of periodontal regeneration. At first, the principles of periodontal regeneration are defined as:

1. A functional epithelial seal that should be no more than 2 mm in length.
2. Connective tissue fibers that are inserted into the previously exposed root surface to reproduce both periodontal ligament and the dentogingival fiber complex.
3. New acellular, extrinsic fiber cementum must be reformed on the previously exposed root surface.
4. Alveolar bone height must be restored to within 2 mm of the cemento-enamel junction.

In general, periodontal regeneration is part of the healing process of the periodontal tissues after surgical intervention. Thus, the events and interactions that occur during healing have a substantial impact on the healing result, which normally is characterized by a long junctional epithelial attachment (Caffesse et al., 1995; Beaumont et al., 1984). In order to change the results of healing, which is one of the major goals of regenerative therapy, our understanding of the basic events has to be substantially improved. In several reviews the involvement of growth factors, their interactions and the different cell types have driven knowledge about healing events and the organization of the blood clot, but still the precise mechanisms in periodontal healing and regeneration have not been elucidated (Aukhil, 2000; Caffesse and Quinones, 1993). During the initial phase a fibrin meshwork is established and later organized. Even during these steps variations may occur: recently it has been detected that the properties of the fibrin meshwork change considerably as a reaction to mechanical stress (Weisel, 2008; Weisel, 2007; Weisel, 2011; Varju et al., 2011).

Early periodontal regeneration studies investigated the importance of different components of the periodontal tissues in a series of animal experiments. Based on the results of these studies the concept of guided tissue regeneration (GTR) was established (Nyman et al., 1982a; Nyman et al., 1982b; Nyman et al., 1981; Nyman et al., 1980; Karring et al., 1980; Ellegaard et al., 1974b; Ellegaard et al., 1974a; Ellegaard et al., 1973). This concept introduced the use of a physical barrier in order to guide and change events after periodontal surgery. Even though this clinical concept was established, the basic biological events associated with the noted periodontal regeneration were unknown and not further investigated for many years.

When the GTR concept was introduced into clinical practice failures were experienced and, as a result, some people concluded that the basic biological concept did not work. This was mostly due to the fact that in many cases the original concept and protocols were not meticulously followed and the properties of the materials which were introduced into the periodontal wound were not known. The first human experimental study for periodontal regeneration used a filter paper made of cellulose, which was fixed around the diseased root surface and then the tissues were closed (Nyman, et al., 1982). Afterwards a block biopsy sample was taken and the tooth together with the surrounding tissues was removed. Later on a different barrier was manufactured and was introduced in general practice, which was not made of cellulose but of expanded tetrafluorethylene, which has completely different properties with regard to diffusion, adhesion and wettability. From then on the concept of tissue regeneration was largely based on mechanical interventions.

The first approach to introduce biological factors was based on systematic investigations and observations of the early events of root and ligament formation (Slavkin et al., 1989; Gestrelius et al., 1997; Gestrelius et al., 2000).
From these studies it was noted that secretion and deposition of enamel matrix proteins on the dentin surface was based on the activity of cells arising from the Hertwig’s epithelial root sheath. Hammarstrom (1997) was able to demonstrate a layer of enamel matrix proteins in histological sections in different animals and experimental studies. Enamel matrix proteins would then initiate the differentiation of cells from the dental follicle into cementoblasts (Hammarstrom, 1997; Hammarstrom et al., 1997).

In contrast to these results, others were not able to demonstrate any secretion of enamel matrix proteins by epithelial root sheath cells and questioned this early concept of enamel matrix proteins (Bosshardt, 2008; Nanci and Bosshardt, 2006).

To date, the precise steps of cementoblast differentiation and the importance of enamel matrix proteins in this process are still not known; however, there is an ongoing discussion based on the basic cellular and molecular biological effects leading to the deposition of enamel matrix proteins on the root surface (Nanci and Bosshardt, 2006; Bosshardt and Sculean, 2009).

Despite this fact, there is a very large number of growth factors that have been identified as being important in wound healing and tissue regeneration. Further research so far has not resulted in any major breakthrough with regard to using these biological agents for periodontal tissue regeneration, and the influence of the orchestration of the different cell types that are involved in these complex healing events.

The introduction of the enamel matrix proteins into clinical practice resulted in a large number of clinical studies where it was demonstrated that indeed regenerative therapy using these proteins resulted in clinical gain of attachment and bone healing (Sculean et al., 1999a; Sculean et al., 1999b; Sculean et al., 1999c; Sculean et al., 2000; Sculean et al., 2001; Sculean et al., 2002; Ebersole et al., 1982; Jepsen et al., 2004; Meyle et al., 2004; Jepsen et al., 2008; Meyle et al., 2011; Needleman et al., 2001; Needleman et al., 2005; Needleman et al., 2006). But still the postulates that were formulated as the basis of periodontal regeneration could not be fulfilled, as already stated in the initiator’s review (Bartold).

In addition, it is known that during the development of periodontal ligament and root formation, the first events are the interactions of the fiber systems between the periodontal ligament and the dentin (Bosshardt and Schroeder, 1992). These interactions are the result of very complex cellular activity originating from cementoblasts sitting on the fiber system of dentin that is not yet mineralized and connecting the fiber systems in order to achieve a mechanically resistant connection. After the fiber systems have been connected with each other, the whole system mineralizes during the following years, thus leading to the well known periodontal ligament and anchorage of the root in acellular extrinsic fiber cementum (Bosshardt and Selvig, 1997).

Despite the demineralization of the root surface by acids or chelating agents during regenerative therapy, the dentin itself is still mineralized and thus a real interconnection of the different fiber systems does not take place even though a new cementum layer is deposited on top of the cleaned, previously diseased root surface. According to some investigators, regenerative cementogenesis along established but formerly diseased and denatured root surfaces is not achieved in the true sense of the term (Schroeder, 1992).

In many histological samples it is obvious that during sample preparation the covering layer of newly formed cementum is (artificially) separated from the root surface. This does not occur when a natural periodontal ligament is handled in the same way and prepared for histological analysis (Bosshardt and Sculean, 2009). In some specimens, bacteria have been detected on the dentin surface, indicating that this contamination could also be responsible for the gap formation (Bosshardt et al., 2005).

Thus the question arises of how strong the interconnection is between the newly formed cementum layer and the root surface. In addition, the type of mineralized tissue formed is another point of discussion: according to Bosshardt this resembles newly formed bone and not acellular extrinsic fiber cementum (Bosshardt et al., 2006).

Assessment of human histological samples from regenerative procedures have demonstrated periodontal regeneration in terms of new cementum, bone and periodontal ligament. Furthermore, clinical measurements and radiographs have also demonstrated the clinical success of this type of therapy by a combination of reduced probing depths together with gain of clinical attachment. However, to date, it has not been proven that regenerative treatment is really improving the anchorage of the tooth in the surrounding tissues.

As another conceptual problem for this treatment approach, data are missing that demonstrate that through regenerative therapy, either using mechanical barriers or biologically active proteins, the longevity of the tooth is improved, i.e., that this type of treatment avoids tooth loss.

References


Needleman IG, Giedrys-Leeper E, Tucker RJ and Worthington HV. Guided tissue regeneration for periodontal infra-bony defects. *Cochrane Database of Systematic Reviews* 2001; CD001724.

Needleman IG, Worthington HV, Giedrys-Leeper E and Tucker RJ. Guided tissue regeneration for periodontal infra-bony defects. *Cochrane Database of Systematic Reviews* 2006; CD001724.


Group C

Consensus Paper

Periodontal regeneration - fact or fiction?

Moderator: Murakami, Shinya, Osaka University, Japan
Initiator: Bartold, Mark, University of Adelaide, Australia
Reactor: Meyle, Joerg, University of Giessen, Germany

Working Group C:
Agarwal, Ruchi, Private Practice, Melbourne, Australia
Anagnostou, Fani, Paris Diderot University, France
Bakalyan, Vardan, Yerevan State Medical University, Armenia
Bunyaratavej, Pintippa, Mahidol University, Thailand
Chitguppi, Rajeev, Terna Dental College-Navi Mumbai, India
Darby, Ivan, University of Melbourne, Australia
Gamal, Ahmed, Ain Shams University, Egypt
Jacob, Shaiju, International Medical University, Malaysia
Jin, Yan, Fourth Military Medical University, China
John, Janice, Private Practice, India (Transcriber)
Kale, Rahul, M.A.Rangoonwaala College of Dental Sciences, India
(Librarian)
Liechter, Jonathan, University of Otago, New Zealand
Minh, Nguyen Thi Hong, National Hospital of Odonto-Stomatology, Vietnam
Nagata, Toshihiko, University of Tokushima Graduate School, Japan
Nazreth, Bianca, India
Nishida, Mieko, Sunstar Inc, Japan
Pack, Angela, University of Otago (Retired), New Zealand
Patnaik, Samarjeet, India
Shibutani, Toshiaki, Asahi University, Japan
Singh, Preetinder, SDD Hospital & Dental College, India
Soeroso, Yuniarti, Universitas Indonesia, Indonesia
Spahr, Axel, University of Sydney, Australia
Yang, Yueh Chao, Taiwan
Yeung, Stephen, University of Sydney, Australia

Introduction

To discuss the topic of periodontal regeneration this working group determined the need to clarify some definitions relating to the biological and clinical outcomes of periodontal regeneration. Subsequently the group considered two key issues:

1. What are the benefits of periodontal regeneration?
2. What are additional considerations that should be taken into account when using regenerative agents?

A number of recommendations were thus developed. The background for the discussion was presented in the Initiator Paper. The fundamental question raised for discussion was whether periodontal regeneration is “fact or fiction.” To answer this question, a comprehensive narrative review of the literature was presented. It was noted that many regenerative techniques have been developed with the aim of obtaining reliable and clinically
significant periodontal regeneration. To date there has been some success but in general the procedures are very technique-sensitive and often clinically unpredictable. There is no doubt that periodontal regenerative procedures have been shown to be biologically successful at the histological level. Furthermore, the clinical outcomes of periodontal regeneration (particularly guided tissue regeneration) have been shown to be stable over the long term (at least up to 10 years). However, whether the slight clinical improvements offered by periodontal regenerative procedures are of cost or patient benefit with regards to improved periodontal health and retention of teeth remains to be established. It was concluded that there is more work required to move periodontal regenerative medicine to a more reliable and clinically predictable procedure, and that future research will need to focus on further understanding of the biology of both developmental and regenerative processes.

**Definitions**

**Biological definition of periodontal regeneration**
Periodontal regeneration is a biological term defined histologically as reconstitution (*restitutio ad integrum*) of the tooth’s supporting tissues, including alveolar bone, periodontal ligament and cementum over a root surface deprived of the attachment apparatus.

**Clinical perspective of periodontal regeneration**
From a clinical point of view periodontal regeneration will be reflected in gain of clinical attachment and reduced probing pocket depth. However, using these parameters it is not possible for a clinician to differentiate between reparative healing and periodontal regeneration. For these reasons, and because of the wide range of regenerative materials available, the clinical outcome can best be considered as reconstruction rather than regeneration.

**Definition of periodontal reconstruction**
Reconstruction of periodontal tissues is a clinical term characterized by reparative and/or partial regenerative healing, which results in improvement of clinical (gain of clinical attachment, reduced probing pocket depth) and radiographic parameters.

**Question 1. What are the benefits of periodontal regeneration?**
Periodontal regeneration has the potential to improve prognosis and longevity of the tooth. Systematic reviews suggest that the use of membranes, grafting materials with membranes and/or regenerative materials such as enamel matrix proteins, yield superior outcomes in terms of clinical attachment gain, pocket reduction and radiographic bone gain compared to open flap debridement alone (Needleman et al. 2006; Trombelli et al., 2002; Reynolds et al., 2003; Sohrabi et al., 2012).

Clinically, periodontal regeneration remains difficult to achieve in a predictable and substantial way (Needleman, 2006). Periodontal regenerative procedures have been shown to be technique-sensitive. The outcomes of periodontal regeneration are influenced by patient, defect, materials, and operator factors that may require the use of evidence-based decision algorithms. Control of inflammation and infection is a pre-requisite before undertaking reconstructive/regenerative procedures. Under ideal conditions and careful case selection, significant clinical improvement can be achieved.

**Question 2. What additional considerations which should be taken into account when using regenerative agents?**
Recognizing that approved products and devices have been used with proven efficacy and no reported severe adverse reactions, certain issues still exist in the use of regenerative materials which must be acknowledged. These include:
- Cost/benefit
- Ethnic, religious and cultural issues
- Hybrid or copy agents
- Off-label use
- Risk of disease transmission
- Risk of unwanted immunological reactions
- Risks not apparent at the time of product release
- Unrealistic dentist/patient expectations

**Recommendations**
From this consensus report the following recommendations regarding periodontal regeneration were made:

1. Recognize and understand the difference between regeneration and reconstruction.
2. Control of inflammation and infection is a prerequisite before and after undertaking reconstructive/regenerative procedures.
3. Case selection is critical to the treatment outcome.
4. Be aware of the limitations of assessment criteria for evaluating the outcomes of reconstructive/regenerative procedures.
5. Recognize that reconstructive/regenerative procedures are technique-sensitive and the outcome may be variable.

**Conclusion**
Periodontal regeneration can result in improvement of clinical and radiographic parameters and has the potential to enhance the prognosis and longevity of teeth.
References


Group D
Initiator Paper
Implants - Peri-implant (hard and soft tissue) interactions in health and disease: The impact of explosion of implant manufacturers

Saso Ivanovski

School of Dentistry and Oral Health, Griffith University, QLD, Australia

Introduction

Osseointegration is defined as “a direct, structural and functional connection between ordered, living bone and the surface of a load-carrying implant” (Listgarten et al., 1991). Direct bone-to-implant contact was first described by Brånemark et al. (1969) and histologically demonstrated by Schroeder et al. (1978) as “functional ankylosis.” Albrektsson et al. (1981) described successful clinical treatment outcomes of 2895 threaded titanium screw implants placed using a strict surgical protocol. Subsequent animal studies showed that implants with various designs and surface configurations become osseointegrated, and analysis of numerous retrieved implants documented that osseointegration is also a reality in humans (Schenk and Buser, 1998). The temporal wound healing events leading to osseointegration were shown to involve coagulum formation, granulation tissue formation, the development of a provisional matrix, woven bone formation, parallel-fibered bone formation, and eventually lamellar bone formation (Berglundh et al., 2003).

The soft tissue attachment to implants is similar to teeth, with the presence of junctional epithelium and connective tissue fibers, although it is noteworthy that some important differences exist in that the fibers around implants are parallel rather than perpendicular to the surface, and the connective tissue surrounding the implant is less vascular than that surrounding teeth (Berglundh et al., 1991). Berglundh et al. (2007b) showed that, while the formation of a junctional epithelium occurs within approximately 2 weeks of implant placement, the maturation of the soft tissue complex needs 6-8 weeks to establish after implant placement in an animal model. DeAngelo et al. (2007) concluded that soft tissue maturation, as evidenced by stable probing, was achieved in approximately 4 weeks from the time of implant placement in humans. Importantly, it is universally accepted that adhesion of the soft tissues to the implant is critical for the maintenance of osseointegration (Klinge et al., 2006).

In terms of evaluating the performance of dental implant therapy, it must be recognized that it is no longer acceptable to simply consider the continuing presence of the implant at the site of insertion (implant survival) as a suitable measure of clinical outcome. Instead, it is important that the implant is free from biological, mechanical and aesthetic complications (implant success). In this regard, recent systematic reviews of longitudinal clinical studies of a mean 5-year follow-up have shown that implant survival rates were high, at 96.3% after 5 years and 89.4% after 10 years for single tooth restorations, and 96.4% after 5 years and 93.9% after 10 years for fixed prosthesis in partially edentulous patients (Jung et al., 2012; Pjetursson et al., 2012). However, the rate of technical, biological and aesthetic complications is also high, at up to a combined 33.6% (Pjetursson et al., 2012).

It is widely recognized that implant-related characteristics can influence the outcome of treatment (Capelli, 2013). Combined with the continual increase in implant manufacturer numbers and the associated variations in implant design, this has the potential to affect the establishment and maintenance of osseointegration, as well as the incidence and management of complications. This review will evaluate implant-related characteristics that can influence soft and hard tissue healing around implants. Furthermore, the way that implant factors may affect the incidence and management of complications affecting the peri-implant tissues will be explored.
The ‘explosion’ of implant manufacturers

It is difficult to precisely estimate the number of companies providing implant components as this information is not available in the published scientific literature, but anecdotal evidence suggests that numbers have continued to increase exponentially over the years. One reason for this is that implant dentistry has been a high growth market over the past decade, growing at approximately 20% per year up to 2007, and more modestly since. Furthermore, as implants are treated as medical devices by regulatory bodies, the requirements for registering new products are less demanding than those required for pharmaceuticals, providing a low barrier to entry by new manufacturers. The method used by the industry to estimate the number of implant companies in the market is by evaluating the number of dental implant company exhibitors at dental conferences and trade shows. In this regard, an analyst report issued by the investment firm Morgan Stanley in March 2013 stated that “the number of dental implant competitors has increased by 29% in 2 years from 183 to 236” based on exhibitors at the International Dental Show. Similarly, internal research by a leading implant company found that the number of implantology exhibitors at various dental shows and conferences in 2013 was 480, compared to 413 in 2011 and 120 in 2003. Irrespective of the accuracy of these data, it is clear that the number of manufacturers is large and has increased significantly over the past decade.

Implant - peri-implant interactions in health

Albrektsson et al. (1981) concluded that there were six major factors influencing osseointegration. These were implant material, implant design, implant finish, status of the bone, surgical technique and implant loading conditions. These observations are still relevant today and it is important to note that the first three properties [material, (macro-) design and (micro-) finish] are related to the implant characteristics and can therefore be subject to variation during the manufacturing process.

Implant material

The primary consideration with regards to the implant material is its biocompatibility. The original Brånemark protocol used commercially pure titanium and this is still considered the gold standard material for implant use. Indeed, the vast majority of currently available implants are made of commercially pure (grade IV) titanium. Alternatives are titanium alloys (e.g., grade V titanium (Ti-6Al-4V) or titanium-zirconia alloy (TiZr)) and zirconia implants, made currently either of yttria-stabilized tetragonal zirconia polycrystals (Y-TZP) or yttria-partially stabilized zirconia (Y-PSZ) (Wenz et al., 2008; Ehrenfest et al., 2010). The alloys are generally used for increasing strength, especially in narrow diameter implants, while the zirconia implants have been advocated on the basis of improved aesthetics. Importantly, the vast majority of long-term studies report on commercially pure titanium implants with some short-term studies on titanium alloy implants (Barter et al., 2012), while zirconia implants cannot be recommended due to a lack of long-term studies (Wenz et al., 2008; Andreiotti et al., 2009).

Implant macro-features

The macro-design of implants can vary greatly, and there are several key considerations in the way that implant macro-design can affect treatment outcomes. Firstly, there is a requirement to achieve good primary stability of the implant, without excessive trauma at the osteotomy site which may result in necrosis. A second consideration is the ability to achieve a good seal at the implant-abutment margin in order to obtain good marginal integrity of the soft tissues, thus preventing future mechanical and biological complications. A third consideration is the ability to maintain the marginal bone levels during the initial physiological remodeling phase, which may be particularly important in aesthetic areas.

Implant shape and size

The shape of the implant body should allow implant insertion with adequate primary stability while minimizing trauma to the recipient tissue. The most common current design is the solid screw threaded implant (including parallel wall and tapered designs), which is supported by abundant long-term data. Alternatives are hollow screws and cylinders, which are usually inserted using the ‘press-fit’ method. A systematic review of randomized controlled trials that compared different implant types did not find differences in implant failures between different implant shapes (Esposito et al., 2007). However, an earlier review found that press-fit implants were associated with more long-term marginal bone loss (Sennorby and Loos, 1998).

A concern in regards to hollow cylinder designs is that the implants are impossible to treat if bone loss occurs (Baelum and Ellegaard, 2004). It should be noted that virtually all major implant manufacturers currently use the threaded solid screw design, with the press-fit designs having been abandoned some years back.

In terms of implant size, length and diameter do not appear to be related to implant failure (Lee et al., 2005). A systematic review investigating short implants of 5-9 mm (majority 8 mm) found high (>99%) cumulative survival rates (Annibali et al., 2012), suggesting that short implant length does not adversely affect treatment outcomes. Indeed, a recent meta-analysis of 12 studies with minimum 1-year follow-up has shown good treatment outcomes with 6 mm long implants (Srinivasan et al., 2013). Similarly, narrow diameter implants (≤3.5 mm) have been shown to have good treatment outcomes (Sohrabi et al., 2012), showing that implant diameter does not negatively affect treatment. However, mini-implants
(1.8–2.9 mm), commonly used for orthodontic and interim prosthodontic treatment, do not have sufficient evidence to support their use in definitive treatment (Bidra and Almas, 2013). It should be noted that implant manufacturers continue to push the boundaries in terms of implant length and diameter, and practitioners should exercise caution in using implants less than 6 mm long or 3 mm in diameter.

The implant-restoration interface
Generally implants have three components - the implant itself, an abutment that facilitates the attachment/retention of the restoration and the restoration itself. The design of the implant-abutment interface can have an influence on the nature of the post-loading remodeling process at the coronal margin of the bone crest. Traditional criteria for success of implant treatment have allowed for early crestal bone loss of up to 1 mm and ongoing annual bone loss of up to 0.2 mm to be considered a “normal” physiological response (Albrektsson et al., 1986). However, this notion is now being challenged, with contemporary implant designs aimed at preventing marginal bone loss. This is achieved by improving the nature of the connection between the implant and the abutment/restoration, which then has the dual purpose of minimizing early crestal bone loss due to physiological re-modelling, as well as minimizing future mechanical and biological complications that may arise from poor fit between the implant componentry. Several implant design features may be important in this regard:

1. Internal vs external connection
2. Horizontal offset of the implant-abutment junction (platform switching)
3. Macrogeometry at the implant collar

1) Internal vs external connection
The connection that allows the prosthetic superstructure to attach to the implant can be either external (a projection outside the implant body) or internal (within the body of the implant). The original Brånemark implant design had an external hexagon that was developed to facilitate implant insertion (Brånemark et al., 1985). Although this system was associated with good long-term implant survival outcomes, it does have the drawback of allowing micromovement under high off-axis occlusal forces, which may in turn result in abutment screw loosening or even fatigue fracture (Jemt et al., 1991; Becker and Becker, 1995).

Internal connection implant systems have gained popularity because of a perceived higher resistance to bending and improved force distribution over external configurations (Asvanund and Morgan, 2011; Freitas et al., 2011). This is achieved through their ability to dissipate lateral loads deeply within the implant and to resist joint opening due to a deep and rigid connection (Steinebrunner et al., 2008; Bernardes et al., 2009; Sailer et al., 2009; Seetoh et al., 2011), resulting in improved protection of the abutment screw from stress. A systematic review assessing internal and external connections (Gracis et al., 2012) found that the type of connection influenced the incidence of screw loosening, with more loose screws reported for externally connected implant systems. However, it was acknowledged that appropriate pre-loading may decrease the incidence of screw loosening.

Internal connection systems adapted by various manufacturers differ in a variety of parameters, including the intimacy of approximation between the abutment’s surface and the internal implant walls, depth of penetration of the abutment in the fixture, presence of anti-rotational interlocking, number and shape of anti-rotational or guiding grooves and abutment diameter at the platform level (Wiskott et al., 2007; Steinebrunner et al., 2008; Bernardes et al., 2009; Coppedé et al., 2009; Tsuge and Hagiwara, 2009). These factors can have a significant impact on clinical procedures and protocols, including length and number of appointments, component and laboratory costs, maintenance intervals, and incidence of complications.

Therefore, it is of great importance that clinicians understand the detailed characteristics of any systems that they intend to utilize. In this context, it is also noteworthy that there are a number of manufacturers who produce ‘compatible’ abutments to established systems that may not accurately fit the parent implant (Mattheos and Janda, 2012). Clinicians should ensure that appropriate componentry is utilized, including adequate communication and direction to the dental laboratory.

2) Horizontal offset of abutment at implant interface (platform switching)
It has been proposed that a horizontal mismatch between the diameter of the implant and the abutment can result in little to no change in crestal bone height following insertion (Lazzara and Porter, 2005). This has resulted in the development of several implant systems that feature an abutment-implant interface that is internally offset in relation to the external edge of the implant, a design feature that is referred to as ‘platform switching.’

The rationale proposed for this approach is that the internal re-positioning of the implant-abutment interface would shift the inflammatory cell infiltrate formed at this interface away from the crestal bone, resulting in biologic width re-establishment in a predominantly horizontal rather than vertical dimension (Lazzara and Porter, 2005). This in turn minimizes vertical bone resorption associated with the physiological remodeling associated with biologic width formation. It has also been proposed that platform shifted implants have a biomechanical advantage by moving stress concentration away from the outer edges of the implant (Maeda et al., 2007).
A recent systematic review and meta-analysis of nine clinical trials concluded that platform switching was indeed a desirable design feature that minimizes vertical crestal bone loss (Al-Nsour et al., 2012). The authors identified several confounding factors that should be considered when interpreting the results, such as the apico-coronal position of implants in relation to crestal bone, the presence of various implant micro-textures, the degree of platform switching and the reliability of examination methods.

### 3) Macrogometry of threads at the implant collar

Biomechanical modelling studies have found that peak horizontal and vertical loading forces occur at the top of the marginal bone (Stoiber, 1988). Based on these observations, a smooth implant collar was advocated to minimize the horizontal forces. However, this approach did not yield the desired outcome, and a modified implant macro-geometry with minute threads at the collar has been advocated as a more effective alternative (Hansson, 1999), particularly when combined with an internal conical implant abutment connection (Abrahamsson and Berglundh, 2009). The superiority of the micro-thread compared to the smooth collar design has been supported by animal and human studies (Abrahamsson and Berglundh, 2006; Lee et al., 2007; Nickenig et al., 2009). In contrast, the micro-topography of the implant surface does not appear to influence marginal bone loss (Abrahamsson and Berglundh, 2009). However, it has been proposed that laser micro-grooves at the implant collar result in perpendicular, rather than parallel, orientation of fibers to the implant surface, potentially resulting in a superior attachment, although the clinical implications of this are not yet known (Ketabi and Deporter, 2013). In summary, the implant-abutment/restoration interface in contemporary implant designs is focused on minimizing technical complications by reducing the incidence of screw loosening, as well as minimizing crestal bone loss during the initial remodeling phase.

While appropriately designed internal connections are largely responsible for improved outcomes in terms of screw loosening, reduction in crestal bone loss is likely to be the result of a combination of features, including internal connection, platform switching and micro-thread design of the implant collar. However, the precise combination of these interdependent parameters that results in the best outcomes is yet to be determined in long-term clinical trials.

### Implant surfaces

Osseointegration is a biological process that involves a cascade of events which occur at the tissue-implant interface. These involve clot formation and the initial adsorption of serum components immediately following implant placement, an immune-inflammatory response to implant insertion, the migration and attachment of undifferentiated mesenchymal cells onto the implant surface, their proliferation and differentiation, the formation of extracellular matrix, and finally its mineralization and maturation. Several features of the implant surface can influence the rate and extent of bone-implant contact, and surface modification has been advocated as a method for enhancing osseointegration (Junier et al., 2009; Wennberg and Albrektsson, 2009; Ehrenfest et al., 2010).

There are two broad methods used to modify the implant surface (Ehrenfest et al., 2010). In the first approach, the interface is improved chemically by incorporating inorganic phases, such as calcium phosphate, or organic molecules, such as proteins, enzymes or peptides, on or into the TiO$_2$ (titanium dioxide) layer. Implants with thick hydroxyapatite (HA) layers were initially advocated as a way to improve the speed and extent of osseointegration, but were found to result in implant failure due to delamination of the HA coating (Piattelli et al., 1995). While thin calcium phosphate coating technology may solve the problems associated with thick calcium phosphate coatings, there is a lack of human clinical data to support their superiority over conventional micro-rough surface implants (Junier et al., 2011). Furthermore, there is no convincing evidence to support the use of implants with organic molecule coatings (Junier et al., 2011).

In the second approach, the interface is improved physically by modifying the architecture of the surface topography at the micrometer or nanometer level. In particular, it has been shown that the micro-level topography of the implant surface can influence the extent and speed of osseointegration around the implant (Wennberg and Albrektsson, 2009). In the most widely recognized classification of micro-level topography proposed by Albrektsson and Wennberg (2004), smooth surfaces were proposed to have an Sa value (arithmetic mean deviation of a surface) of <0.5 µm; minimally rough surfaces have an Sa of 0.5-1 µm, moderately rough surfaces have an Sa of 1-2 µm, and rough surfaces have an Sa of >2 µm.

In animal studies, moderately rough titanium implants were shown to have a superior bone-to-implant contact compared to minimally rough implants (Buser et al., 1991), as well as superior torque removal values (Buser et al., 1998). These results have been replicated in histological analysis of human samples (Lazzara et al., 1999; Ivanoff et al., 2001; Ivanoff et al., 2003; Grassi et al., 2007). Notably, histological analysis of the sequential healing events following implant placement demonstrated evidence of superior early healing associated with moderately rough compared to minimally rough
surfaces (Abrahamsson et al., 2004). Furthermore, initial bone formation around the moderately rough surface implants occurred not only at the exposed bone wall of the surgically created recipient site (distance osteogenesis), but also along the osteophytic implant surface (contact osteogenesis), which was not observed on the minimally rough implants (Berglundh et al., 2003; Abrahamsson et al., 2004).

Additional changes to moderately rough surfaces via chemical modification has resulted in nanoscale features and changes in chemical composition and/or hydrophilicity, which have resulted in greater bone-implant contact in animal (Buser et al., 2004; Berglundh et al., 2007a) and human studies (Orsini et al., 2007; Lang et al., 2011). Notably, longitudinal time-course histomorphometric studies have shown that while moderately rough implants result in both earlier and ultimately greater bone-implant contact compared to minimally rough implants (Abrahamsson et al., 2004), the chemically modified surfaces only accelerate osseointegration, with no differences in the final bone-implant contact values compared to moderately rough implants (Buser et al., 2004; Berglundh et al., 2007a; Lang et al., 2011).

Many currently available implant systems employ a combination of chemical and physical modifications. However, it should be noted that implant surfaces are generally poorly characterized, with microscale topography being the most widely reported parameter, while other important parameters such as topographical uniformity, nanoscale features and purity have not been documented (Wennerberg and Albrektsson, 2009; Ehrenfest et al., 2010).

Clinical relevance of implant surface modification

In the clinical context, while the original machined Bränemark implants had a minimally rough topography, the vast majority of implant systems that have been commercially available over the past decade have a micro-rough topography, which is within or very close to the Sa values of the moderately rough category (Sa 1-2 μm). More recently, a third generation of chemically modified surfaces with nanoscale features has become commercially available. It is noteworthy that there are a large number of studies that document the clinical performance of first generation machined and the various second generation ‘micro-rough’ implants, but there are relatively few clinical studies that report on the medium- to long-term performance of newly developed chemically/nanoscale modified implant surfaces.

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 (Lindqvist et al., 1996). However, poorer results may be obtained in achieving osseointegration with machined implants in compromised sites, such as the posterior maxilla (Becktor et al., 2004), and patients such as smokers (Balshe et al., 2008). Animal data would suggest that moderately rough implant surfaces may result in improved clinical outcomes, such as decreased healing times and increased success in compromised sites and patients. However, there is a scarcity of human clinical studies to substantiate these hypotheses, as there are few randomized controlled clinical trials that directly compare the relative performance of different implant surfaces, especially in compromised situations. 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 (Esposito et al., 2007).

In the absence of large randomized controlled clinical trials, a review of cohort studies may be used to ascertain the relative performance of micro-rough and machined implants. Lambert et al. (2009) 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). Furthermore, there is evidence from meta-analysis of cohort studies that micro-rough implants perform better than machined implants in augmented sites in the maxilla (Del Fabbro et al., 2008; Lambert et al., 2009), as well as in smokers (Balshe et al., 2008).

In the clinical context, an important consideration is the influence of the emergence of micro-rough surfaces on the utilization of short implants. This is because implant survival is higher when short implants are used then when vertical bone augmentation is utilized to overcome bone deficiency, especially in the posterior mandible (Esposito et al., 2009). In this context, it has been shown that short micro-rough implants have a greater survival rate than machined-surfaced implants (Feldman et al., 2004; Renouard and Nisand, 2005; Annibali et al., 2012).

In summary, moderately rough implants appear to improve the speed and extent of bone-implant contact in histomorphometric studies, which is also supported by meta-analysis of clinical cohort studies that suggest that these implants perform better than those with minimally rough machined surfaces. However, it should be noted that surface characterization of implants is generally poor, which has implications in the context of the ever increasing number of manufacturers. Further, it should be noted that new generation nanoscale modified implants have inadequate surface characterization, and are generally not supported by long-term clinical studies. So, although there is good clinical rationale for the use of micro-rough implants, practitioners should exercise caution when choosing implants for clinical use, and ensure that the relevant surfaces have good long-term clinical evaluation.
Implant — peri-implant interaction in disease

Peri-implant disease

The 6th European Workshop on Periodontology defined the term “peri-implant disease” as a “collective term for inflammatory reactions in the tissues surrounding an implant,” with peri-implant mucositis described as “the presence of inflammation in the mucosa at an implant with no signs of loss of supporting bone” and peri-implantitis as an “inflammatory process around an implant, characterized by soft tissue inflammation and loss of supporting bone” (Lindhe and Meyle, 2008; Zitzmann and Berglundh, 2008). Peri-implant mucositis is a reversible disease whose pathogenesis and diagnosis does not fundamentally differ from gingivitis around teeth (Lang et al., 2011). Peri-implantitis is a multi-factorial disease that is similar in clinical features and aetiology to periodontitis, although critical histopathological differences exist between the two lesions (Berglundh et al., 2011). Notably, the apical extension of the lesion is more pronounced in peri-implantitis than in periodontitis, and in contrast to periodontitis lesions, peri-implantitis lesions lack a “self-limiting” process and extend to the bony crest, exhibiting signs of acute inflammation with large amounts of osteoclasts lining the surface of the crestal bone (Berglundh et al., 2011; Lang and Berglundh, 2011).

The incidence of peri-implantitis has been reported in the range of 16 - 58%, and is highly dependent on the definition used to describe the disease (Fransson et al., 2005, Zitzmann and Berglundh, 2008, Koldsland et al., 2010). A systematic review by Heitz-Mayfield (2008) identified poor oral hygiene, history of periodontitis and cigarette smoking as strong risk indicators for peri-implant disease. The association between periodontitis and peri-implantitis (Ong et al., 2008; Lee et al., 2012) and the similarity in bacterial pathogens associated with the two lesions (Mombelli and Lang, 1998; Renvert et al., 2007) point towards a common bacterial aetiology. Indeed, the aetiology of peri-implantitis appears to be multi-factorial, and changes in local ecological conditions that favor the growth of bacterial pathogens may be viewed as the true origin of peri-implant disease (Mombelli and Décaillat, 2011). The presence of the implant-abutment connection at the gingival/subgingival margin is important in this context, and given that this is the subject of great variation among different manufacturers, the choice of implant design may be important, especially in susceptible patients. Indeed, regardless of one’s view on the relative importance of the bacterial biofilm in the initiation of the peri-implantitis lesion, it is widely accepted that multiple features of implant design, and the ability of the practitioner to appropriately manage these, have a significant impact on the development of peri-implant disease (Lang and Berglundh, 2011; Qian et al., 2012).

Two aspects of implants that may play a role in the development and progression of peri-implant disease are the implant-abutment/restoration connection and the implant surface.

Implant-abutment connection and peri-implant disease

It has been shown that bacteria find their way through the microgap at the implant/abutment interface and reside within the internal components of implants, and this provides them with an environment sheltered from host defenses (Quirynen and van Steenberghe, 1993; Persson et al., 1996; Jansen et al., 1997). The design of the implant/abutment interface determines the size of the microgap and therefore will influence the degree of microleakage (Tesmer et al., 2009), with the biological consequence being soft tissue inflammation that can lead to bone loss (Hermann et al., 2001).

As previously discussed, the nature of the connection (external vs internal) can have an impact on technical complications, such as screw loosening (Gracis et al., 2012). It is reasonable to expect that loosening of the restoration would have a negative impact on the health of the peri-implant tissues, as the interface between the implant and abutment is usually below the mucosal margin. Indeed, the incidence of biological complications has been linked to technical complications in a clinical study (Kim et al., 2013). Clearly, the stability of the implant-abutment interface is important in minimizing biological complications, and in this regard an internal connection appears to offer an advantage (Gracis et al., 2012).

It should also be considered that the nature of the implant-abutment connection (e.g., platform switching) may also influence the diagnosis of peri-implantitis, as it may influence the ability to probe around implants (Lang and Berglundh, 2011).

Another consideration in relation to the design of the implant-abutment/restoration connection relates to the potential for peri-implant tissue problems caused by clinician error. Incorrect seating of implant componentry, and in particular subgingival cement retention, are problems that can create a local environment that is conducive to the initiation of peri-implantitis, especially in susceptible patients. Wilson (2009) showed that excess luting cement was associated with peri-implant disease in 81% of 39 cases. Once the excess cement was removed, the clinical signs of disease resolved in 74% of cases. A recent study has shown a direct correlation of the depth of implant crown margin below the mucosal margin and the amount of undetected residual cement (Linkevicius et al., 2013), underlining the importance of avoiding or limiting the sub-mucosal extent of the restorative margin.

It is generally recognized that iatrogenic factors (e.g., excess cement remnants, inadequate restoration-abutment seating, over-contouring of restorations, implant mal-positioning, technical complications) can initiate...
peri-implant disease (Lang and Berglundh, 2011; Qian et al., 2012). Clinicians should have appropriate clinical training and have a thorough understanding of the relevant implant system in order to avoid these problems, which may cause significant peri-implant tissue disease in susceptible patients.

**Implant surface characteristics and peri-implant disease**

With regard to the interaction of implant surfaces and peri-implant disease, the two key issues are whether certain implant surfaces are more prone to disease, and whether implant characteristics influence the treatment of peri-implantitis.

It has been suggested that the roughness of the implant surface as well as its chemical composition has a significant impact on the amount and quality of plaque formation (Teughels et al., 2006). Indeed, hydroxyapatite (HA)-coated and rough-surfaced (Sa>2µm) implants have been associated with increased incidence of biological complications (Åstrand et al., 2004; Piattelli et al., 1995). However, these findings are of limited relevance to contemporary practice, as the implant systems used in these studies are no longer manufactured. Furthermore, the initiation of bone loss around HA-coated implants was associated with the delamination of the coating, and hence the biological mechanisms are different from conventional peri-implantitis pathogenesis. A recent systematic review based on human clinical trials found no evidence of increased susceptibility to peri-implantitis for currently available moderately rough surfaces, although it was acknowledged that there is a scarcity of available data on this topic (Renvert et al., 2011). Of particular interest is a prospective, multicenter, randomized, controlled 5-year clinical trial comparing a hybrid implant design (coronal component of implant was machined) with fully micro-rough implants, which showed no difference in peri-implantitis incidence (Zetterqvist et al., 2010). However, it should also be noted that there is experimental evidence from pre-clinical animal studies that some currently available moderately rough surfaces may be more susceptible to peri-implant disease progression (Albouy et al., 2008; Albouy et al., 2009), but these findings need to be validated by clinical trials.

In terms of treating peri-implantitis, the ultimate goal is to regenerate the lost bone and achieve osseointegration to the previously contaminated implant surface. In this regard, better outcomes have been reported with moderately rough compared to machined implant surfaces, although full defect resolution has not been demonstrated and there is variability in the way that different moderately rough implants perform (Renvert et al., 2009). This finding is somewhat surprising because it has been shown that increased surface roughness has a significant impact on biofilm formation (Teughels et al., 2006) and a smoother surface texture may be easier to decontaminate (Dennison et al., 1994). A possible explanation is that the rougher surface may provide improved support for the developing blood clot after surgery and thus facilitate greater bone healing in contact with the implant surface (Persson et al., 2001).

**The impact of the ‘explosion’ of implant manufacturers**

The obvious consequence of the increasing number of implant manufacturers is that the clinical and scientific community will have difficulties assessing and evaluating different systems. We can take some comfort in that over 90% of implants worldwide are produced by fewer than 10 of the top implant companies, most of which are supported by sound scientific evidence. However, many of the new manufacturers are marketing their products on the basis of cost effectiveness, rather than innovation aimed at achieving superior clinical outcomes. These manufacturers often have ‘copycat’ designs that are marketed as being ‘compatible’ with well-established manufacturers. This can result in poorly fitting componentry that predisposes to future technical and biological complications. Emerging evidence, in the form of case reports, suggests that ‘compatible’ or ‘clone’ abutments can have significantly different geometry compared to the original abutments (Mattheos and Janda, 2012), which may lead to future technical and biological problems. Inevitably, the quality of the components will vary, but the impact of this on clinical outcomes has not been evaluated in the scientific literature.

Another challenge of the increasing number of implant manufacturers is related to the nature of implant treatment, which often involves multiple visits over a prolonged period, followed by essential long-term maintenance. Combined with the increasing mobility of the population, this can result in cases where practitioners have to complete treatment initiated elsewhere or deal with complications involving treatment undertaken by another practitioner. This can pose significant challenges to even experienced clinicians and critical requirements for successful management would be the clinician’s experience and special training, as well as access to the appropriate tools and devices.

It is widely recognized that peri-implant disease can be initiated by iatrogenic factors arising from poor management or understanding of implant componentry. Therefore, caution needs to be exercised by practitioners when choosing the source of implant componentry, including that utilized by the dental laboratory. Central to this is education to ensure that clinicians have a thorough understanding of the way that implant-related characteristics may influence clinical outcomes.
The ‘explosion’ of implant manufacturers - the developing world context

In many ways, the challenges of the increasing number of implant manufacturers are common to both the developed and developing world. Inevitably, as the living standards in the developing world improve, there will be increasing demands for dental implant treatment. There is also the issue of dental tourism, whereby patients from developed countries visit developing countries in order to obtain treatment at a lower cost (Barrowman et al., 2010). Implant dentistry is attractive in this regard as it involves high value work and hence the savings can be considerable. However, because of the prolonged nature of implant treatment, the outcomes can be adversely affected by disjointed treatment and parts being undertaken in different countries. These problems may be exacerbated by differences in the availability of componentry from newer, less established manufacturers between countries.

With their focus on offering more cost-effective dental implant components, ‘value’ manufacturers will be major suppliers in the developing markets. Practitioners have a responsibility to carefully evaluate the implant systems that they utilize in order to ensure that quality clinical outcomes are achieved.

The decisions should be made on the basis of a sound evidence base from publications in quality peer-reviewed journals. Furthermore, there is a need for manufacturer-independent undergraduate and postgraduate education in order to ensure that practitioners are familiar with the guiding principles of contemporary dental implantology, in order for them to be well placed to evaluate new products from implant manufacturers.

Summary

1. The best-documented implants have a threaded solid screw-type design and are manufactured from commercially pure (grade IV) titanium. There is good evidence to support implants ≥6 mm in length, and ≥3 mm in diameter.

2. Integrity of the seal between the abutment and the implant is important for several reasons, including minimization of mechanical and biological complications and maintaining marginal bone levels. Although the ideal design features of the implant-abutment connection have not been determined, an internal connection, micro-grooves at the implant collar, and horizontal offset of the implant-abutment junction (platform switch) appear to impart favorable properties.

3. Implants with moderately rough implant surfaces provide advantages over machined surfaces in terms of the speed and extent of osseointegration. While the favorable performances of both minimally and moderately rough surfaces are supported by long-term data, moderately rough surfaces provide superior outcomes in compromised sites, such as the posterior maxilla.

4. Although plaque is critical in the progression of peri-implantitis, the disease has a multi-factorial aetiology, and may be influenced by poor integrity of the abutment/implant connection. Iatrogenic factors, such as the introduction of a foreign body (e.g., cement) below the mucosal margin, can be important contributors.

5. Clinicians should exercise caution when using a particular implant system, ensuring that the implant design is appropriate and supported by scientific evidence. Central to this is access to and participation in quality education on the impact that implant characteristics can have on clinical outcomes. Caution should be exercised in utilizing non-genuine restorative componentry that may lead to a poor implant-abutment fit and subsequent technical and biological complications.

References


Esposito M, Murray-Curtis L, Grusovin MG, Coulthard P and Worthington HV. Interventions for replacing missing teeth: different types of dental implants. *Cochrane Database of Systematic Reviews* 2007; 4:**CD003815**.


Feldman S, Boitel N, Weng D, Kohles SS and Stach RM. Five-year survival distributions of short-length (10 mm or less) machined-surfaced and Osseotite implants. *Clinical Implant Dentistry and Related Research* 2004; **616**:23.


Herrmann JS, Buser D, Schenk RK, Schoolfield JD and Cochran DL. Biologic width around one-and two-piece titanium implants. *Clinical Implant Dentistry and Related Research* 2001; **12**:559-571.


Jung RE, Zembic A, Pjetursson BE, Zwahlen M and Thoma DS. Systemic review of the survival rate and the incidence of biological, technical and esthetic complications of single crowns on implants reported in longitudinal studies with a mean follow-up of 5 years. *Clinical Oral Implants Research* 2012; **23 (Suppl 6)**:2-21.


Pjetursson BE, Thoma D, Jung R, Zwahlen M and Zembic A. A systematic review of the survival and complication rates of implant-supported fixed dental prostheses (FPDs) after a mean observation period of at least 5 years. *Clinical Oral Implants Research* 2012; 23 (Suppl 6):22-38.


Group D
Reactor Report
Implants - Peri-implant (hard and soft tissue) interactions in health and disease: The impact of explosion of implant manufacturers

Young-Bum Park

Yonsei University, Seoul, Korea

Introduction

The Initiator Paper for Workgroup D by Ivanovski (Journal of the International Academy of Periodontology 2015; 17/1 Supplement) thoroughly reviews the topic of peri-implant (hard and soft tissue) interactions in health and disease and the explosion of implant manufacturers. All of the major issues regarding this important topic are covered and I have very few comments with regards to the general content of this review. Below I have noted some specific issues that should be considered by the group in their deliberations:

Comment 1: With regard to implant shape and size it is worth noting a recent systematic review that addresses the long-term evidence of the same success rate of short implant length between 6-8 mm (Karthikeyan et al., 2012)

Comment 2: In the section covering “Macrogeometry of threads at the implant collar” it would be useful to have some discussion on transmucosal one-piece implants, which have been developed for immediate loading or restoration and that have no interface between fixture and abutment near the alveolar ridge crest (Carinci, 2012)

Comment 3: In the section covering “Clinical relevance of implant surface modification,” ultraviolet treatment, photofunctionalization to re-activate the surface and prevent aging of implant surface should be considered (Att and Ogawa, 2012).

Comment 4: In the section on “Peri-implant disease” we should consider referencing both American Academy of Periodontology and European Federation of Periodontology position statements and guidelines. (American Academy of Periodontology, 2013, European Workshop on Periodontology, 2008). In addition, genetic factors as contributing factors to peri-implant diseases should be considered.

Comment 5: In the section covering “The ‘explosion’ of implant manufacturers” the increased usage of milled custom abutments using various materials for aesthetics and the convenience of easily making implant restorations through the development of advanced CAD/CAM technology should be considered (Alikhasi et al., 2013; Kutkut et al., 2013; Oderich et al., 2012; Magne et al., 2011; Hjerpe et al., 2011)

References


Ivanovski S. Implants - peri-implant (hard and soft tissue) interactions in health and disease, the impact of explosion of implant manufacturers *Journal of the International Academy of Periodontology* 2015; 17/1 (Supplement):57-68.


Introduction

This workgroup met with the objective to address the key events in the establishment and maintenance of the soft and hard tissues during osseointegration, and how implant characteristics can influence these events. In addition, implant-related factors that may affect the etiology, progression and treatment of peri-implant disease were discussed.

The initial discussion focused on clarifying definitions relating to peri-implant health and disease. Following this, the group considered and discussed the conclusions presented in the initiator’s review paper. From this paper four key questions were identified for discussion, and recommendations were made. The key questions were:

1. What are the implant-related factors that are important for hard tissue integration?
2. What are the implant-related factors that are important for soft tissue integration?
3. What is the recommended supportive therapy for patients with implant-supported prostheses?
4. Is there a long-term predictable treatment that can be recommended for peri-implantitis?

Definitions

The definition of peri-implant disease (both peri-implant mucositis and peri-implantitis) as defined by the 6th European Workshop on Periodontology was accepted and used...
to determine consensus on the management of these two conditions. It was determined that the literature provides good evidence to support the concept that even though dental plaque is important for the development of both peri-implant mucositis and peri-implantitis, these conditions are of multi-factorial etiology and may be influenced by poor integrity of the abutment/implant connection. Other iatrogenic factors such as excessive cement are also important contributors in the development of peri-implant disease.

**Osseointegration**

A direct, structural and functional connection between ordered, living bone and the surface of a load-carrying implant” (Listgarten et al., 1991).

**Peri-implant disease**

A collective term for inflammatory reactions in the tissues surrounding an implant.

**Peri-implant mucositis**

The presence of inflammation in the mucosa at an implant with no signs of loss of supporting bone.

**Peri-implantitis**

An inflammatory process around an implant, characterized by soft tissue inflammation and loss of supporting bone (Lindhe and Meyle, 2008; Zitzmann and Berglundh, 2008).

**Question 1. What are the implant-related factors that are important for hard tissue integration?**

It was recognised that there are a number of implant-, patient- (systemic health, oral hygiene and pre-existing periodontal disease) and operator-related factors that can influence the integration of dental implants into both hard and soft tissues. Accordingly, dentists should be appropriately trained to understand the importance of these factors and their roles in establishing and maintaining peri-implant health. For the purposes of this discussion other factors related to implant success, including prosthetic design and occlusal loading, were not included.

With regard to implant design it was determined that there is abundant and consistent long-term high level evidence to support the use of threaded, solid screw-type implants manufactured from commercially pure type IV titanium. There is sufficient evidence to confirm good stability and long-term success of implants if they have a length of ≥ 6 mm and a diameter of ≥ 3 mm. Furthermore, there is good evidence demonstrating that implants with moderately rough surfaces provide advantages over machined surfaces in terms of the speed and extent of osseointegration. While both minimally and moderately rough surfaces are supported by long-term data, moderately rough surfaces provide superior outcomes.

Long-term data indicate that moderately rough surfaces provide superior outcomes in compromised sites, such as the posterior maxilla.

There is emerging evidence to indicate that horizontal offset of the implant to abutment junction (platform shift, platform shift) may offer benefits in reducing marginal bone loss as compared to platform matched implant abutment junctions.

**Question 2. What are the implant-related factors that are important for soft tissue integration?**

It is recognized that the integrity of the soft tissue seal (consisting of junctional epithelium and connective tissue adaptation) is crucial for long-term success of dental implants. Crucial to this seal is the formation of the peri-implant biologic width, which is established around the implant at least 4-6 weeks after implant placement. This critical structure must not be impinged upon or disrupted. There is no credible evidence to date indicating that any implant-related factors can improve the soft tissue seal around dental implants.

With regard to implant success it was noted that a critical factor was the integrity of the seal between the abutment and the implant. This seal enables minimization of mechanical and biological complications and at the same time ensures the maintenance of marginal bone levels.

Reasonable evidence is available to indicate that the stability of the connection is maintained better with an internal connection as compared to an external connection. There is evidence demonstrating loosening of abutment screws is greater in those implants with an external connection. If the fixture/abutment is compromised then biological complications are less likely to occur if it is located at the mucosal margin rather than bone level.

Operator-related variables and errors, such as incorrect abutment placement, poor restoration seating and cement remaining at the prosthesis-abutment interface, can all affect the marginal soft tissue integrity.

**Question 3. What is the recommended supportive therapy for patients with implant-supported prostheses?**

It is recognized that there is a physiological remodeling around dental implants once they are loaded. After this initial remodeling phase the condition stabilizes and provides the baseline level for future assessment of tissue parameters (probing depth and bone levels). Therefore, the aim of supportive implant therapy is to maintain the stability of these parameters in health through the control of peri-implant infection and inflammation. Crucial to this is maintaining a good level of oral hygiene. This can be facilitated by good patient compliance with home care of the implants and remaining dentition and also by good prosthetic design, which allows easy access for oral hygiene regimes. Regular professional maintenance is also required to monitor changes in clinical parameters and patient compliance with home care.
The frequency of maintenance visits will vary depending on the risk profile of the patient, as patient susceptibility is an important factor in the development of peri-implant diseases.

There are several key considerations in the prevention of peri-implant diseases. Good evidence supports the need for the establishment of periodontal health around the remaining teeth prior to implant placement. In addition, evidence is strong supporting the need for good maintenance of periodontal health following implant placement.

**Question 4. Is there a long-term predictable treatment that can be recommended for peri-implantitis?**

There is limited long-term (5 years or more) evidence describing techniques and procedures leading to predictable treatment of peri-implantitis. There is some limited short-term data available supporting the use of combined non-surgical and surgical treatment over non-surgical treatment alone. Evidence to date indicates that no available treatments result in total resolution of the problem of established peri-implantitis.

**Recommendations for future directions of research**

On the basis of currently limited good evidence regarding the management of peri-implant mucositis and peri-implantitis, there is need for further ongoing research to help clarify the etiology and management of these conditions. This group identified a number of important areas for future research in the field of peri-implant health and disease:

- Improved understanding of the physiology of the soft tissue around implants in humans.
- Detailed understanding of the role and significance of keratinized tissue around dental implants.
- Determining if there is a critical thickness of marginal tissue for implant success, more complete understanding of the significance and role of the “biologic width,” and further exploration of the nature of soft tissue attachment to titanium alloy and other implant materials.
- Improved understanding of the pathogenesis and epidemiology of peri-implant diseases (mucositis and peri-implantitis).
- Investigating the susceptibility of roughened surface implants with internal versus external abutment connections.
- Establishment of evidence-based protocols for both professional and self-care maintenance of peri-implant health as well as risk assessment of the patient. These should be validated in large-scale practice-based trials.

**References**

Ivanovski S. Implants - peri-implant (hard and soft tissue) interactions in health and disease, the impact of explosion of implant manufacturers. *Journal of the International Academy of Periodontology* 2015; 17/1 (Supplement):57-68.


Introduction

Periodontology is one of the oldest dental specialties in the world that deals with the tooth-supporting soft tissues and alveolar bone in both healthy and diseased conditions. Periodontal disease usually consists of gingivitis and periodontitis (Armitage, 1999). It is arguably the most common disease in humans (Guinness World Records, 2001), partly due to the unique characteristics of the dento-gingival structure and the etiopathogenic nature of the disease (Socransky and Haffajee, 1997; Jin, 2008). Globally, gingivitis predominantly affects adolescents and adults, and advanced periodontitis occurs in 5 to 20% of adults in both developed and developing countries (Söder et al., 1994; Papapanou, 1996; Petersen et al., 2005; Jin et al., 2011; Kassebaum et al., 2014). Untreated severe periodontitis is the major cause of tooth loss in the adult population worldwide (Pihlström et al., 2005; Beaglohole et al., 2009; Jin, 2011, Jin et al., 2011). Indeed, a large proportion of prosthodontic and implant patients have missing teeth, due to untreated and/or poorly controlled periodontitis. It is evident that periodontal infection and inflammation are linked to various systemic diseases, such as cardiovascular disease, diabetes mellitus, dementia, adverse birth outcomes, respiratory diseases and cancers (Pihlström et al., 2005; Williams et al., 2008; Li et al., 2011; Tonetti and Kornman, 2013). Notably, periodontal disease remains a major oral health burden in both developed and developing countries, especially in underprivileged populations (Petersen et al., 2005; Petersen, 2008; Jin et al., 2011; Petersen and Ogawa, 2012). As such, periodontal disease has increasingly attracted the attention of health-care professionals and the public.

Contemporary periodontology has been a highly dynamic and evolutionary field for many decades. Novel concepts in periodontal etiopathogenesis and innovative clinical approaches have been made available to periodontal educators, general dental practitioners, periodontists, medical professionals and government agencies. This article firstly updates readers on the major advances in clinical periodontology, and elaborates the common pitfalls and drawbacks confronting dental practitioners in periodontal practice as well as the potential risk and impacts involved in providing periodontal treatment. In addition, the key issues and proactive strategies for effective management of periodontal patients through interprofessional teamwork and a multidisciplinary approach are highlighted. Finally, directions and perspectives for innovative periodontal research are addressed.

Major advances in clinical periodontology

The past 20th century saw great advances in the discipline of periodontology. Revolutionary concepts and substantial new knowledge, balanced with clinical reality, were developed and verified, thereby laying down the contemporary periodontal paradigm and professional care strategies (Löe et al., 1986; Kornman and Löe, 1993; Page et al., 1997; Armitage, 1999 and 2002; Pihlström et al., 2005; Kornman, 2008; Armitage and Robertson, 2009; American Academy of Periodontology, 2011; Jin, 2011; Jin et al., 2011; Tonetti and Kornman, 2013). The key discoveries and advances are listed in Table 1.

Table 1. Key discoveries in periodontology in the 20th century.

- Role of dental plaque and plaque biofilms
- Natural history of periodontal disease
- Periodontal risk factors/assessment and concept of host susceptibility
- The reality of periodontal regeneration
- Periodontal medicine and integration of oral health and general health
Common pitfalls and drawbacks in periodontal practice

Low awareness of periodontal health and periodontal negligence

Oral health and oral care are highly neglected in both national and international health politics and agendas (Editorial, Lancet, 2009). Because periodontal disease is a relatively ‘silent’ infection and inflammation many patients are unaware of this common oral problem in their daily life. However, its overall impact on patients becomes increasingly noticeable during the long course of disease onset and development, starting with gingival redness, swelling, and bleeding during brushing at the early stage, followed by increased tooth mobility, pathological tooth drifting and migration, eventually ending with multiple tooth loss. These pathological changes seriously affect various oral functions, thereby causing psychological problems with low self-esteem and reduced quality of life, as well as creating a large financial burden for periodontal care and related dental treatments (Jin, 2008; Jin, 2010; Chapple, 2014) (Figure 1).

Unfortunately, a large number of patients in the underprivileged population suffer from untreated severe gingivitis and various forms of periodontitis, and these subjects have a relatively low awareness of their oral/periodontal health. These individuals usually do not seek periodontal care in the first instance; rather they make ‘symptom-driven’ dental appointments at a relatively late stage of disease development, and only if such professional care is available and affordable (Jin, 2010). It is anticipated that the required periodontal treatment and subsequent other dental care needs then become more complicated, costly and less predictable. Indeed, poor management of periodontal patients has emerged as one of the major risks in clinical practice. Moreover, there is a great variability in periodontal referrals due to various reasons (Ong, 1990; Buckley, 1993; Lee et al., 2009). Considering the common occurrence of periodontal disease and the low awareness among the public, significant risk may often arise from periodontal negligence, with increased litigation and periodontally related legal cases (Zinman, 2001); e.g., implant failure due to severe peri-implantitis in periodontal patients and those with periodontal destruction due to poorly delivered and detrimental adjunctive orthodontic treatment.

Gingival recession
Tooth sensitivity
Halitosis
Spacing, drifting & mobility
Chewing & speech problems
Esthetic problems
Psychological impacts
Financial burden
Quality of life
General health

Figure 1. The increasing impacts of periodontal disease on affected patients during the disease course.
Non-evidence-based periodontal practice

In many developing countries, it is assumed that periodontal training in dental curricula remains inadequate and relatively poorly updated, partly due to limitations of well-qualified teaching staff and learning resources. Likewise, in addition to the issue of periodontal negligence, periodontal care in daily practice seems to be delivered through an empirically driven approach following outdated dogma, instead of evidence-based and scientifically verified approaches. The common pitfalls and drawbacks of periodontal care in general dental practice are listed in Table 2.

Table 2. Common pitfalls and drawbacks of periodontal care in general dental practice.

- Lack of updated concepts and knowledge in periodontal science
- Lack of patient communication on disease prevention and health promotion
- Lack of assessment and control of risk factors (e.g., smoking)
- Inappropriate diagnosis, prognosis and poorly sequenced treatment planning with a focus on restorative/reconstructive treatments (e.g., dental implants)
- Limited non-surgical periodontal treatment without appropriate re-evaluation and long-term regular supportive care even in managing susceptible patients
- Undertaking non-evidence-based certain ‘adjunctive’ periodontal treatments
- Inadequate communication and inappropriate decisions on periodontal referrals
- Lack of multidisciplinary management of complex patients through teamwork with specialists in endodontics, orthodontics, prosthetics and implant dentistry
- Low awareness and engagement in periodontal care through integration of oral and general health

Key issues for effective management of periodontal patients

Effective periodontal care should be the primary and essential component of general dental practice; otherwise any dental treatment for periodontal patients may be greatly compromised or ultimately fail (Pihlstrom, 2001). Unfortunately, general dentists tend to show less interest in treatment of periodontal diseases and prefer to focus on restorative procedures (Ong, 1990; Buckley, 1993). Thus, the problem arises that they may eventually have to deal with the consequences of periodontitis-related tooth loss or edentulism, rather than effectively controlling the ‘root’ cause of the problem – uncontrolled periodontal infection and inflammation. In recent years, evidence-based, common risk factors-targeted, health-integrated preventive and care strategies have been advocated and implemented in dental education and clinical practice. Some of the key points for prevention and effective control of periodontal disease have been well addressed (Baehni and Giovannoli, 2004; Jin, 2010), and these critical issues are updated and presented in Table 3.

Table 3. The key issues for prevention of periodontal disease and effective patient management.

- Patient motivation, awareness of oral/periodontal health and reflection of holistic health
- Early prevention through effective plaque control at home and regular professional care
- Routine periodontal screening and recognition, record keeping and appropriate risk assessment through a patient-centered approach
- Appropriate diagnosis, prognosis and formulation of individualized treatment planning through addressing the causes, risk and host susceptibility factors
- Setting achievable treatment goals through good communication with patients
- Avoiding and controlling periodontal risk factors via a common risk factor approach
- Assurance of controlling the ‘root’ of the problem (periodontal disease) and achieving ‘periodontal clearance’, prior to undertaking corrective, regenerative, restorative and prosthodontic treatments
- Long-term, regular periodontal and implant supportive care
- Appropriate arrangements for periodontal referral
- Multidisciplinary management of complex patients through good teamwork and collegiality

One of the most critical issues to be considered is recognition of patients’ risk profiles through appropriate risk assessment and effective control of these risk factors. Identification of the risk is essential, and this strategy should be fully incorporated in clinical practice (Lang and Tonetti, 2003; Nunn, 2003; American Academy of Periodontology, 2008; Jin et al., 2011). This approach has important clinical implications and enables clinicians to address the underlying risk for periodontal disease, and thereby carry out individualized and clearly targeted treatments for more cost-effective therapies and ongoing regular supportive care (American Academy of Periodontology, 2008). A periodontal risk assessment system has been proposed and validated in a longitudinal study (Lang and Tonetti, 2003; Matuliene et al., 2010).

Common non-communicable diseases (NCDs) such as cardiovascular disease, cancer, diabetes and respiratory disease collectively account for about 60% of human deaths worldwide (Ash et al., 2012; Ezzati and Riboli, 2012; FDI, 2013a). Periodontal disease as a common oral NCD shares an array of common risk factors with other NCDs (United Nations General Assembly, 2011; FDI, 2013a,b,c; Jin, 2013), such as tobacco usage, obesity, unhealthy life style and socio-economic factors. From the general health perspective, it is crucial...
to incorporate periodontal health issues into the general health agenda, through the Common Risk Factor Approach (Sheiham and Watt, 2000; Petersen, 2008; FDI, 2013b,d; Jin, 2013) for optimal oral and general well-being of the population.

Management of periodontal patients via multidisciplinary teamwork

It is well recognized that periodontology is closely interlinked with other dental specialties, and periodontal care and patient management should therefore be undertaken on a multidisciplinary basis, especially in complex cases, involving various experts in medicine, endodontics, orthodontics, prosthodontics and implant dentistry (Figure 2). Comprehensive, well-sequenced treatments and properly conducted multidisciplinary care are crucial for optimal treatment outcomes, especially in medically compromised patients, susceptible individuals (e.g., heavy smokers) and those with severe periodontitis. Some important issues should be highlighted to address the specific interdisciplinary interactions in effective management of periodontal patients. Taking the periodontal-restorative interface as an example, some critical points need to be carefully elaborated and executed to achieve the best treatment outcomes. These key issues have been well addressed by Goldberg and colleagues (2001), and they are modified and summarized in Table 4. The interactions of periodontics with other specialties such as endodontics, orthodontics and implant dentistry, as well as the relevant clinical implications, have been intensively discussed and presented elsewhere (Yi et al., 1995; Zachrisson, 1996; Gunne et al., 1999; Sanders et al., 1999; Jorgensen and Nowzari, 2001; Nowzari, 2001; Witter et al., 2001; Harrington et al., 2002; Ong and Wang, 2002; Zehnder et al., 2002; Esposito et al., 2003; Reddy, 2003; Rotstein et al., 2004; Levin et al., 2012; Raj, 2013; Sgolastra et al., 2013).

Table 4. The critical issues related to periodontal-restorative interface in clinical practice.

- Assurance of controlling periodontal disease prior to restorative treatments
- Protection of the biological width via crown lengthening procedure when necessary and appropriate
- Obtaining excellent dental impression and model-making
- Precise design for crown, denture and implant treatments
- Refining crown contour and emergence profile in harmony with gingival tissues
- Appreciation of the clinical value of fabricating provisional restorations for predictable outcomes
- Periodontally friendly placement of restorative margins, selection of compatible materials, achieving optimal marginal fit and undertaking effective plaque control daily
- Recognition of the critical role of occlusion in periodontal and implant treatments
- Mucogingival considerations on the attached gingiva close to the restorative margins
- Critical consideration of the option of shortened dental arches in periodontitis patients

Perspectives and future directions in periodontal research

Periodontal disease is recognized as a major global oral health burden in connection to oral and general health, and it significantly accounts for the global oral health inequality, which is of significant concern to the leading international organizations, such as the World Health Organization (WHO), International Association for Dental Research (IADR) and FDI World Dental Federation (Jin et al., 2011; Petersen and Ogawa, 2012; FDI, 2013b). Although considerable progress has been made in understanding the complex nature and pathogenesis of periodontal disease, as well as its effective management strategy (Page et al., 1997; Kornman, 2008; American Acad-

Figure 2. The periodontal specialty is interlinked with medicine and other dental disciplines, and periodontal care should be undertaken comprehensively through a multidisciplinary team approach for optimal treatment outcomes.
A substantial knowledge gap remains that needs to be addressed through further basic, translational and clinical studies. Future research directions could be further explored and identified on the basis of current knowledge, good evidence and needs in periodontology could be further explored and translational and clinical studies. Future research directions remains that needs to be addressed through further basic, clinical studies. Hopefully, new discovery and innovative approaches in oral/periodontal science could further enhance the effectiveness of prevention and control of periodontal disease in the near future for optimal oral health and general health.

Acknowledgements

This work was supported by the Hong Kong Research Grants Council and the Modern Dental Laboratory/ HKU Endowment Fund.

References


Zachrisson BU. Clinical implications of recent orthodontic-periodontic research findings. Seminars in Orthodontics 1996; 2:4-12.


Introduction

In the Initiator Paper for Workshop E on periodontal education, Professor L. J. Jin clearly stated that common pitfalls and drawbacks in periodontal practice are the result of the fact that in many emerging populations, periodontal components of dental curricula remain highly inadequate and not updated due to limitations in qualified teaching staff and educational resources (Jin 2015). I can add a more significant reason that addresses the lack of a standardized periodontal education, reflecting the epitome of pedagogy. The model I refer to is that used in the United States and Canada, with prescriptive educational standards at the predoctoral and postdoctoral levels. Educational programs are evaluated on a regular basis to ensure compliance with the standards and documentation of outcome measures. Educational standards are established, maintained, and applied by the American Dental Association (ADA) and the Commission on Dental Accreditation (CODA). Every dental curriculum and postdoctoral education program in the United States must adhere to the requirements of CODA. For dental education, each program must include a competency statement and institutional learning objectives for periodontology. Instruction in this area is offered throughout the curriculum and provides the needed foundation skills, knowledge and values. The goal of the predoctoral curriculum at Stony Brook University is to provide students with the knowledge, skills and values to attain competency in the ability to manage patients with moderate and severe periodontitis, and to perform nonsurgical periodontal therapy for gingivitis and slight periodontitis. The predoctoral curriculum of Stony Brook University’s Department of Periodontology includes both didactic (approximately 100 hours) and clinical (approximately 120 hours) components to ensure that this goal is achieved (Department of Periodontology, Stony Brook University Syllabus, 2014). The courses are sequenced to allow students to utilize the knowledge and skills attained from the basic science courses and to relate this information to patient care. Students are introduced to the field of periodontics in the first year through lectures and problem- and case-based learning and they progress through an intense curriculum through the fourth year. The fourth year component of clinical periodontics is conducted in a general practice setting in which the student provides comprehensive care, including diagnosis and nonsurgical periodontal therapy under the supervision of general dentistry faculty. This experience enables the student to understand the primary care role of general dentists in treating and managing periodontal patients, including referral to a specialist when indicated. Specific guidelines for referral to a periodontal postdoctoral student are distributed to faculty instructors and calibrated on an annual basis. The periodontology faculty provide coverage for consultations and three competency examinations (periodontal scaling and root planing, periodontal diagnosis/treatment planning of implants, and periodontal evaluation of treatment provided), and periodontal surgical procedures. In addition, students are required to observe and encouraged to participate in periodontal and implant surgical procedures performed by periodontal postdoctoral students. Student progress and clinical competency in periodontal therapy are evaluated in a series of formative assessments and competency examinations, as listed in Table 1.
The significance of graduation from a CODA accredited curriculum relates to the graduating dentist’s ability to obtain a license to practice dentistry in the United States and enhanced ability to matriculate in a specialty program. A dental specialty is defined as an area of dentistry that has been formally recognized by the ADA as meeting the requirements for recognition of dental specialties as presented by the ADA Council on Dental Education and Licensure (CDEL) (American Dental Association, 2001). Periodontics is one of nine recognized specialties and is defined as that specialty of dentistry which encompasses the prevention, diagnosis and treatment of diseases of the supporting and surrounding tissues of the teeth or their substitutes, and the maintenance of the health, function and esthetics of these structures and tissues (Accreditation Standards for Advanced Specialty Education Programs in Periodontics, 2013). There are six standards for which all United States postdoctoral periodontal programs must demonstrate compliance. The six standards include:

1. Institutional commitment/program effectiveness,
2. Program director and teaching staff,
3. Facilities and resources,
4. Curriculum and program duration,
5. Advanced education students/residents,
6. Research.

There are more than 50 CODA accredited advanced specialty education programs in periodontics (American Academy of Periodontology [AAP], 2007). It is important to note that every accredited program must be administered by a director who is certified by the American Board of Periodontology (ABP). The ABP was formed by the AAP to elevate the standards and advance the science and art of periodontology by encouraging its study and progressing its practice (American Board of Periodontology, 2008). Each program must submit annual reports to CODA and all programs are reviewed through self-study documents and CODA site visits every seven years to ensure continued compliance with the education standards.

CODA accredited programs must be a minimum of 30 months in length and have developed clearly stated goals and objectives appropriate to advanced specialty education, addressing education, patient care, research and service. The goals and objectives of Stony Brook University’s advanced specialty education program in periodontics are to produce clinically competent and highly educated periodontists who will be proficient in the prevention, diagnosis, treatment and/or management of the various periodontal diseases and interrelated systemic diseases and conditions seen in specialty practice. They will also have in-depth instruction and extensive clinical training in periodontal plastic surgery, oral reconstructive surgery, and dental implants. In addition, program graduates are trained to critically review the periodontal literature, so that they will be able to scientifically evaluate new models of therapy during their careers. Specifically, the program’s primary goals and objectives are as follows (Advanced Specialty Education Program in Periodontics, Stony Brook University, 2013):

---

**Table 1. Summary of Stony Brook University predoctoral curriculum and the determination of competency for the practice of periodontics in general dentistry.**

<table>
<thead>
<tr>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
<th>Year 4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Formative Assessments</strong></td>
<td><strong>Formative Assessments</strong></td>
<td><strong>Formative Assessments</strong></td>
<td><strong>Formative Assessments</strong></td>
</tr>
<tr>
<td>Basic science courses</td>
<td>Daily clinical assessments</td>
<td>Daily clinical assessments</td>
<td>Daily clinical assessments</td>
</tr>
<tr>
<td>Dental didactic courses</td>
<td>Dental didactic courses</td>
<td>Dental didactic courses</td>
<td>Dental didactic courses</td>
</tr>
<tr>
<td>Outcomes of care: Clinic II courses</td>
<td>Outcomes of care: Clinic III courses</td>
<td>Outcomes of care: Clinic IV courses</td>
<td>Outcomes of care: Clinic V courses</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Competency Examinations</strong></th>
<th><strong>Competency Examinations</strong></th>
<th><strong>Competency Examinations</strong></th>
<th><strong>Competency Examinations</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Pediatric diagnosis/treatment planning HDC 621</td>
<td>Comprehensive patient treatment plan (HDI 705)</td>
<td>Periodontal scaling/root planing (HDP 821, 822)</td>
<td>Periodontal scaling/root planing (HDP 821, 822)</td>
</tr>
<tr>
<td>Periodontal diagnosis/treatment planning (HDG 621/Year II Periodontics Clinic)</td>
<td>Periodontal diagnosis/treatment plan type 2 (HDP 721)</td>
<td>Periodontal diagnosis/treatment plan type 3/4 (HDP 821, 822)</td>
<td>Periodontal evaluation of treatment (HDP 821, 822)</td>
</tr>
</tbody>
</table>
Goal 1: Educate dentists to become periodontists who are proficient in the diagnosis, treatment planning and therapies that define the specialty of periodontics.

Objective 1. To provide the postdoctoral students with an in-depth knowledge of relevant basic and biomedical sciences as they relate to the etiology, treatment and management of the periodontal diseases and interrelated systemic diseases and conditions, and dental implants.

Objective 2. To develop periodontists who are proficient with the diagnoses, treatment planning, and therapies of periodontal diseases and dental implants, employing the classic and current literature to support appropriate decision-making.

Objective 3. To evaluate postdoctoral students in appropriate methods of patient management and treatment planning through formal and informal opportunities to present, discuss and defend their patient care cases of record with periodontal faculty and their peers.

Objective 4. To provide the postdoctoral students with in-depth instruction and extensive clinical training in periodontal plastic surgery, oral reconstructive surgery and dental implants.

Goal 2: Educate postdoctoral students to be proficient in developing appropriate long-term maintenance therapy for their periodontal and implant patients.

Objective 1. To provide the postdoctoral students with an in-depth knowledge of the theory and practice of periodontics, including dental implants, pertinent to the provision of appropriate maintenance therapy.

Goal 3: Educate postdoctoral students in basic research methods related to periodontal research in order to critically evaluate the periodontal literature.

Objective 1. To provide the postdoctoral students with fundamental knowledge of biostatistics and research design, including the ability to conduct a literature review and critical analysis of new developments in periodontology.

Objective 2. To provide postdoctoral students with opportunities to conduct and publish research and matriculate into Stony Brook University postgraduate degree programs.

Goal 4: Prepare postdoctoral students for the achievement of diplomate status in the American Board of Periodontology.

Objective 1. To provide the postdoctoral students with the abilities, motivation and support to enter the board certifying process and with the knowledge and skills to become Diplomates.

Goal 5: Prepare postdoctoral students to integrate other disciplines to result in optimal comprehensive oral health care and to work in cooperation with referring dentists.

Goal 6: Encourage service to the profession including, but not limited to, didactic and clinical education, involvement in organized dentistry and outreach efforts.

CODA accredited programs must also document their effectiveness using a formal and ongoing outcome assessment process to include measures of advanced education student/resident achievement. As an example of compliance with this standard, the postdoctoral periodontal program at Stony Brook University uses the following outcome measures to evaluate the program’s effectiveness in meeting its goals and objectives:

1. Student evaluation of faculty and the program occurs at the end of each academic year.

2. Student academic performance is monitored through oral and written examinations, written papers, and class participation.

3. Student clinical performance is monitored continuously through the use of electronic records of completed procedures, quarterly reviews, and completed documented cases.

4. Evaluation of the student’s research activity is accomplished by assessing the quality of their oral presentations, and whether the resulting written manuscripts are accepted for publication in a professional journal.

5. Monitoring student performance in the American Academy of Periodontology In-Service Examination.

6. Each student must submit a portfolio that includes 20 case reports and Power Point presentations of their surgical seminars.

7. Students must satisfactorily complete an oral comprehensive examination, which consists of a student clinical case presentation, followed by a simulated American Board of Periodontology certifying examination evaluated by an examination committee of attending faculty.
8. Analysis of anonymous student evaluations of both didactic and clinical faculty and of the program evaluation questionnaire completed by each student upon graduation.

9. Evaluation of anonymous exit questionnaires completed by those patients who have received treatment by students of the advanced education program in periodontics.

10. The program maintains an active alumni association with annual meetings that serve as a venue for discussion and provide opportunity for program enhancement suggestions.

11. In order to receive feedback, we have implemented a survey of program graduates about their professional standing, diplomate status, faculty appointments, presentations at regional and national meetings, and retrospective evaluation of the faculty and program.

12. A formal annual review of the faculty is conducted by the program director that includes an evaluation of the prior year performance and discussion and suggestions for its enhancement in the next academic year.

The well-organized system of predoctoral periodontal education and advanced specialty education in periodontics in the United States is certainly not global. This is true for not only countries with emerging populations but also for highly developed countries. For example, although Japan has institutions that train qualified postgraduate students in the field of periodontics, Japan does not have well-organized advanced periodontal programs and standards for advanced specialty programs in periodontics that compare to those in the United States (Osawa et al., 2014). As indicated in Professor L. J. Lin's initiator paper, the inadequacy of periodontal dental curricula has led to the significantly less than optimal global oral health (Jin, Journal of the International Academy of Periodontology 2015; 17/1 Supplement). A major step to correct this issue would be the development of comprehensive standardized curricula for dental and advanced periodontal education programs that could use the CODA model as a resource. Each country would ideally establish its own accrediting agency to establish, maintain and apply relevant education standards. The process may be difficult among emerging populations due to resource and manpower issues. However, once initiated there will be tangible benefits toward evidence-based dentistry, with the elimination of variability of quality and contents among teaching programs that in time will lead to optimal global periodontal health.

References

Accreditation Standards for Advanced Specialty Education Programs in Periodontics. Commission on Dental Accreditation 2013; 1-34.
Department of Periodontology Stony Brook University Syllabus, 2014.
Osawa G, Nakaya H, Mealey BL, Kalkwarf K and Cochran DL. Specialty education in periodontics in Japan and the United States: Comparison of programs at Nippon Dental University Hospital and the University of Texas Health Sciences Center at San Antonio. Journal of Dental Education 2014; 78:481-495.
Group E
Consensus Paper
Interprofessional education and multidisciplinary teamwork for prevention and effective management of periodontal disease

Moderator: A. Kumarswamy, Yerla Medical Trust Dental College, India
Initiator: Jin, Lijian, The University of Hong Kong, Hong Kong, SAR, China
Reactor: Iacono, Vincent, Stony Brook University, USA

Working Group E:
Byakod, Girish, Rangoonwaala Dental College, India
Chiu, Gordon, Private Practice, Hong Kong
Duygu, Ilhan, Private Practice, Istanbul, Turkey
Fernandes, Benette, Srinivas Institute of Dental Sciences, India
Kemal, Yulianti, Universitas Indonesia, Indonesia
Loomer, Peter, New York University College of Dentistry, USA
Masud, Mahayunah, University Institute Technology Mara, Malaysia
Narongsak, Laorisin, Srinakharinwirot University, Thailand
Pillai, Nihar, Private Practice, India (Transcriber)
Shorab, Mohammed, Fiji National University, Fiji
Tan, Benjamin, National University of Singapore
Thakur, Roshni, DY Patil Dental College, India (Transcriber)
Xuan, Dong-Ying, Southern Medical University, China
Zhang, Jin Cai, Southern Medical University, China

Introduction
The background for this group’s discussion was presented in the Initiator’s review (Jin 2015). This paper focused on the key issues relating to interprofessional education and a multidisciplinary teamwork approach for the prevention and effective management of periodontal disease. A number of important issues were identified for effective periodontal management, including the role of general dental practitioners in identification of risk factors and risk management as well as the emerging evidence on the link of periodontal disease to a number of systemic diseases and conditions. The need for a multidisciplinary approach in managing periodontal patients through the teamwork among general dental practitioners, specialist dentists and medical practitioners was identified as key to successful treatment outcomes. An overarching theme of periodontal literacy for patients, dentists and allied health professionals was then developed. From this framework four key questions were identified for further discussion:

1. What are the challenges that we face to achieve global periodontal literacy?
2. What are the strategies which can be embraced to achieve global periodontal literacy?
3. What resources would be needed to achieve global periodontal literacy?
4. What would be the operational plan to achieve global periodontal literacy?

In these deliberations a prime consideration was the particular role, if any, that the International Academy of Periodontology (IAP) could play in these processes.
Definition of “global periodontal literacy”

Following some discussions the group agreed that global periodontal literacy should be defined as “the understanding and awareness of periodontal health and diseases by the dental profession and the public.”

Question 1. What are the challenges that we face to achieve global periodontal literacy?

This question needs to be addressed at a number of different levels that recognize that the challenges we face to achieve global periodontal literacy are present in dental education, the healthcare profession, regulatory agencies, governments and among the public.

With regard to the dental profession it was clear that there is a need to change the mindset and attitude of dental educators, students and practitioners to understand the importance of appropriate periodontal evaluation and patient management. In order to achieve this, the shortfalls in effective accreditation processes need to be overcome and processes that will ensure compliance of educational standards need to be in place. In order to maintain educational standards, core competencies for the delivery of periodontal care need to be established. This can best be achieved through the development of formative and summative assessment methods that ensure achievement of the competencies.

The public must also be educated to achieve global periodontal literacy. However, a number of obstacles have been identified that hinder the progress. Demographic, socio-economic and cultural diversity is always an issue as we try to gain acceptance by the public of good oral and periodontal health, and this is usually linked to a general lack of awareness of periodontal health and appreciation of the benefits of periodontal care. With the emergence of the electronic age and easy access to medical information via the worldwide web, the significance of the public obtaining misinformation from alternative resources is ever increasing. Finally, a general level of insufficient understanding of risk factors for periodontal diseases (i.e., smoking) continues to hamper efforts to fully inform the public regarding periodontal disease and its management. Clearly there are very significant issues with regard to behavioral modification and public understanding of periodontal disease and periodontal care.

Question 2. What are the strategies that can be embraced to achieve global periodontal literacy?

Strategies to address the above issues were determined to be leveled at the dental profession and the public. With regard to strategies to enhance the profession’s role in attaining global periodontal literacy, the group determined a number of approaches that should be considered. The formation of a pool of experts to develop and propose guidelines to achieve periodontal health was considered to be an essential starting point to achieve this goal. Through these panels, dental educators and practitioners could be fully informed at an evidence-based level on the ability of periodontal therapy to enhance the outcomes of dental treatments. Subsequently, models of formative and summative assessment methods should be developed to ensure the achievement of core competencies. In doing so, guidelines could be formulated for accreditation, which would promote the development of educational standards, their compliance and the identification of core competencies.

Other novel approaches to enhance the profession’s role in attaining global periodontal literacy included the establishment of an award system to recognize contributions to the achievement of global periodontal literacy. Furthermore, it was considered important to develop an interactive website by creating segments for the profession and to utilize the social media outreach to enhance the profession’s perception of the importance of periodontal health and care.

Strategies to enable the public’s role in attaining global periodontal literacy also require consideration of a number of approaches. In order to engage the public it was considered desirable to partner with stakeholders in developing an educational campaign. For example, media campaigns to improve public perception on the importance of periodontal health and care must be undertaken. By working with appropriate agencies access to periodontal care could be enhanced. It was considered desirable to change the mindset and attitude of the dental profession and to utilize the social media outreach to enhance public perception on the importance of periodontal health and care.

Question 3. What resources would be needed to achieve global periodontal literacy?

In order to achieve the above goals it was considered essential to recognize there will be significant resource implications. The greatest resource we have is the dedicated educators willing to participate in programs to train both dentists and the public. This resource must continue to be carefully nurtured to ensure the future is well supported by these experts. Contemporary education models must be adopted globally. For example, “vertical” models for dental education should be embraced, as they will enhance the training of dental students in a more holistic approach to patient care and management. In parallel with maintaining a good educational model and pool of educators, and notwithstanding the role universities play in this process, other sources of support must be recognized and developed.
These would include education and research foundations by recognized specialist bodies such as the American Academy of Periodontology, European Federation of Periodontology, Asian Pacific Society of Periodontology, and other regional dental and periodontal societies. The role of the media (both print and electronic) cannot be underestimated, and when further formulating the goals of global periodontal literacy this powerful conduit to the public must not be overlooked. In addition, government and non-government agencies could be pivotal in providing valuable resource support for our goal of global periodontal literacy. Finally, we cannot discount the valuable support that can be provided by commercial partners to achieve this goal. An excellent example of this is the outstanding support by the dental industry for this International Academy of Periodontology Conclave.

**Question 4. What would be the operational plan to achieve global periodontal literacy?**

In order to further this plan for global periodontal literacy, an action plan was discussed. Initial needs were identified for the IAP Board to prioritize the strategies for their implementation in a reasonable timeline and to identify the appropriate resources to achieve the goals. To ensure good ongoing outcomes these processes would need to be continuously assessed and reviewed.

**Recommendations**

From this consensus report the following recommendations are made to achieve global periodontal literacy:

1. **Role of the International Academy of Periodontology**
   - IAP to form a pool of experts to give guidelines for minimal and optimal periodontal health care, while considering logistical difficulties in different regions of the world.

2. **Training the educators for dental students**
   - Must be equipped with skills to train dental students to evaluate the periodontal status of their patients, including risk assessment and treatment planning.
   - Be able to help the students to understand the importance of assessing the periodontal needs of their patients.
   - Must have the necessary skills to evaluate and assess dental students’ knowledge of periodontal health care.
   - Be able to demonstrate to students the importance of interdisciplinary dentistry.
   - Be able to encourage students to participate in outreach/extension activities as expected by socially responsible clinicians.

3. **Training the educators for postgraduate/post-doctoral students**
   - Agencies need to be identified that would ensure postgraduate/post-doctoral periodontal educational standards on a global basis.
   - Development of an international pool of academic and clinical periodontists who would serve as a mentoring source for those programs in the process of either initiating and/or enhancing their postgraduate/post-doctoral programs. The IAP would be seen as a logical contributor to such a program.

4. **Research**
   - Research must be recognized as the cornerstone to advance periodontal health literacy.
   - International periodontal societies should pool their resources and knowledge to develop or initiate research protocols that could be universally applied for the enhancement of periodontal health. The IAP would be seen as an appropriate body to coordinate such a program.
   - Engagement of the corporate sector as a resource and mutual colleague should be encouraged so as to enable global research initiatives.

5. **IAP awards as an effective mechanism to enhance global periodontal literacy**
   - It was discussed and decided that awards at various levels could be granted to dental students, undergraduate/pre-doctoral and graduate/post-doctoral educators for the recognition of their achievements in educational and research programs related to periodontal education.
   - Incentives by the IAP for every institution through essays/competitions/projects for innovations in periodontal health care for all patient demographics from pediatric through geriatric patients.

**Reference**

Iacono, VJ. Enhancing global periodontal and oral health by standardizing education systems. *Journal of the International Academy of Periodontology* 2015;17/1 (Supplement):74-79.

IAP Meeting Chile 2015

Update and New Developments in Periodontics and Implants for the Specialist and General Dentist

Santiago - Chile
April 17th -18th / 2015

Aula Magna Universidad San Sebastián
Campus Bellavista, Bellavista N° 07 (intersection with Pio Nono)

Speakers:
Niklaus Lang; Thomas Van Dyke; George Hajishengallis; Gustavo Garlet; Ricardo Teles; Alp Kantarci; Sebastian Ciancio; Magda Feres; Ahmed Gamal; Mark Bartold; Anton Sculean; Vincent Iacono; Joerg Meyle; Lisa Mayfield; Jamil Shibli; Jorge Gamonal; Rolando Vernal; Fernando Fuentes; Gustavo Mazzey and Antonio Sanz

Poster competition: cash prizes for the outstanding poster presentations

Contact:
Romina Fiabane SPCh
02 - 23357692
soc.periodoncia@gmail.com

Registration Fees:
> students USD 200
> peridontal society members USD 250
> non members USD 300