CE article
The dental operating microscope in endodontics

trends & applications
Bioactivity in restorative dentistry:
A user’s guide

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Lecture programme, abstracts
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Dear readers and friends,

Welcome to ROOTS SUMMIT 2018! We are delighted to be in historic Berlin in Germany and to be hosting our meeting in the European School of Management and Technology (ESMT). This majestic building was the headquarters of the former German Democratic Republic State Council. The imposing architectural aesthetics of the building are spectacular. After the great success of ROOTS SUMMIT 2016 in Dubai, this year’s edition could not have found a more ideal location.

When introduced to ESMT, I was pleased to find that their focus is on three principles: leadership, innovation and analytics. These items have also been very much part of the DNA of ROOTS for the past 20 years. We are pleased to be able to have our event in a school setting that reflects our ideals too.

**Leadership** is shown by the over 50 countries represented at this meeting, guided by their top opinion leaders and most forward-thinking endodontists and dentists.

**Innovation** is what people are seeking whenever they attend a continuing education course, innovation in terms of treatment planning, visualisation, irrigation protocol, instrumentation, filling techniques, etc.

**Analytics** are key to any successful treatment and something that all ROOTS members take very seriously. Analysing what to do, what equipment to use, single appointment versus multiple, restorative options, etc. is a critical component in treating patients. The fact that ROOTS members confer with each other globally 24 hours a day speaks volumes to how seriously everyone attending the ROOTS SUMMIT regards the subject of planning endodontic treatments.

Dr David E. Jaramillo has organised a topical and relevant meeting with an extremely high level of scientific relevance. Our impressive list of some of the world’s leading endodontic speakers will translate the science to how it can benefit you by benefiting your patient. As is always the case at a ROOTS SUMMIT, we have speakers from multiple countries and backgrounds, including a mix of academia, education and clinical practice. In addition to the ten speakers David has organised for us, Dr Freddy Belliard has scheduled 17 diverse and unique hands-on workshops, some of which sold out well in advance of the SUMMIT.

To many participants, the highlight of a ROOTS SUMMIT is viewing the poster and case presentations submitted by their fellow members of the ROOTS Facebook group. Both of these competitions will take place on 29 June. We received an enthusiastic response and a very high level of submissions to participate in this part of the programme. David has narrowed it down to ten posters and ten presentations. Over the years, several of our main-stage speakers have come from this segment of the programme.

The entire programme, especially the hands-on workshops, would not be possible without the generous and unconditional support of our sponsors. Please spend some time talking to these kind people who support ROOTS on an ongoing basis and help make this meeting possible. You will be among some of the best and most knowledgeable people marketing endodontic products anywhere in the world, so please make good use of your time with these valuable partners. They are a great resource for knowledge and technique information. You will be surprised how much they also have to teach you.

We will have a very busy, interesting and extremely educational few days in Berlin. Thank you for joining us at ROOTS SUMMIT 2018!

Stephen Jones
Guest Editor
Co-Chairman of the ROOTS SUMMIT
editorial
Dear readers and friends
Stephen Jones (Guest Editor)

ROOTS SUMMIT special
Lecture programme, abstracts and speaker information

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Dr Frank C. Setzer

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Dr Georgi Tomov

technique
Cutting endodontic access cavities—for long-term outcomes
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tribute
“He brought a world of enthusiasm and knowledge to the global endodontic community”
Fred Michmershuizen

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### Hands-on courses

**Thursday, 28 June 2018**

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<th>Time</th>
<th>Session</th>
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<td>9:00–10:30</td>
<td>Modern instrumentation of the root canal—an introduction to the S1 reciprocation one file system with the efficient, flexible and safe S1 Plus files&lt;br&gt;Speaker: Johan Ohlin/Sponsor: Sendoline AB</td>
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<td>Impact of the dental operating microscope on the diagnostic and therapeutic stages of root canal therapy&lt;br&gt;Speaker: Dr Sergio A. Rosler/Sponsor: Seiler Instrument &amp; Mfg Co., Inc.</td>
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<td>Paradigm shift to 3-D endodontics: XP-endo sequence, anatomical shaping and cleaning with the exclusive adaptive core technology&lt;br&gt;Speaker: Klaus Lauterbach/Sponsor: FKG Dentaire S.A./American Dental Systems GmbH</td>
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<td>Technological advancements for safe root canal preparations: reciprocating preparation with simultaneous length determination&lt;br&gt;Speaker: Dr Mario Zuolo/Sponsor: VDW GmbH</td>
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<td>10:30–11:00</td>
<td>Coffee break</td>
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<tr>
<td>11:00–12:30</td>
<td>Technological advancements for safe root canal preparations: reciprocating preparation with simultaneous length determination&lt;br&gt;Speaker: Dr Mario Zuolo/Sponsor: VDW GmbH</td>
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<td>How to become a hero for your patients transforming endodontic failures into successful cases: 5 different uses of MTA in endodontics&lt;br&gt;Speaker: Dr Ricardo Tonini/Sponsor: Produits Dentaires SA</td>
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<td>Intraosseous anesthesia: the key for successfully and immediately anesthetizing hot pulps&lt;br&gt;Speaker: Dr Stéphane Diaz/Sponsor: Dental Hi Tec</td>
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<td>One file fits all? Facts and fiction&lt;br&gt;Speaker: Dr Bernard Bengs/Sponsor: Coltèn/Whaledent GmbH</td>
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<td>12:30–14:00</td>
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<td>14:00–15:30</td>
<td>A universal, safe and efficient combination for success in root canal treatment&lt;br&gt;Speaker: Dr Hugo Sousa Dias/Sponsor: Mani Inc.</td>
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<td>Irrigation: Past and current state&lt;br&gt;Speaker: Beatriz Del Valle/Sponsor: Neolix SAS</td>
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<td>Back to the roots: Retreatments done the easy way&lt;br&gt;Speaker: Dr Sebastian Bürklein/Sponsor: Komet Dental Gebr. Brasseler</td>
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<td>Value added cleaning and disinfection with Laser Activated Irrigation—new paths with PIPS and SWEEPS: evidence and critical analysis&lt;br&gt;Speaker: Prof. Roeland De Moor/Sponsor: Fotona d.o.o.</td>
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<td>15:30–16:00</td>
<td>Coffee break</td>
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<td>16:00–17:30</td>
<td>Treatment of endodontic perforations with bioceramic materials&lt;br&gt;Speaker: Dr Mario Zuolo/Sponsor: Angelus Industria de Produtos</td>
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<td>Root canal retreatment lectureship&lt;br&gt;Speaker: Dr Bing Fan/Sponsor: Zumax Medical Co, Ltd</td>
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<td>Morita TR ZX2: An innovative and clever device that saves time and increases safety&lt;br&gt;Speaker: Dr Sebastian Riedel/Sponsor: J. Morita Europe GmbH</td>
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<td>Obturation in 3-D continuous wave technique or hydraulic condensation: how, when and where?&lt;br&gt;Speaker: Dr Walter Vargas Obando/Sponsor: Meta Biomed Inc.</td>
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Lecture programme

ROOTS SUMMIT 2018

Day 1: Friday, 29 June 2018
08:45–09:00 Opening
Dr Freddy Belliard & Stephen Jones

09:00–11:00 Invasive cervical resorption: A clinical approach
Dr Elisabetta Cotti

11:00–11:30 Coffee break

11:30–13:00 Guided endodontics: Possibilities and limitations
Dr Gergely Benyőcs

13:00–14:00 Lunch break

14:00–16:00 Improve your microscope skills to improve outcomes
Dr Carlos Aznar Portoles

16:00–16:30 Coffee break

16:30–18:00 The role of bioceramics in clinical endodontics
Dr Josette Camilleri

Day 2: Saturday, 30 June 2018
09:00–10:30 Root canal therapy or vital pulp therapy? Success determined by proper diagnosis Opening
Dr Jenner Argueta

10:30–11:00 Coffee break

11:00–13:00 Pain and infection management in a contemporary endodontics office
Dr Jorge Vera

13:00–14:00 Lunch break

14:00–16:00 Improve your microscope skills to improve outcomes
Dr Carlos Aznar Portoles

16:00–16:30 Coffee break

16:30–18:00 The role of bioceramics in clinical endodontics
Dr Josette Camilleri

Day 3: Sunday, 1 July 2018
08:30–09:00 Results of poster competition and case presentations
Moderated by
Dr David Jaramillo

09:00–10:30 Reliable adhesive post-endodontic restoration in the hands of the endodontist
Dr Daniel Černý

10:30–11:00 Coffee break

11:00–13:00 Improving retreatment outcomes
Dr Mario Zuolo

13:00–14:00 Lunch break

14:00–17:00 The Art of Endodontics
Dr Stephen Buchanan

17:00–17:15 Closing
Dr Freddy Belliard & Stephen Jones
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Jenner Argueta
(Guatemala)
SPEAKER
Dr Jenner Oscarly Argueta completed his DDS at Universidad de San Carlos de Guatemala’s dental school in Guatemala in 2011. He also earned a master’s degree in endodontics from the same university in 2014. Since then, Argueta Zepeda has taught endodontics at the Universidad Mariano Gálvez de Guatemala in Guatemala. He has run a private clinical practice focusing on micro-endodontics and micro-restorative dentistry since 2011.

Argueta Zepeda has published scientific articles on root canal therapy and lectured at various events in Latin America, the US, the Middle East and Europe. He was elected the President of the Academia de Endodoncia de Guatemala (endodontic academy of Guatemala) in 2016. From 2012 to 2014, he was Assistant Professor of Endodontics at the University of Warwick in the UK.

Belliard is a member of the Spanish Dental Association and the Spanish Endodontic Society, and has owned a practice specialising in micro-endodontics, microsurgery and post-endodontic restorations in Guadalajara, Spain, since 1999. In addition, he moderates two endodontic social media forums, ROOTS and Endolatinos.

Gergely Benyőcs
(Hungary)
SPEAKER
In 2001, Dr Gergely Benyőcs graduated summa cum laude from Semmelweis University in Hungary and completed his master’s degree at the Department of Conservative Dentistry of the same university in 2003.

He specialises in endodontic treatment and is the owner of the PreceDent dental center in Budapest, Hungary, which offers high-level endodontic treatment using a microscopic approach and cutting-edge technology. Benyőcs lectures both nationally and internationally.

Freddy Belliard
(Mexico)
CHAIR
In 1997, Dr Freddy Belliard graduated from the Pontificia Universidad Católica Madre y Maestra in Santiago, Dominican Republic, at which he also served as a professor from 1999 to 2005. He received his master’s degree from the Instituto de Estudios Avanzados en Odontología “Dr. Yury Kuttler” in Mexico City in 1999 and his D.D.S. from the European University of Madrid in Spain in 2009. From 2012 to 2014, he was Assistant Professor of Endodontics at the University of Warwick in the UK.

Belliard is the co-chairman of the 2018 ROOTS SUMMIT in Berlin.
Stephen Buchanan
(USA)
SPEAKER
Dr Stephen Buchanan received his dental degree in 1978 from the University of the Pacific Arthur A. Dugoni School of Dentistry, San Francisco, CA, where he was Valedictorian of his class. In 1980 he completed the endodontic graduate programme at Temple University in Philadelphia, PA.

He began pursuing three-dimensional anatomy research early in his career. In 1986, he became the first person in dentistry to use micro-computed tomography technology to show the intricacies of root structure.

In 1989, he established Dental Education Laboratories (DEL) a state-of-the-art training facility devoted to hands-on instruction where he teaches endodontic treatment, retreatment and segmented file retrieval. In addition to hands-on training courses at the DEL campus in Santa Barbara, California, Dr Buchanan is a frequent guest lecturer and live demonstration presenter for the ADA, AAE, AAED, AGD as well as for numerous dental societies around the world. He is a regular contributor to Dentistry Today and various endodontic journals as well as a contributing author to Pathways of the Pulp. Early in his career, Dr Buchanan identified the power of video and film media in training, and produced the award-winning video series, The Art of Endodontics.

Dr Buchanan holds a number of patents for dental instruments and techniques. Most notably, he was the first to introduce variable-tapered instruments for use in endodontic therapy and pioneered a system-based approach to treating root canals.

Dr Buchanan’s most recent work in hands-on training is the development of 3-D printed surgical training replicas: TrueTooth and TrueJaw. These 3-D printed replicas are anatomically precise human teeth and jaws—perfect for teaching endodontic therapy, implantology, prosthodontics and general restorative procedures. TrueTooth and TrueJaw radiograph accurately with 2-D and 3-D imaging. TrueJaw replicas have separately segmented cortical and trabecular bone, periodontal ligaments, and gingiva tissues with elastic PDL’s, providing a life-like oral surgery procedure experience. TrueJaw and TrueTooth are produced and sold by Dr Buchanan’s research and development company, Dental Engineering Laboratories, LLC.

Dr Buchanan is a Diplomate of the American Board of Endodontics and a Fellow of the International and American Colleges of Dentists. He currently serves as Clinical Guest Professor at the University of Southern California School of Dentistry and the University of California at Los Angeles School of Dentistry, and as Guest Lecturer, Loma Linda University School of Dentistry.

Dr Buchanan maintains a full-time private practice limited to endodontics and implantology in Santa Barbara, California, USA.

Josette Camilleri
(Malta)
SPEAKER
Dr Josette Camilleri studied dental surgery at the University of Malta; her doctoral degree was supervised by the late Prof. Tom Pitt Ford from King’s College London Dental Institute in the UK. She has worked at the Faculty for the Built Environment of the University of Malta and is currently an associate professor at the Faculty of Dental Surgery of the same university.

Camilleri specializes in dental materials and her main research interest is mineral trioxide aggregate. She is the editor of the book Mineral Trioxide Aggregate in Dentistry: From Preparation to Application (Springer, 2014). She contributed chapters to Harty’s Endodontics in Clinical Practice, edited by Prof. Bun San Chong, and Glass-Ionomers in Dentistry, edited by Dr Sharanbir K. Sidhu. Additionally, she has published over 90 papers in peer-reviewed international journals, is a reviewer for a number of international journals and lectures.

Daniel Černý
(Czech Republic)
SPEAKER
Dr Daniel Černý received his dental degree from the Charles University’s Faculty of Medicine in Hradec Králové, Czech Republic, in 1998. Between 1998 and 2007, he worked as an assistant professor at the same faculty. He is currently completing his doctoral degree with a focus on adhesive post-endodontic treatment at Palacký University Olomouc in the Czech Republic. Since 2001, he has maintained a private practice limited to adhesive dentistry and endodontics in Hradec Králové.

Černý has been the President of the Czech Endodontic Society since 2015. He was the co-founder and first President of the Česká akademie dentální estetiky (Czech academy of dental aesthetics) from 2007 to 2009.
From 2009 to 2013, he served on the editorial board of LKS—Časopis České stomatologické komory (journal of the Czech Dental Chamber). He is also the co-founder of the Dental Summit congress in Prague, Czech Republic. He has been the co-owner and director of the HDVI continuing education institute since 2010. Černý has contributed four chapters to dental books and lectures both nationally and internationally.

Elisabetta Cotti
(Italy)
SPEAKER
Dr Elisabetta Cotti received her DDS from the University of Cagliari in Italy. In 1991, she received a certificate and a master’s degree in endodontics from the Loma Linda University in the US. She is the chair of the department of conservative dentistry and endodontics at the school of dentistry and director of the one-year postgraduate programme in endodontics at the University of Cagliari. She also teaches in the Advanced Education Program in Endodontics at the University of Bologna in Italy and is a lecturer in the Department of Endodontics at the Loma Linda University. She also works in a private practice limited to endodontics.

Cotti is the author of several papers in the field of endodontics and has a specific interest in periapical pathology, immature teeth, complex case management, imaging techniques, and interactions between periapical periodontitis and systemic conditions. She is an active member of the Italian Society of Endodontics, at which she has served as executive member for ten years, and a member of the European Society of Endontology, at which she has served as country delegate for seven years. She is the past President of the Societá Italiana di Traumatologia Dentale (Italian society of dental traumatology).

David E. Jaramillo
(USA)
CHAIR
Dr David E. Jaramillo is Associate Professor of Endodontics at the University of Texas Health Science Center at Houston in the US.

He obtained his D.D.S. in 1986 from the Universidad Autonoma de Guadalajara in Mexico, where he also completed his postgraduate training in endodontics 1990. He was formerly Clinical Assistant Professor of Endodontics at the University of Southern California, Los Angeles, and Loma Linda University. He was the Clinical Director of Endodontics, endodontics course director in the International Dentist Program and a researcher at the Center for Biofilms USC and Center for Dental Research at Loma Linda University.

Jaramillo has lectured at meetings of endodontic associations in 12 countries and has published more than 20 peer-reviewed papers and six book chapters. Dr Jaramillo is the official Scientific Chairman of the ROOTS SUMMIT 2018 in Berlin.

Stephen Jones
(USA)
CHAIR
During a 30-year career in dental sales, Stephen Jones has been fortunate to hold positions with many different areas of responsibility, particularly various sales and marketing roles in the dental field. Jones is currently responsible for international sales in Asia and Latin America at Centrix Dental, and is the co-chairman of the 2018 ROOTS SUMMIT in Berlin.

John Munce
(USA)
SPEAKER
Dr C. John Munce received both his dental degree and his training in endodontics from Loma Linda University in the U.S. Munce is Professor of Graduate Endodontics at both Loma Linda University and the University of Southern California in the US. He is also founder and CEO of a clinical endodontics products company, CJM Engineering.

Munce is a frequent international lecturer and the primary author of the chapter “Preparation for endodontic treatment” in the 50th anniversary seventh edition of Ingle’s Endodontics. Clinical concepts and techniques originated by Munce have been published in a number of primary endodontic textbooks, most recently in the sixth edition of Ingle’s Endodontics and the tenth edition of Pathways of the Pulp, and he co-authored a chapter on mineral trioxide aggregate repair of post perforations in Dr Nadim Baba’s prosthodontics textbook Contemporary Restoration of Endodontically Treated Teeth. Munce is a Diplomate of the American Board of Endodontics, a Fellow of the International College of Dentists and past President of the California State Association of Endodontists.
Carlos Portoles (Spain)  
SPEAKER  
Dr Carlos Aznar Portoles received his BDS from the International University of Catalonia in Spain in 2004. In 2009, he completed an MSc programme in endodontics at the same university. In 2014, he completed a postgraduate programme in endodontics at the Academic Centre for Dentistry Amsterdam in the Netherlands.

Aznar Portoles has been practising as a general dental surgeon for Integrated Dental Holdings since 2004. He also currently runs a private practice limited to endodontics and endodontic microsurgery in Santpoort-Zuid, Netherlands.

He is the author of several endodontic-related articles and lectures regularly at national and international meetings.

Jorge Vera (Mexico)  
SPEAKER  
Dr Jorge Vera graduated from the National Autonomous University of Mexico in Mexico City in 1989. In 1993, he received a postgraduate endodontic certificate from the Tufts University School of Dental Medicine in Boston, Massachusetts, in the US.

Vera teaches endodontics at the Universidad Autónoma de Tlaxcala in Mexico and has been running a private practice limited to endodontics since 1993.


Mario Zuolo (Brazil)  
SPEAKER  
Dr Mario Zuolo gained his DDS from the University of São Paulo in Brazil in 1981. Afterward, he specialised in endodontics. He completed a master’s degree in molecular biology at the Federal University of São Paulo in Brazil. Thereafter, he earned a PhD in clinical dentistry with a special focus on endodontics from the University of Campinas’s School of Dentistry of Piracicaba in Brazil.

Zuolo was a teaching fellow in endodontics at the University of Iowa College of Dentistry in the US and Professor of Endodontics at the school of professional development of the Associação Paulista de Cirurgiões-Dentistas (São Paulo dental association) in Brazil. He has a private practice limited to endodontics in São Paulo.

Zuolo has written several scientific articles and lectures nationally and internationally on endodontic clinical topics focusing on contemporary endodontic treatment and retreatment. He is a co-author of the book Reintervention in Endodontics (Quintessence, 2014), which has also been published in Spanish, Portuguese, Greek, Russian and German.
### Invasive cervical resorption: A clinical approach
**Dr Elisabetta Cotti**

Invasive external cervical resorption is a dangerous form of invasive root resorption with an etiology that is still unclear, but often related to traumatic injuries of the teeth, ranging from mild to acute events. If not detected and treated, it may lead to tooth loss. This pathology is not easy to detect and define, and diagnosis requires a careful clinical examination, an evaluation of the history of the tooth and the use of advanced radiographic techniques.

As far as treatment is concerned, the resorptive process should be interrupted. Root canal therapy may be required, and it should ensure good disinfection of the root canal system and optimal sealing of endodontic–periodontal pathways. Further treatment may require surgical intervention. Bioactive cements are useful in this treatment approach.

### Guided endodontics: Possibilities and limitations
**Dr Gergely Benyőcs**

Guided endodontics could be a future tool for both specialists and general practitioners to carry out more conservative endodontic treatment in a feasible way. In this presentation, Dr Gergely Benyőcs will share his experience in guided endodontics, considering the most recent evidence in the literature. He will point out the possibilities and limitations of this procedure, illustrated by successful cases and failures.

### Root canal therapy or vital pulp therapy?
**Success determined by proper diagnosis**
**Dr Jenner Oscarly Argueta Zepeda**

When it comes to the prevention or management of periapical pathosis, the job of an endodontist involves more than just providing root canal therapy. The primary aim should be a first-step intervention focused on the treatment of the disease located in the pulp tissue, providing a proper environment to allow recovery of the damaged tissue.

The main goal of this lecture is to provide clinical and scientific information regarding the clinician’s decision between a conventional root canal therapy and giving the pulpal tissue the opportunity to survive, with subsequent multiple benefits for the patient.

At conclusion of the lecture, participants should be able to:

- list the clinical criteria for a reliable long-term prognosis for vital pulp therapy clinical cases;
- assess the biological mechanisms that current materials provide for pulp tissue recovery and reparative/reactive dentine bridge formation; and
- describe all factors to be considered in deciding whether a case is a good candidate for root canal therapy or a vital pulp therapy procedure.
11:00–13.00
Pain and infection management in a contemporary endodontic office
Dr Jorge Vera
This lecture is designed to address common problems in diagnosis encountered when dealing with patients presenting with symptoms mimicking odontogenic pain. Most of those patients have undergone multiple dental interventions, which have resulted in exacerbation of their symptoms rather than relief. Neurovascular orofacial, and neuropathic pain syndromes are some examples.

The second part of the lecture will deal with common anaesthetic problems and how to solve them, as well as a rationale for the use of analgesics and antibiotics in an endodontists office.

14:00–16:00
Improve your microscope skills to improve outcomes
Dr Carlos Aznar Portoles
The dental operating microscope is widely used in endodontics, but not always in the most effective manner. In this lecture, Dr Carlos Aznar Portoles will describe how the endodontist and his or her team can use the microscope most efficiently. He will provide guidance on how the clinician can improve his or her microscope skills and will describe common mistakes and how they negatively affect the workflow. He will describe how proper use of the microscope can improve clinical results, reduce stress, and help avoid neck and back pain, which is common among dental practitioners.

16:30–18.00
The role of bioceramics in clinical endodontics
Dr Josette Camilleri
Bioceramics are a new range of endodontic materials. These materials have a specific chemistry and microstructure. They are based on tricalcium silicate and contain additives to enhance the material properties in clinical use. It is important that a clinician be able to differentiate between the various material types and appreciate that the material’s composition plays a role in its performance clinically.
The practice of endodontics requires precision and great attention to detail. These depend on the training, skills and experience of the clinician. Most endodontic procedures are carried out in dark and confined places, and fractions of millimetres may decide the outcome of treatment. Over the past decades, endodontics has gained not only basic and clinical scientific knowledge, but also has taken technological quantum leaps. Due to the intricate nature of endodontic treatment, practitioners have always sought to improve their vision of the operational field.

Advantages of dental microscopes

Better vision requires enhanced magnification and illumination, and both microscopes and loupes have been widely adopted. Operating microscopes have a number of advantages compared to loupes. Loupes are worn on the head and may be used with or without external light sources. This necessitates weight limitations and restricts the oculars to the bare minimum of lenses needed for magnification. By contrast, the microscope is a self-supported unit; therefore, additional lenses or prisms are not a concern. This has meaningful implications with regard to ergonomics and visualization.

The attachment of loupes to glasses dictates a design that angles the binoculars inward in order for the viewer to focus on the object. As a result, the practitioner’s eyes also rotate medially. This is similar to near object accommodation by the naked eye which can lead to eye muscle strain and fatigue. By contrast, microscope binoculars are arranged in a parallel orientation. This arrangement is facilitated by prisms that let the incoming light beams reach the eyes also in a parallel direction. This simulates the observation of a distant object: a straight, forward-looking gaze that causes less muscle stress and fatigue. In addition, from an ergonomic perspective, working correctly with a dental microscope improves overall body posture and may reduce neck and back pain.

Commercially available microscopes provide adjustable magnification ranging from approximately 4 x to 25 x magnification, while most loupes provide fixed magnification between 2.5 x and 6 x. Magnification can be divided in low magnification (~ 2 x–8 x), mid magnification (~ 8 x–16 x), and high magnification (~ 16 x–25 x). Low, mid and high magnification are applicable for different procedural steps throughout nonsurgical and surgical endodontic treatment. Low magnification is mainly applicable for an overview of the operating field. Mid magnification is used for the main procedural steps throughout root canal therapy and endodontic surgery. High magnification is used for the identification of minute structures and documentation of the finest details. Using a microscope significantly increases a practitioner’s accuracy. However, it must be mentioned that there is a learning curve and working at both mid and high magnification will...
require the practitioner to slow down movements to avoid unintended actions on the smallest of anatomical structures. As a result of working in a small-scale environment, new types of micro-instruments also were introduced to the dental profession.

History of microscopes in endodontics

The idea of using microscopes in dentistry is not new. Bowles suggested and used a dental microscope as early as 1907. In endodontics, dental operating microscopes were first introduced by individual clinicians and then adopted by endodontic specialty programmes throughout the United States. The American Association of Endodontists was an early proponent of training in microscopes for endodontic residents and successfully advocated for the Commission on Dental Accreditation to include a microscope proficiency standard to the CODA educational standards for postgraduate endodontic programmes in 1998. The latest standard requires the teaching of magnification devices “beyond that of magnifying eyewear” at an in-depth level, which is the highest of the levels of knowledge prescribed by CODA. Based on two surveys in 1999 and 2008, the accessibility and use of the microscope by endodontists increased from 52 per cent to 90 per cent. It is now also increasingly being used by other specialties and in dental education.

Microscope use for nonsurgical procedures

For the endodontic practitioner, the dental microscope is useful for diagnosis and clinical procedures. The microscope may aid diagnostically in identifying caries, insufficient crown or restorative filling margins (Fig. 1), or assessing craze or fracture lines. During root canal therapy, magnification and illumination provided by the operating microscope aids with caries removal, access preparation, removal of pulp chamber calcifications, identification of root canal orifices, identification of cracks and fracture lines (Fig. 2), and the treatment of internal resorptions. Under the microscope, subtle changes in dentine colour and texture become apparent, such as developmental lines on the pulp floor guiding the practitioner towards root canal orifices, or the darker colour of the pulp floor itself, allowing the practitioner safer dentine removal.

High magnification can help in the localisation and instrumentation of obstructed and calcified canals, the
identification of canal bifurcations (Fig. 3), the removal of canal obstructions such as denticles and calcifications, and obturation (Figs. 4a & b). Additional primary endodontic procedures benefitting from microscope use include vital pulp therapy and regenerative endodontics by allowing careful and gentle manipulation of the pulpal tissues or a blood clot, respectively. Enhanced vision also aids in the treatment of dental anomalies, such as dens invaginatus, or fused teeth.

In endodontic retreatments, the microscope is helpful in identifying and removing leftover filling materials, such as sealer remnants, pastes or gutta-percha, silver points and carrier-based materials, posts or fractured instruments (Figs. 5a–d). It also aids in nonsurgical perforation repair, allowing the practitioner to clean the perforation site and place the perforation repair material more precisely.

Microscope use for surgical procedures

Surgical endodontics has been completely transformed by microscopic procedures. For many years surgical burs and amalgam for root-end fillings were the standard of care. The incorporation of the microscope, and also to a certain degree the endoscope, together with the use of ultrasonic tips and biocompatible filling materials, has evolved the classical apicoectomy into modern endodontic microsurgery. All steps of endodontic microsurgery are carried out under varying degrees of magnification, including flap preparation, osteotomy, identification of root apices, root-end resection, inflammatory tissue removal, observation of the resected root surface (Fig. 6), root-end preparation, root-end filling, and suturing. The microscope is also helpful for cervical or external resorption or perforation repairs.

Treatment effects

There has been great debate over whether the use of magnification would actually increase the success rate of endodontic procedures. It is an accepted fact in endodontics that microbes and their endotoxins are responsible for the majority of inflammatory periapical lesions. Healing of these lesions in cases of a diagnosis of pulp necrosis has been associated with disinfection of the root canal system, reduction of the microbial content, filling of the root canal system and the permanent restoration of the tooth. It is thus assumed that the identification and treatment of all parts of the root canal system increase the chances of a successful treatment and good long-term prognosis. Ample literature has been published with regard to the identification of additional canals with the help of higher magnification and illumination. The effectiveness of vision enhancement for the detection of second mesiobuccal canals (MB2) in maxillary molars was assessed both in vitro and in vivo. The detection rate of MB2 canals in vitro was shown to be 90 per cent with the operating microscope and 52 per cent without aided vision. Gorduysus et al. demonstrated that the percentage of MB2 canal negotiation increased with the aid of higher magnification. Burley et al. described the successful identification of MB2s in 312 maxillary first and second molars in 57.4 per cent of the cases when using the operating microscope, 55.3 per cent with dental loupes and 18.2 per cent with unaided vision. In first maxillary molars, the incidences of MB2 identification were 71.1 per cent, 62.5 per cent and 17.2 per cent for the microscope, dental loupes and no magnification groups, respectively. Stropko treated a total 1,732 maxillary molars working at times with unaided vision and at times with a dental microscope. With more experience and a dental microscope, the incidence of locating MB2 canals increased from 73.2 per cent to 93.0 per cent in first molars and from 50.7 per cent to 60.4 per cent in second molars. Microscope use also increased the number of root
canal orifices located in mandibular molars, and significantly increased the quality of access cavity preparation and the accuracy of canal identification when treatment was performed by dental students recently instructed in microscope use.

**Nonsurgical treatment outcomes**

It was long uncertain if microscope usage resulted in improvements in nonsurgical treatment outcomes. Del Fabbro et al. conducted two Cochrane Reviews, in 200923 and 201524, to identify randomized controlled trials and quasi-randomized controlled trials comparing endodontic therapy performed with or without one or more magnification devices. Neither in 2009, nor in 2015, were the authors able to identify a single study reporting the outcome of either nonsurgical or surgical endodontic therapy matching the strict criteria put forward in their study. Hence, the authors concluded that it was unknown if and how any magnification device affected the treatment outcome, in particular, since a great number of factors besides the microscope can have a significant impact on the success of endodontic procedures. The authors suggested future long-term, well-designed randomized clinical trials. Recently, however, a study published by Monea et al.25 assessed the impact of the operating microscope on the outcome of nonsurgical treatments of a consecutive series of 184 comparable teeth diagnosed with pulp necrosis and chronic apical periodontitis performed by postgraduate students. Success was defined as a decrease or disappearance of the radiolucency following the recommendations of the European Society of Endodontology. After follow-up periods of six months and 18 months there were significant differences between microscope and control groups, with 94.8 per cent versus 87.5 per cent (healed and improved) at six months, and 95.9 per cent and 91.9 per cent at 18 months. At 18 months, 89 per cent of cases available for follow-up in the microscope group were classified as completely healed.

**Surgical treatment outcomes**

Another systematic review by del Fabbro et al.26 to investigate the use of magnification devices in endodontics identified three prospective clinical trials evaluating the outcomes of endodontic surgery. The authors were unable to identify significant differences in outcomes depending on treatment with loupes, microscope or an endoscope and suggested that different magnification devices could only minimally affect the outcome. In two meta-analyses, Setzer et al. described the differences in outcome of three techniques for endodontic surgery.27,28 Investigated were clinical studies that applied traditional endodontic surgical techniques (TRS), including 12 studies with a total sample size of 925 teeth using no magnification, straight surgical handpieces and amalgam root-end filling and a cumulative success rate of 59.0 per cent; seven studies using contemporary surgical procedures (CRS) with a collective sample size of 610 teeth, employing magnifying loupes, ultrasonic root-end preparation and biocompatible filling materials and a cumulative success rate of 88.1 per cent; and nine studies on endodontic microsurgery (EMS) with a total of 699 teeth using the identical techniques as CRS with the only differences being the use of high-power magnification devices such as microscopes or endoscopes instead of loupes and a cumulative success rate of 93.5 per cent. The cumulative success rate of the EMS group was significantly higher than the CRS group, which only employed loupes, and the TRS group, which used no magnification. The EMS group combined studies that employed both the dental microscope and the endoscope. It needs to be mentioned that these studies are comparable as both microscopes and endoscopes provide high-power magnification and illumination and also because the microscope is used for the majority of the steps of the surgical procedure in the studies where an endoscope was used during root-end preparation. The endodontic microsurgery procedures demonstrated significantly better cumulative success rates than the studies that only employed loupes when all 16 studies with a total of 1,309 teeth were compared. Seven of 16 studies provided information on the individual tooth type (four for CRS and three for EMS), demonstrating a significant difference in probability of success between the groups for molars. Tsesis et al.29 provided an updated systematic review on endodontic surgery in 2013 and also confirmed a statistically significant difference in successful outcomes of both microscope and endoscope-assisted procedures compared to loupes.

**Microscope features and upgrades**

Modern dental microscopes have evolved considerably with regard to features and options available to the dental clinician. Depending on personal preferences and possible locations in the operatory, floor-standing, wall- or ceiling-mounted units are available. While standard microscopes come with basic optics and light options, certain accessory features are recommended for endodontic purposes. Surgical procedures will require greater angulations to view resected root surfaces and other surgical details. At a minimum, a microscope should be equipped with 180-degree-tiltable binoculars to address the angulation requirements and an eyepiece with a reticle. A reticle is a set of fine lines, most commonly in the shape of crosshairs or concentric rings, that provides proper centering on the object in focus and allows for easier individual calibration (parfocaling) of the microscope. It also is an indispensable tool for documentation. Since light and the object image reach the binoculars virtually free of shadows, microscope photography and recording allow for excellent image quality for docu-
mentation and clinical operations. However, this requires perfect calibration with an external monitor and a reticle to center the image. Full high-definition and three-chip cameras are the gold standard for video recording and available as external or internal solutions. Screenshots from video recordings can be obtained at higher quality by using post-processing software applications that allow for image stacking. For still photography new generation digital mirrorless cameras have demonstrated advantages compared to DSLRs.

There is a variety of additional upgrades for core microscope functions. Instead of fixed focal distances that limit the microscope to an object distance of 200 mm, 250 mm or 300 mm, variable focal distance adapters have become available, allowing for easier switching between practitioners and easier adjustment to patients of different statures. These are offered in top-of-the-line microscopes, often in conjunction with electrical zoom and fine focus options that allow smooth and stepless adjustments of both magnification and focus. Extendable (foldable) binoculars were introduced for better ergonomics. Magnetic arrest functions (clutch) are available for increased stability, particularly for microscopes with several documentation ports and attachments. The practitioner can choose from a variety of light sources. The traditional standard is still halogen (yellowish hue, peak at 600–700 nm, ~3,300 K) and the brightest option is xenon (like daylight, homogeneous spectrum 400–700 nm, ~5,500 K), making it most useful for the identification of fine details in deeper areas of the root canal system and documentation. Recently LED lights (green part of emission spectrum, low at 450 nm and 550 nm, ~5,700 K) became available and offer a significantly longer lifetime, however, at a reduced brightness compared to xenon.

Case study

Mandibular right first molar, nonsurgical root canal treatment had been completed five years ago. Originally, a new crown restoration had been planned. However, the periapical radiograph revealed periradicular radiolucencies (periapical and in the furcation area; Fig. 7). The patient received a recommendation to extract the tooth due to the bone loss in the furcation. There were no symptoms and periodontal probing depths were within normal limits, suggesting an endodontic problem as the origin of the furcation defect. Nonsurgical retreatment was initiated. The clinical image shows the previously treated four canals with infected gutta-percha filling (Fig. 8). Under high magnification, a furcation canal (Fig. 9, arrow) and a third distal canal (Fig. 10) were located.

The postoperative radiograph shows the retreated tooth with five main canals (Fig. 11). The one-year follow-up radiograph demonstrates the complete resolution of the periradicular radiolucencies and permanent restoration of the tooth (Fig. 12).

Conclusion

The dental operating microscope has become an integral part of endodontic practice. For both nonsurgical and surgical endodontic therapy it is indispensable for excellency. Besides the obvious benefits for clinical practice, evidence has become available that demonstrates better outcomes compared to treatment without vision enhancement or magnifying eyewear. Treatment rendered using the dental operating microscope results in superior care for patients, and modern endodontic therapy is more effective because of its use.


References

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Nd:YAG laser-assisted removal of instrument fragments

Dr Georgi Tomov, Bulgaria

The Nd:YAG lasers tested in laboratory studies have been claimed to be able to successfully manage the removal of instrument fragments within root canals. This is done in four ways, all correlated to temperature effects:

1. Laser melts the dentine around the fragment and then Hedstrom files are used to bypass and retrieve the fragment.
2. Laser melts the entire fragment.
3. Laser energy melts the solder, connecting the fractured instrument with a brass tube charged with solder and placed at the exposed coronal end of the fragment.
4. Laser welds the file fragment positioned within a metal hollow tube (e.g. Endo-Eze® Tip, Ultradent Products; Figs. 1a & b).

The removal of a claimed minimum amount of root dentine can be attributed to the potential given to the user of Nd:YAG laser to distinguish dentine from obstructions by the difference in acoustics produced by the two materials. Ebihara et al. observed that some orifices of the dentinal tubules were blocked with melted dentine after laser irradiation. Yu et al. found that the temperature rose by 17°C to 27°C, but argued that, since the initial temperature was lower than human body temperature, these results were irrelevant.

The findings demonstrated that a pulsed Nd:YAG laser irradiation has the capability of removing broken files. The success rate reported by Yu et al. was 55 per cent. However, the thermal effects found after Nd:YAG irradiation in dry root canals were considerable (Figs. 2a–c). Thus, the focus now is on the outcomes of using a laser fibre inserted into a hollow tube (alone or in the presence of solder) both to avoid dentinal carbonisation and to achieve welding between the separated file and metal tube.

Intraoral laser welding

The intraoral laser welding phenomenon is well researched. Even for metals that absorb well, such as steel, the laser light is initially reflected. A small percentage...
of the laser light is absorbed, heating the metal surface. The increased surface temperature increases the absorption of the laser power. This creates a snowball effect, in which the material is rapidly heated by the laser, leading to melting and the consequent formation of a weld.

Hagiwara et al. performed laser welding on stainless steel or nickel-titanium files using an Nd:YAG laser in order to evaluate the retention force between the files and the metal extractor. Additionally, they evaluated the increase in temperature on the root surface during laser irradiation. They reported that the retention force on stainless steel was significantly greater than that on nickel-titanium. The maximum temperature increase was 4.1 °C. The temperature increase on the root surface was greater in the vicinity of the welded area than at the apical area. Scanning electron microscopy (SEM) revealed that the files and extractors were welded together. Similar results were found by Tomov (unpublished data; Fig. 3).

In vitro study

Cvikl et al. used a brass tube charged with solder and placed at the coronal end of the fractured instrument in their in vitro experiment. Nd:YAG laser energy was used to melt the solder, connecting the fractured instrument with the brass tube. They reported that the fractured endodontic instruments were removed successfully in 17 out of 22 cases (77.3 per cent) in which more than 1.5 mm was tangible. When less than 1.5 mm was tangible, the removal success rate decreased to three out of 11 cases (27.3 per cent).

These results obtained from in vitro experiments indicate that the laser welding method is effective in removing broken instruments from root canals, but its efficacy has to be further verified in clinical trials.

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Fig. 3: SEM image of a K-type file after Nd:YAG laser irradiation at 400 mJ and 10 Hz revealing a melted metal surface with an irregular granular structure after solidification.
Cutting endodontic access cavities —for long-term outcomes

Dr L. Stephen Buchanan, US

Errors accumulate during procedures. That’s the reason botching the access at the start of an RCT is so much more devastating than say, problems that come from misfitting a gutta-percha cone just before finishing the case. Miss a canal and the case is going down, regardless of how brilliant the remaining procedure is carried out. Perforate the tooth, and suddenly titanium starts looking better. Cut huge access cavities, and expect to see relatively huge numbers of root-fractured teeth within five years of treatment. Simply cheat the access procedure by beginning the instrumentation of canals before a straight, perfectly smooth path has been cut to each canal orifice, and be punished every time a file, an irritating needle, an explorer, a gutta-percha point, a paper point or a plugger is taken into each of the canals scores of times.

This is not a critique so much as an admission of the ways that teeth and their root canal systems have taught me, usually the hard way, to spend whatever time is needed to create perfect entry paths into canals, before I attempt to work in them. So why do I have to have a talk with myself before beginning every access cavity—even after doing this for 35 years—to be certain to hit the mark I know must be met before it is safe to venture further?

Zen and the art of endo access

Robert Persig, in his book Zen and the Art of Motorcycle Maintenance, described being deeply frustrated when a bolt stripped as he was attempting to remove the side covers to the engine of his motorcycle, before rebuilding it. The rebuild could not continue until he was able to circumvent this problem. He had expected to spend several days completing the mission, yet he was amazed at the fury he experienced when faced with this conundrum.

The more he thought about it, the more mystified he became about his instinctual response, until he realized that he was tweaked because he had grossly under-valued this part of the long rebuild procedure, thinking mostly about the more dramatic routines to follow, such as cracking the cylinder case, honing the cylinder, replacing the piston and putting it all back together afterward.

When he realized that nothing was going to progress until he had successfully removed the side cover, he made removing that side cover a separate and important mission, an accomplishment that would deliver satisfaction in and of itself, if it could be completed during the next several hours spent.
So it is with endodontics. When we realise how critical the quality of our access preparations is to the remainder of the case, it feels like fingernails on a chalkboard to head into a canal before securing an ideal path into it. Aristotle got it right—excellence is a habit, not a character trait. So what do the habits of access excellence look like in this 21st century?

Failing to plan is planning to fail

Atul Gawande, in his book *The Checklist Manifesto,* describes the importance of planning not just which procedure to do, but how every single aspect of that procedure must be planned in detail, from start to finish, if consistently ideal results are the goal.

Does the preoperative imaging accurately describe the anatomical challenges? Does the clinician have adequate magnification and light? Are the cutting tools adequate and well chosen? Are the locations, angles and depths of entry determined before beginning the procedure? Have maximal safe cutting lengths been marked on access burs? Are there procedures in place to deal with calcified canals that defy location? And so on.

In other words, the Alfred E. Neumann attitude of “What, me worry?” is not appropriate during this critical event. Conversely, when each of these critical elements is included in the treatment planning and execution of an ideal access cavity preparation, the rest of the procedure becomes progressively simpler as the finish is approached.

Radiographic imaging

We wouldn’t even attempt RCT without Roentgen’s invention of the dental radiograph, so it is not much of a stretch to claim the critical necessity of ideal preoperative radiography. Ideal preoperative X-ray imaging must include a straight-on angle that splits the mesial and distal contacts perfectly—taken either as a periapical or as a bitewing X-ray image, then at least one ideal off-angle view in order to capture data from the Z-plane (buccolingual) of the tooth in question.

In my practice, a mesial off-angle view of anteriors and premolars works well, because it is much easier to capture than a distal angle, and in anteriors and premolars the mesial view reveals as much radicular anatomy as...
a distal view. In molars it is different. In molars a distal view is far preferable to a mesial off-angle view, as the mesial view superimposes the body of the root over the distally curved root structure, while the distal view casts the apical root end sideways, where it can be more easily seen on the radiographic image.

Of course, cone-beam CT (CBCT) imaging is the unfair endodontic imaging advantage. If told I could have either a microscope or a CT machine, but not both, I would choose 3-D imaging every time. Only CBCT imaging can capture the mesial view of root structure—the view in which we see “The Secret Life of Root Canals”—the buccolingual plane containing the greatest degree of anatomic complexity. One of the greatest joys of having a CT machine in practice is knowing, for sure, before the access procedure is begun, that there is only a single canal in the mesiobuccal root of an upper molar. Conversely, one of the few negative experiences to be had with this technology is when the reconstructed volume shows two or three canals, in a root that has given up only one to the clinician’s exhaustive search.

The first gift of CBCT imaging to the field of endodontics has been the gift of finding all canals in a given tooth. Its second gift is the great diminution of access size possible, because the access cavity is no longer the primary viewing port into the pulp chamber and beyond. In fact, CT imaging is the only view needed into the anatomic verities of root canal spaces, allowing access cavities to be used exclusively as treatment, rather than as exploratory portals. Ultimately, RCT access procedures will be done with CT-generated drill guides, allowing molars to be treated through three to four 1-mm pea-holes, rather than the 2- to 4-mm access cavities used today.

Outline form

So what are the objectives we consider when planning the invasion of a root canal space? Basically, all the best access cavities are cut in a balance between conservation and convenience form. We cut as little tooth structure as possible, while ensuring ideal pathways into each canal. Access outline form objectives become fairly simple then; we demand convenience form, otherwise we cannot complete our task, yet we always...
strive to preserve the structural integrity of the tooth. This boils down to three easily remembered objectives:

1. In anteriors and premolars, conservation form is found in the mesial-to-distal dimension. Traditionally, anterior access cavity outline form has been triangular because of the mesial and distal pulp horns in these teeth—logical until we consider the structural consequences, a needless weakening of coronal tooth structure to insure these lateral pulp horns are cleaned out, when the smallest undercut with a #2 Mueller Bur or Buc-1 ultrasonic tip (Spartan) could suffice as well. Premolars have pulp chambers like the shape of a hand, which is fortunately arranged in a buccolingual direction, the angle of the recommended slot-like access cavity outline form is buccolingual as well, simultaneously combining convenience and conservation form.

2. In posterior teeth, premolars and molars, it is important to remember that their occlusal surfaces are not centred over the root structure, but are skewed toward the idling cusp side of the root structure. As pulp chambers are centred in the root structure, not centred under the occlusal surface, access in posterior teeth is best accomplished by cutting near working cusps, while staying 1–2 mm away from idling cusps (Fig. 2).

3. In molars, conservation form is held by avoiding the distal half of the occlusal plane, as ideal file paths from the distal canals of upper and lower molars are canted severely to the mesial, so much so that distal canals of lower molars are best referenced to the MB or ML cusp tips, and distobuccal canals of upper molars are best referenced to the palatal cusp tips. Convenience form is achieved by cutting the mesial wall of molar access cavities parallel to the mesial surface of the tooth (Fig. 3).

**Back from the abyss**

I was taught Schilder technique at University of the Pacific by Dr Michael Scianamblo and after grad school by Dr Cliff Ruddle. I understood the clinical imperative Dr Schilder had placed on cutting an access adequate to treat the entire root canal system in a predictable manner,
and I enjoyed working through the large access cavities and the generous coronal canal shapes he recommended until I was brought up short by Dr. Carl Reider, a well-known prosthodontic lecturer from Southern California.

When I asked what he most wanted from the endodontists he referred his patients to, he said he wished we could “just suck the pulp out, without cutting any tooth structure.” As we talked, I came to better understand the structural imperative of saving teeth in the long term, setting me on a quest for tools and methods that would allow us to achieve the same consistently ideal endodontic outcomes, through smaller access openings and coronal canal shapes.

Ultimately, it was the inspiration for my invention of the Maximum Flute Diameter (MFD) limitations on GT and GTX rotary files (DENTSPLY Tulsa Dental Specialties), the LAX (line angle extension) Guided-Access Diamond Burs by SybronEndo, as well as obturation methods using flexible condensation devices, such as System-B Continuous Wave electric heat pluggers (SybronEndo) and GT/GTX Obturators (DENTSPLY Tulsa Dental Specialties).

The Itty Bitty Access Committee

Since that initial awakening in the ‘80s, it has felt like being a lone voice in the wilderness until the past ten years, when a new generation of dentists and endodontists, steeped in the new reality of implant dentistry as an alternative to RCT, have taken up the cry for longer-term outcomes through improved structural preservation, ultimately becoming what I jokingly call The Itty Bitty Access Committee (IABC).

As so often happens, somebody outside of our specialty, a general dentist named Dr. David Clark, started lecturing on the access elephant in the endodontic living room. He got my buddy Dr. John Khademi turned on to the possibilities that more conservative access cavities could offer the specialty, and one by one a group of young endodontists joined the game of who can do a perfect RCT through the smallest access cavity. This ad hoc group of talent became the IABC club.

The cases shown in Figures 4 to 10—mostly done by IABC members—make me very happy and afraid at the same time. What the heck are they doing? Little, tiny entries, leaving pulp chamber roofs intact, lateral pulp horns unroofed as well, or just total RCT through previously cut restorative cavities!

After getting over my initial shock at what they were accomplishing, I came to understand that the future of endo is very good in these extremely talented hands, and I saw that the procedure I was developing for endodontic surgery—CT-guided endodontic surgery (CT-GES)—could be applied to conventional treatment as well (Figs. 11a–12d).

And morning breaks over the field of endodontics.

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A complete list of references is available from the publisher.

about

Dr. L. Stephen Buchanan, DDS, FACD, FICD, is a diplomate of the American Board of Endodontics, a fellow of the American and International Colleges of Dentists and serves as part-time faculty to the UCLA and USC graduate endodontic programmes. He holds patents on the Endobender Plier (SybronEndo), System-B and Continuous Wave obturation tools and methods (SybronEndo), GT and GTX file systems (DENTSPLY Tulsa Dental Specialties), LA Access Burs (SybronEndo), and Bu: ultrasonic tips (Spartan/Obtura). Buchanan lives in Santa Barbara, California, where he enjoys a practice limited to conventional and microsurgical endodontics and dental implant surgery. He is the founder of Dental Education Laboratories, a hands-on training facility in Santa Barbara that he has directed for 28 years.
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Bioactivity in restorative dentistry: A user’s guide

Dr Fay Goldstep, Canada

Introduction

The word “bioactivity” is one of the latest buzzwords in the dentistry. It is highlighted as a feature in many restorative products with different and conflicting claims. This has stirred up confusion and controversy surrounding the concept. This article will attempt to provide clarity for the practising restorative dentist regarding the following: What is bioactivity? What are bioactive products? How can they be used to provide the best dental care?

The term “bioactive material” originated with Dr Larry Hench in 1969. He was looking for an improved graft material for bone reconstruction needed by injured returning soldiers of the Vietnam war. Hench was searching for a material that could form a living bond with tissues in the body. All the available materials at the time were rejected by the body. He developed bioglass (calcium silicophosphate glass), a completely synthetic material that chemically bonds to bone.1 Hench defined a bioactive material as “one that elicits a specific biological response at the interface of a material which results in the formation of a bond between the tissues and the material”.2

For simplification and clarity in discussing bioactive restorative materials, it is best to separate them according to their mechanism of action. There are three separate mechanisms that are demonstrated by bioactive restorative materials (Table 1 lists examples of bioactive restorative materials by their mechanism of action). A bioactive restorative material can display one or more of the following actions:

1. remineralises and strengthens tooth structure through fluoride release and/or the release of other minerals;
2. forms an apatite-like material on its surface when immersed in body fluid or simulated body fluid over time;4
3. regenerates live tissue to promote vitality in the tooth.

Table 1: Examples of bioactive restorative materials by their mechanism of action. Bioactivity increases with each mechanism: materials that remineralise, only remineralise; materials that deposit hydroxyapatite also remineralise; materials that stimulate pulpal regeneration also remineralise and deposit hydroxyapatite.

Dental caries is the cumulative result of consecutive cycles of demineralisation and remineralisation at the interface between biofilm and the tooth surface. Oral bacteria excrete acid after consuming sugar, leading to demineralisation. Hydroxyapatite crystals are dissolved from the subsurface. Remineralisation is the natural repair process for non-cavitated lesions. It relies on calcium and phosphate ions, assisted by fluoride, to rebuild a new surface on the existing crystal remnants in the subsurface.5

Under normal physiological conditions at a pH of 7, saliva is supersaturated with calcium and phosphate ions, making caries progress slow. As the pH is lowered, higher concentrations of calcium and phosphate are required to reach saturation with respect to hydroxyapatite.6 This is called the “critical pH”, the point where equilibrium exists and there is no mineral dissolution and no...
mineral precipitation. The critical pH of hydroxyapatite is around 5.5 and that of fluorapatite is around 4.5. This varies with individual patients. Below critical pH, demineralisation occurs, while above critical pH, remineralisation occurs (Figs. 1 & 2).43

If fluoride is present in the plaque fluid, it will penetrate the enamel, along with the acids at the subsurface, adsorb to the apatite crystal surface and protect the crystals from dissolution.6 This coating makes the crystals similar to fluorapatite (critical pH of 4.5), ensuring that no demineralisation takes place until the pH reaches this point. Fluoride present in solution at low levels among the enamel crystals can markedly decrease demineralisation.7, 8

When the pH returns to 5.5 or above, the saliva, which is supersaturated with calcium and phosphate, forces minerals back into the tooth.8 Fluoride increases remineralisation by bringing calcium and phosphate ions together and is preferentially incorporated into the remineralised surface, which is now more acid-resistant.

The benefits of fluoride are maintained long term through the mechanism of fluoride reservoirs. Fluoride is retained intracorally after fluoride treatments, such as fluoridated toothpaste and fluoride varnish application, and is then released into the saliva over time.8, 9 Fluoride can remain on teeth, mucosa or dental plaque or within bioactive restorative materials. Fluoride retention is clinically beneficial, since it can be released during cariogenic challenges to decrease demineralisation and enhance remineralisation.5

When the enamel and dentine no longer have adequate structure to maintain their mineral framework, cavitation takes place and simple remineralisation is an insufficient treatment. Tooth preparation and restoration are now required.

Bioactive restorative materials replace dental hard tissue and help to remineralise the remaining dental structures. Glass ionomer cements and their derivatives, such as resin-modified glass ionomers, compomers and giomers, fall into this category.
Glass ionomer cements

Glass ionomer cements were developed in the early 1970s. They are particularly valuable for caries control in high caries risk patients and in areas where location or isolation create restorative challenges (Figs. 3a & b). Glass ionomers have a true chemical bond with dental tissue. They encourage remineralisation of the surrounding tooth structure and prevent bacterial microleakage through ion exchange adhesion with both enamel and dentine. A new, ion-enriched layer is created at the tooth–glass ionomer interface. This layer contains phosphate and calcium ions from the dental tissue, and calcium (or strontium), phosphate and aluminium from the glass ionomer cement. The remineralisation process creates a harder dentine surface (Fig. 4). Restoration fracture is usually cohesive, leaving the ion exchange layer firmly attached to the cavity wall. The dentinal tubules are sealed and protected from bacterial penetration.

In order to eliminate the physical property disadvantages of glass ionomers and harness their remineralising benefits, dental researchers have produced an assortment of glass ionomer derivatives: resin-modified glass ionomers, compomers and giomers. Two product lines in this category are ACTIVA BioACTIVE-RESTORATIVE (Pulpdent; Fig. 5) and the Beautifil giomer family of restorative materials, including Beautifil II and Beautifil Flow Plus (SHOFU; Fig. 6). Studies have shown ACTIVA’s remineralisation potential through fluoride release and recharge and calcium release. Giomers are used in restorative dentistry as equivalent to composite resin, in all their applications.

Giomers

Giomers represent the hybridisation of glass ionomer and composite resin properties: the fluoride release and recharge of glass ionomers, and the aesthetics, physical properties and handling of composite resins. The giomer concept is based on PRG (Pre-Reacted Glass) technology: a glass core, surrounded by a glass ionomer phase enclosed within a polyacid matrix. Studies show that dentine remineralisation occurs at the preparation surface adjacent to the giomer.

Giomers, through the creation of fluoride reservoirs, release and recharge fluoride efficiently, significantly better than do compomers and composite resins, although not as well as glass ionomers. The clinical performance of giomers has been tested against those of hybrid resin composites. Giomers have been found to compare positively for all criteria.

Materials that deposit hydroxyapatite

Some bioactive materials not only remineralise by adding minerals to tooth structure, but also create an apatite-like material on their surfaces when immersed in body fluid or simulated body fluid over time. There are...
two chemical classes of these bioactive restorative materials: calcium silicates and calcium aluminates.21, 22 These materials are non-resin-based. Both materials set with an acid–base reaction and produce an alkaline pH after setting. High pH levels (7.5 or higher) appear to stimulate more active and complete bioactivity.4

Ceramir (Doxa Dental; Fig. 7) is a calcium aluminate material developed for cementation. An in vitro study found that this apatite-forming bioactive cement can occlude artificial marginal gaps. This is beneficial clinically at the margin of the prepared tooth and cemented restoration. It suggests that bioactive dental materials may significantly improve clinical outcomes and longevity of dental restorations.23

Calcium silicates have also been shown to deposit hydroxyapatite.23 Even more importantly, they can stimulate the regeneration of live tissue: dentine, pulp, blood vessels and bone.24–26

Materials that can regenerate live tissue

Some bioactive materials not only remineralise and form hydroxyapatite, but also regenerate live tissue. This is crucial in many restorative and pulp-related treatments. One major example is vital pulp therapy. The goal of vital pulp therapy (direct pulp capping and pulpotomy) is to treat reversible pulpal injury arising from trauma, caries or restorative dentistry. These injuries destroy the normal tissue architecture at the pulp–dentine interface, but can be healed if the wound is properly protected.27

Treatment must maintain pulp vitality and function and restore dentine continuity below the injury through hard-tissue bridge formation.28 Optimal quality of this hard-tissue bridge is essential to the long-term success of vital pulp therapy.29, 30 There is a pulp tissue-specific response to the capping material, and this determines the quality of the dentine bridge.29

Calcium hydroxide products have been used in vital pulp therapy for many years. The ability of calcium hydroxide to promote dentine bridge formation and enhance wound healing is well established.31 However, calcium hydroxide has inadequate physical properties and produces poorly formed dentinal bridges containing tunnels.32 This has directed research to seek out new materials for this therapy.

The first of these materials created for practical clinical use was mineral trioxide aggregate (MTA).33 MTA was originally developed as a root end filling material for apicectomy procedures and to repair root perforations.34 Indications for its use have expanded broadly within restorative dentistry and paediatric dentistry.27

MTA is a calcium silicate-based material (derived from Portland cement) with high sealing ability and excellent biocompatibility. MTA-based materials stimulate faster formation of dentinal bridges that are of better quality than those of calcium hydroxide.35, 36 Since the mid-1990s, MTA has been recognised as the standard in conservative pulp vitality treatment.29 MTA-based materials have limitations however:

– long setting time;38
– weak mechanical properties;38
– difficult handling;38
– may produce tooth discoloration;39
– may contain heavy metals.40

Much research has followed to build on the advantages of MTA while eliminating most of the disadvantages. One such material is Biodentine (Septodont; Fig. 8). It was formulated by improving the physical and handling properties of MTA-based endodontic repair cement technology and creating a dentine replacement material with significant reparative qualities.

Biodentine can be used as a complete dentine replacement material to treat damaged dentine in both the crown and the root with clinical indications that exceed those of MTA and other related Portland cement calcium silicate products.21 Biodentine can be used as a:

– cavity base/liner in deep carious lesions;
– pulp capping agent in vital pulp therapy (both direct pulp capping and pulpotomy);
– root repair material for perforations, resorptions, apicification and root end filling material in endodontic surgery; and
– restorative material to replace missing or defective dentine.

It cannot be used to replace enamel.

The advantages of Biodentine over MTA and modified MTA materials include:

– ease of handling;
– high viscosity;
– shorter setting time (12 minutes);
– better physical properties;⁴¹
– composition containing raw materials with known degree of purity;⁴² and
– good colour stability, so there is no discoloration.⁴³

Biodentine is a tricalcium silicate-based material. Its mechanical properties compare to those of dentine, and it can be used as a dentine substitute in both the crown and the root.⁴⁴–⁴⁶ It stimulates deposition of hydroxyapatite when exposed to tissue fluids.⁴⁷ It is non-toxic as tested on human pulp cells.⁴⁸ Studies have shown complete dentinal bridge formation after six weeks in human teeth.⁴⁹

Biodentine provides a hermetic seal that protects the dental pulp by preventing bacterial infiltration. This creates a protected environment where healing can take place. The seal is created through micromechanical retention by infiltrating the dentine tubules and by stimulating odontoblasts to deposit dentine.²⁵

It is the calcium-releasing ability of pulp capping materials that induces pulp tissue regeneration. Tricalcium silicate-based materials like Biodentine produce calcium hydroxide as a product of hydration.⁵₀

The calcium silicate setting reaction is as follows:

\[
2\text{Ca}_3\text{SiO}_5 + 3\text{H}_2\text{O} \rightarrow 3\text{CaO} \cdot 3\text{SiO}_2 \cdot 3\text{H}_2\text{O} + 3\text{Ca(OH)}_2
\]

Calcium silicate in the powder interacts with water, leading to the setting and hardening of the cement. This produces hydrated calcium silicate gel and calcium hydroxide. Calcium hydroxide can now stimulate pulp regeneration within a gel-like material that is strong and not porous; this harnesses the regenerative powers of calcium hydroxide without its physical disadvantages.

Biodentine in vital pulp therapy, through the action of calcium hydroxide in this enhanced physical state, boosts the deposition of reparatory dentine by odontoblasts. This creates a dense dentine barrier,⁵¹, ⁵² as well as heals damaged pulp fibroblasts.⁵³ Clinical results have confirmed Biodentine’s ability to preserve pulp vitality even in very difficult cases. It has the potential to heal pulps, avoiding what may have been inevitable endodontic involvement in the past.

**Resin-modified calcium silicates**

Studies have shown that the presence of a resin matrix modifies the setting mechanism and calcium leaching of calcium silicates.⁵⁴ A partial pulpotomy clinical study compared TheraCal (BISCO), a light-cured, resin-modified calcium silicate base/liner designed for direct and indirect pulp capping, with non-resin-containing materials Biodentine and ProRoot MTA (Dentsply Sirona). The results showed that Biodentine achieved complete dentinal bridge formation in all teeth. The rates for bridge formation were 56 % for ProRoot MTA and 11 % for TheraCal.⁵⁵ Normal pulp organisation was seen in 66.6 % of the teeth in the Biodentine group, 33.3 % of the ProRoot MTA group and 11.1 % of the TheraCal group. The study concluded that the non-resin-based partial pulpotomy materials perform better than the resin-based materials and present potential for the best clinical outcomes.⁵⁵

Another recent study compared Biodentine with TheraCal with respect to how they each affect inflammation and regeneration of the pulp in a direct pulp capping *in vitro* model. TheraCal was shown to increase inflammatory cells and decrease the regenerative processes of the pulp, whereas Biodentine did not increase inflammation and supported the regenerative processes of the pulp.⁵⁶

These two studies seem to suggest caution in using resin-based materials for vital pulp therapy. Biodentine has good biocompatibility and bioactivity for use in vital pulp therapy.
Calcium silicates as endodontic sealers

The ability to deposit hydroxyapatite and regenerate live tissue has brought calcium silicate technology into the scope of endodontic sealers. After obturation, there is generally contact between the obturating materials and the periapical tissue. The success of treatment greatly depends on the integrity of the obturated seal to prevent recurrent infection of the periapical space.

The introduction of bioactive endodontic sealers has changed the concept of obturated seal from hermetic sealing with inert materials to biological bonding with bioactivity.57 The sealer becomes a filler, not only a sealer.

Calcium silicates are well suited to endodontic obturation owing to the following properties:58

– high pH (antibacterial);
– hydrophilic (use moisture present in dentinal tubules to initiate set);
– biocompatible;
– do not shrink or resorb;
– excellent seal (bond chemically and mechanically to dentine); and
– ease of use (can be used with many methods of condensation).

Furthermore, they are bioactive:

– remineralise hard tissue;
– deposit hydroxyapatite to improve the seal over time;
– regenerate and heal surrounding periapical tissue.

BioRoot (Septodont; Fig. 9) has been developed to incorporate these bioactive traits. Research has shown:

– Hydroxyapatite formation upon setting reaction: Bio-ceramic sealers bond to dentine through the process of alkaline etching. This is due to the alkalinity of the sealer. A mineral infiltration zone develops between the dentine and the sealer.59

– Tissue healing: A study that compared the effects of BioRoot RCS on human periodontal ligament cells with the standard zinc oxide eugenol-based root canal sealer, Pulp Canal Sealer (Kerr Dental), showed BioRoot to have fewer toxic effects on periodontal ligament cells and that it induced greater secretion of angiogenic and osteogenic growth factors. These properties are essential in periapical tissue regeneration.60, 61 BioRoot also showed excellent biocompatibility when compared with many other contemporary endodontic sealers.62

Conclusion

With a bit of simplicity and focus on the essentials of bioactivity in dentistry, it becomes clear that bioactivity is now an essential part of the practice of clinical dentistry. Dentists can now harness the potential to remineralise and generate tooth material and heal biological structures for their ultimate objective: attaining the best possible clinical outcomes for their patients.

Editorial note: A list of references is available from the publisher.

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Dr Fay Goldstep has been an ADA (American Dental Association) Seminar Series Speaker and lectured at the ADA, Yankee, American Academy of Cosmetic Dentistry, Academy of General Dentistry and Big Apple dental conferences. She has lectured nationally and internationally on proactive/minimal intervention dentistry, soft-tissue lasers, electronic caries detection, healing dentistry and innovations in hygiene. Dr Goldstep has served on the teaching faculties of the postgraduate programmes in aesthetic dentistry at the State University of New York at Buffalo, universities of Florida and Minnesota, and University of Missouri–Kansas City in the US. She sits on the editorial boards of the Oral Health Journal (healing/preventative dentistry), Dental Tribune U.S. Edition and Dental Asia. She is a fellow of the American College of Dentists, International Academy for Dental-Facial Esthetics and American Society of Dental Aesthetics. Dr Goldstep has been a contributing author to four textbooks and has published more than 60 articles. She has been listed as one of the leaders in continuing education by Dentistry Today since 2002. Dr Goldstep is a consultant to a number of dental companies and maintains a private practice in Toronto in Canada. She can be contacted at epdot@rogers.com.
Hot modified technique with a new biosealer

Drs Alfredo Iandolo, Massimo Calapaj & Dina Abdellatif, Italy

Introduction

The long-term success of endodontic treatment is basically based on adequate 3-D cleaning of the endodontic space after root canal shaping, followed by complete 3-D obturation of the complex root canal system. The endodontic space is composed of areas that are easily accessible to hand and rotary instruments (the main canals) and, as confirmed by many clinical and histological studies, some spaces that are difficult to access or even inaccessible (isthmuses, loops, lateral canals, ramifications, deltas and dentinal tubules; Fig. 1). For that reason, mechanical shaping is not able to reach all areas of the complex root canal system, regardless of the technique used, leaving parts of the root canals untreated. Therefore, it is necessary to carry out endodontic biochemical cleaning (for the accessible and inaccessible areas). Once these areas have been cleaned, they can be filled and obturated with gutta-percha and sealer during the obturation phase.

When it comes to obturation, there are different techniques, mainly warm and cold techniques. In the literature, there are no significant differences regarding whether warm obturation techniques are better than cold techniques, but it is logical and well-demonstrated that the warm filling techniques can fill the endodontic space in a 3-D way.

As already mentioned, it is not only the main canal that is present in the endodontic space, but there are different anatomical configurations. Therefore, if we use cold filling techniques, most of these spaces will not be filled. In brief, in the pursuit of excellence, we must try to clean almost all of the endodontic space and then fill it nearly completely.
Together with gutta-percha, the most commonly used sealers are those based on zinc oxide, as well as eugenol and resin. In recent years, a new generation of sealers, the bioactive sealers, less toxic and with greater healing capacity, have been released on the market. However, these biosealers have two major disadvantages:

- The first is that they must be used with the cold single-cone technique because they cannot be heated; therefore, they are not able to obturate the endodontic space in 3-D.
- The second disadvantage is their consistency after hardening. They harden a great deal, and in the case of retreatments, the problem becomes more complicated.

Recently, a new biosealer was introduced, ROeko GuttaFlow bioseal (COLTENE). This is not a pure biosealer because it is composed partly of gutta-percha fluid and partly of calcium silicate particles. It is less toxic than other sealers and biosealers, guarantees micro-expansion within the endodontic space after hardening, and therefore more hermetic filling, and has excellent regenerative capacity.

Furthermore, its composition offers two great advantages:

- The first is that it can be used with warm vertical compaction, so it can obturate in a 3-D way.
- The second is its consistency after hardening. It does not become extremely hard like other biosealers do, so it can be easily removed in the case of retreatments.

**Using GuttaFlow bioseal**

This article demonstrates and discusses a modified warm filling technique using GuttaFlow bioseal. Several clinical cases are shown with follow-ups using this technique (Figs. 2–4).

Obturating all of the endodontic space is very important for the final treatment outcome. This new biosealer combines fluid gutta-percha with a suitable sealer at room temperature and bioceramics in an automix syringe (Fig. 5). Setting time ranges between 10 and 15 minutes.

What we call the 3-D obturation technique is, in fact, an efficient and reliable way to fill even a complex anatomy. For the current warm modified technique, we used the System B heat source (Kerr), but any similar device could also be used.

After choosing the correct gutta-percha master cone, we prepared the biosealer and inserted it into the root canal with the proper tip. We then inserted the gutta-percha cone to the working length and began the 3-D obturation technique. In order to reach our aim, we decreased the heat carrier temperature to 130–150 °C instead of the average 200–250 °C, as this is sufficient.
Penetration depth was reduced to three seconds, rather than the usual five seconds, and the heat carrier was inserted to 4 mm short of working length. Conventionally, to dissolve the gutta-percha in the apical third, the heat carrier has to reach 3 mm from working length. However, with this modified technique, the heat carrier can be stopped also at 6–10 mm from working length. The clinician does not have to reach the desired working length in one stroke, but can use another stroke until the desired length is reached.

With this modified technique, the gutta-percha itself does not have to enter the accessory canals, as the bioceramic sealer will flow into any hidden canals. In in vitro tests, it was shown that the modified obturation technique allowed the sealer to advance deeper inside lateral canals in comparison with the conventional single-cone technique (Figs. 6–8).

By increasing the penetration speed of the heat carrier, we increase the pressure and this is needed to ensure the biosealer penetrates throughout the endodontic space. With the new warm modified technique, the biosealer sets only around two minutes earlier than with the normal technique. This happens owing to using the reduced heat settings and fast penetration.

With aid of 3-D obturation, the sealer is allowed to do its job in areas that are difficult to reach, while it is pushed further down into the canal by the slightly melted gutta-percha on top.

**Conclusion**

Shaping, 3-D cleaning and 3-D obturation are the three key parameters for achieving short- and long-term success in endodontics. Nowadays, many sealers are available, including biosealers, but the latter have some disadvantages, such as being limited to use with cold techniques and hardening a great deal. In order to guarantee a secure obturation, we must try to fill the endodontic space as much as possible, and achieving this with cold techniques is not possible.

Instead, with the benefit of a new biosealer, GuttaFlow bioseal, we can achieve 3-D obturation using a modified obturation technique. This new biosealer has less toxicity than other sealers and biosealers do, and the bioactive components of the obturation material enhance the healing process, as they stimulate the rebuilding of bone and dentinal tissue, which is favourable for the actual sealing of the canal.

**contact**

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VISIT US!
Bioactive materials for root canal obturation

Prof. Bogdan Shumilovich, Dr Vladimir Rostovtsev, Dr Lianna Adunts, Dr Andrey Fonstein & Dr Eugeniy Stanislavchuk, Russia

Introduction

In our previous cases (published in 2012 and 2013) have already described the properties and clinical capabilities of the ROEKO GuttaFlow and GuttaFlow 2 systems (COLTENE), based on the polydimethylsiloxane (PDMS) chemical compound, which is a linear polymer of dimethylsiloxane.1–3 The properties are due to the chemical capabilities of the substance. The amount of dimethylsiloxane units in the structure can reach up to 15,000. Depending on the chain length of the polymer, substances with different physical properties can be obtained. The viscosity of such compounds increases with increasing length, which corresponds to a transition from very motile, gas-like liquids, to more viscous oils and, finally, to resinous substances.3–5

Cold obturation technique for bioactive sealing and filling

The GuttaFlow and GuttaFlow 2 systems operate on the principle of absolute bio-inertness. All materials and substances used in clinical dentistry can be conditionally divided into three major groups:

1. Bio-inert: do not interact with surrounding tissue
2. Bio-resorptive: during contact with surrounding tissue are absorbed and/or destroyed
3. Bioactive: affect the surrounding tissue during contact.

Given the increased interest of clinicians and researchers in the bioactive methods of root canal obturation, the new bioactive system of cold free-flow gutta-percha was created by COLTENE.6–8

The system was based on the...
already existing GuttaFlow and GuttaFlow 2 and given all the best qualities of its predecessors. GuttaFlow bioseal (Fig. 1) was created according to the formula of sealer + free-flow gutta-percha + bioglass and consists of the following components:

- basis with gutta-percha (in powder form with a particle size of less than 30 μm), zinc oxide and barium phosphate
- bioglass
- sealer with PDMS, silicone oil, paraffin oil, zinc dioxide (X-ray contact slowness), platinum catalyst, colouring pigment and micro-crystals of silver (bactericidal effect).

Such an arrangement provides to the system, in addition to the unique properties of GuttaFlow, a number of characteristics:

- no need for mechanical compaction;
- the presence of a prolonged bactericidal effect;
- obturation on the principle of no heating, no shrinkage (0.2% expansion);
- excellent fluidity;
- simplicity and speed of clinical use; and
- the ability to absorb hydroxyapatite crystals on the biocrystal particles (the importance of this property and its role in determining the clinical effectiveness of the system are explained later in the article).

The properties of bioglass as a material capable of contacting the native bone were first described in 1969. It consists of silicon, calcium oxide, hydroxy phosphates and sodium phosphates. Today, owing to the expressed osteoinductive effect, bioglass is widely used in medicine (e.g. traumatology and dentistry). Owing to its high pH, antibacterial properties are strongly pronounced. Thus, GuttaFlow bioseal has unique chemical, physical and bioactive properties regarding the formation of hydroxyapatite crystals, the main structural unit of hard tooth tissue, which ensures the maximum quality of sealing and the biocompatibility of the material.10, 11

As already mentioned, GuttaFlow bioseal contains a finely dispersed gutta-percha, PDMS, platinum catalyst, zirconia, silver (preservative) and colourant. In addition to all these, the new material contains finely dispersed particles of bioactive glass-ceramic, which provides the formation of hydroxyapatite crystals on the surface, which causes...
excellent adhesion to the dentine and tightness of the obturation. In addition, the presence of silver particles in ceramics, according to some data, has the effect of conservation of the root canal. Nowadays, only mineral trioxide aggregate and bioglass have similar regenerative properties.12, 13

Seven-year follow-up of a clinical case obturated with GuttaFlow 2

Tooth #45 (Figs. 2a & b) was obturated with GuttaFlow 2 and served for seven years as a retainer tooth for a clasp prosthesis, experiencing additional loads. It is evident that the slight extrusion of the material at the apex did not affect the periodontal condition. At the same time, the material was not absorbed, proving its absolute bio-inertness.

Step-by-step protocol

The step-by-step protocol for activating the new system is absolutely identical to that of GuttaFlow 2. Before using the syringe applicator, the protective cap should be re-removed and replaced with a mixing tip (automix). When the plunger is pressed, the evenly mixed material without bubbles leaves the mixing tip in a 1:1 ratio. Flexible mixing tips can only be used once and must be disposed of after use.

1. It is extremely important to ensure the dryness of the biomechanically processed root canal. For insurance, lay down another one of the same size with an exposure of 40 seconds after removing the last paper point in a dry condition. If it is dry and dense upon removal, you can proceed to obturation.
2. Determine the correct size gutta-percha master point (from the master apical file).
3. Distribute the GuttaFlow bioseal on the mixing block and introduce it into the canal on the master point.
4. Introduce the master point for the entire working length and adapt it.
5. Introduce the tip of the mixing tip to the maximum possible depth (no closer than 5 mm to the apex; the size of the spout corresponds to ISO file size 80) depress the plunger until the material appears in the mouth of the canal, ensuring a gradual and smooth flow from the tip.
6. Cut the master point heated to 200 °C.

Clinical examples obturated with GuttaFlow bioseal

In 2016, the system was applied for clinical approbation at the postgraduate dentistry department of the Voronezh State Medical University named after N.N. Burdenko in Russia. In both cases, endodontic treatment was primary, the apex locator behaved as usual (DentaPort ZX, Morita) and there were no clinical complaints after the root obturation (Figs. 3 & 4).

Molar with chronic fibrous pulpitis

A 47-year-old patient complained of spontaneous radiating pain in the region of the lower jaw on the left that amplified with temperature stimuli. Visual and instrumental examination revealed a cavity in tooth #38. After the standard diagnostic protocol, the diagnosis was chronic fibrous pulpitis of tooth #38 (Fig. 5a).

At the request of the patient, endodontic treatment was performed. The preparation was carried out using the HyFlex CM and HyFlex EDM file systems (both COLTENE).

At the request of the patient, endodontic treatment was performed. The preparation was carried out using the HyFlex CM and HyFlex EDM file systems (both COLTENE).

The choice of the system is obvious. Once the glide path had been established to ISO size 15, we analysed the pronounced curve (Fig. 5b) and selected a rotary tool for increased flexibility and an obturation system that does not require condensation, which would have been impossible under the conditions. In our opinion, GuttaFlow bioseal coped brilliantly with the task, achieving reliable obturation not only along the entire length of the canals, but also of a pronounced delta in the apical part (Fig. 5c).

Fig. 6a: Initial situation. Fig. 6b: Control radiograph after obturation. Fig. 6c: Radiographic situation after six months. Fig. 6d: Radiographic situation after nine months.
Repeated endodontic treatment

A 49-year-old patient presented with acute pain affecting tooth #46. According to the patient, the tooth had previously been treated for compound caries. For ten years, the tooth had been covered with a metal-ceramic crown. The pain had begun three days before, and the patient had visited the clinic where she had been treated previously. After CBCT examination, the patient was referred to the department (Fig. 6a).

After the standard diagnostic protocol, the diagnosis was chronic granulomatous periodontitis of tooth #46. The tooth had previously been treated with resorcinol-formalin method. At the request of the patient, repeated endodontic treatment was performed. After debridement and negotiation of the glide path to ISO size 15 with hand tools (reamer and H-file), the subsequent preparation was carried out using the HyFlex CM system with a standard irrigation protocol (5% sodium hypochlorite, 17% EDTA, water, EndoActivator). The treatment steps were irrigation, preliminary and final mechanical and chemical treatment, followed by obturation and radiographic inspection (Fig. 6b). At the recall after six months, the patient was without complaints, and radiographic monitoring (Fig. 6c & d) traced the positive dynamics of regenerative processes after endodontic treatment.

Conclusion

GuttaFlow bioseal is the logical continuation of the existing materials of GuttaFlow and GuttaFlow 2, and in addition to its own unique osteoinductive qualities, has the same obturation properties as its predecessors. We express the firm belief that the availability of the GuttaFlow bioseal system in the dentist’s arsenal will significantly expand the clinical possibilities of the endodontic practice, since there is nothing more physiological than the patient’s natural tooth.

Editorial note: A list of references can be obtained from the publisher.

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Orthograde apical application of an MTA plug in a tooth without constriction

Dr Angela Gusyska, Bulgaria

Introduction

The minor apical foramen should be maintained at its initial position and size after chemomechanical endodontic procedures. If the apical constriction is breached and transported, cleaning procedures will be compromised and obturation significantly difficult to carry out well.

Apical root resorption is a pathological condition of the inflammatory response, characterised by the processes of cement and/or dentine depletion, resulting from the activity of resorptive cells called dentoclasts (a subclass of osteoclasts).1–3 Treatment of the apical resorptive processes is likely to occur through removal of the pulp and granulation tissue, as well as interruption of the blood supply to the root.

Fig. 1: Initial radiographic status of tooth #46. Fig. 2: Control radiograph to assess the removal of a separated lentulo.
supply to these tissues, which is necessary for the development of resorptive cells. In many cases of incomplete root canal therapy, there are resorptive changes in the apical zone. One of the major challenges in endodontic treatment of teeth with open apices due to resorption is achieving effective debridement, canal disinfection and subsequent sealing of the root canal space. The key point is to form an apical barrier or a stop against which one can place the sealer and gutta-percha while avoiding over-extrusion.\textsuperscript{4, 5} Mineral trioxide aggregate (MTA) is a reliable material owing to its biocompatibility and good sealing properties, which provide opportunities for the regeneration of periapical tissues, such as periodontal ligament, bone and cementum.\textsuperscript{6–8}

These properties make MTA a suitable material for the management of apical zone sealing in cases of resorption and without physiological constriction. The present case report describes a retreatment case of a mandibular molar, complicated by lack of constriction and a separated endodontic instrument.

Case report

A 34-year-old female patient was referred for endodontic treatment of tooth #46 because of a separated endodontic instrument in the mesial root, which was observed on the initial radiograph (Fig. 1). The patient’s chief complaint was mild pain in the mandibular right posterior region during chewing. She gave a history of a root canal therapy on the same tooth four years earlier. There was no other relevant medical history.

Based on the clinical and radiographic findings, root canal therapy was initiated. A rubber dam was placed and the tooth was accessed without the need for anaesthesia. Crown-down preparation was performed for orthograde endodontic treatment. The mesiobuccal canal was negotiated with a size 0.06 C-file and the separated instrument was removed under magnification with a dental operating microscope (16 x, Zeiss), and a control radiograph was taken (Fig. 2). The root canals were cleaned and shaped with ProTaper rotary instruments (Dentsply Maillefer). The mesial canals were prepared up to F3. All of the canals were irrigated with a copious amount of 5.25\% sodium hypochlorite and 17\% EDTA. This was followed by irrigation with 0.9\% saline to remove any remnants of hypochlorite and EDTA. Haemorrhage and exudate from the apical region of the distal canal were observed during the instrumentation, which suggested resorption exteriorisation. The canals were dried with absorbent paper points, and calcium hydroxide paste (ApexCal, Ivoclar Vivadent) was placed in the canals as an intracanal medicament, followed by temporary restoration with glass ionomer cement.

The calcium hydroxide paste was removed ten days later. The complete removal of paste from the root canal
walls was accomplished by passive ultrasonic irrigation and 10% citric acid, using an endodontic tip (ESI, EMS) for more precise cleaning. Taking into consideration the extent of the apical root resorption, it was decided to perform orthograde MTA obturation of the distal canal space to arrest the resorption. The material was placed into the canals with the MAP System carrier (Produits Dentaires; Fig. 3) by the means of a 5 mm apical plug and was condensed vertically with a hand plugger. After radiographic examination of the accuracy of the apical plug (Fig. 4) and a setting period, the entire canal and the mesial canals were obturated with TotalFill BC (FKG Dentaire; Fig. 5). The orifices were adhesively sealed and the tooth was definitively restored with light-curing composite and prepared for a crown.

The patient was recalled after one month (Fig. 6), three months (Fig. 7) and six months (Fig. 8) for clinical and radiographic follow-up. Clinical examination of tooth #46 found it to be functional without sensitivity to percussion or palpation. The tooth showed normal physiological mobility and no periodontal pockets on probing. The periapical radiographs showed satisfactory periapical bone density with no sign of periapical radiolucencies and no further progression of the resorptive process around the distal apical zone. The treatment was definitively finished with a crown. After one year, the patient was recalled again, and the tooth was found to be symptom-free. No percussion sensitivity was observed. The periapical radiograph showed a satisfactory image (Fig. 9).

Discussion

Not every resorptive process in the apical zone can be observed on an initial periapical radiograph. Only thickening of the periodontal ligament space was discovered in this case, and the resorptive process in the apical zone was detected clinically and measured with endodontic instruments because of the superimposition of the structures.

Three-dimensional sealing of the endodontic space is one of the main goals of root canal therapy and is essential for preventing apical and coronal leakage. One of the characteristics of a biomaterial is its ability to form an apatite-like layer on its surface when it comes into contact with physiological fluids in vivo or with simulated body fluid in vitro. MTA is a bioactive material that is mainly composed of tricalcium silicate. Scientific investigations have shown that MTA can release various ions that conduct and induct hard-tissue formation. MTA presents some advantages, including its physical characteristics that guarantee expansion during the attachment, which favours sealing, and the biological properties of calcium hydroxide. MTA forms calcium oxide when in contact with water, which then, when in contact with tissue fluids, forms calcium hydroxide and triggers the same repair process in the tissue. Some recent studies have reported on the success of MTA as a root apical barrier, with rates ranging from 76.5% to 91.0%.

The antimicrobial activity of MTA seems to be associated with elevation of pH. Torabinejad et al. observed an initial pH of 10.2 for MTA, rising to 12.5 in three hours, and it is known that a pH level of 12.0 can inhibit most microorganisms, including Enterococcus faecalis. When there is an open pathway of communication between the root canal and the periodontium, it must be sealed to prevent bacterial leakage. This obturation sealer should be biocompatible and should favour regeneration of the supporting periapical structures.

The apical level of root canal preparation and the border of obturation have been discussed in the literature for several decades. Sealers for the root canal space in cases of advanced resorption have also been thoroughly
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examined. Therefore, the development and maintenance of a seal is considered to be a major prerequisite to improving the outcome of root canal therapy. The absence of physiological narrowing is a challenge to the achievement of satisfactory early and late therapeutic results. It makes probable either the overpressing of necrotic, infected material when preparing the endodontic space or the overpressing of the sealer when sealing the root canal.

There is ongoing discussion about the application of calcium hydroxide paste as an intracanal medicament. Some research has shown that the remains of calcium hydroxide on the dentinal walls had no significant effect on MTA microleakage.\(^1\) In contrast, others have suggested that the remnants react and form calcium carbonate, which interferes with apical sealing.\(^2\) Others have suggested that the combination of calcium hydroxide and MTA in apexification procedures may favourably influence the regeneration of the periodontium.\(^3\) In teeth with chronic periapical lesions, there is a greater prevalence of Gram-negative anaerobic bacteria. When the root canal is mechanically prepared, 35 % of the area remains untouched, including the apical bacterial biofilm.\(^4\) Because these areas are not reached by instrumentation, the use of an intracanal medicament such as calcium hydroxide paste is recommended to aid in the elimination of the bacteria and lipopolysaccharides, and to increase the likelihood of clinical success.\(^5\) Lipopolysaccharide, a bacterial endotoxin, causes the formation of periapical lesions. Currently, calcium hydroxide paste is still a medicament of choice for inactivation and detoxification of this bacterial endotoxin in vivo.\(^6\) Based on previous research, we used a calcium hydroxide paste in the treatment protocol for the present case and observed a successful clinical outcome. Recurrent examinations and radiographs are necessary for follow-up of the clinical outcome and to avoid the need for surgical interventions.\(^7\)

Conclusion

MTA is an appropriate material for apical sealing in cases of resorption, as it leads to the avoidance of surgical apical procedures with a similar prognostic outcome.

The author denies any conflicts of interest related to this study.

Editorial note: A list of references can be obtained from the publisher.

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about

Dr Angela Gusiyska received her degree in dentistry from the Faculty of Dental Medicine at the Medical University of Sofia in Bulgaria in 1997, and she specialised in operative dentistry and endodontics at the same university in 2003. Since 1998, she has been an assistant professor in the Department of Conservative Dentistry at the university. Her research interests are in the regeneration of the periapical zone, nanotechnology and bio ceramics in endodontics and aesthetic rehabilitation of dentition. She completed her PhD thesis, Orthograde Treatment of Chronic Apical Periodontics—Biological Approaches, in 2011. She has presented scientific papers at national and international dental meetings.

Dr Gusiyska’s practice is focused on microscopic endodontic treatments. She is a member of the Bulgarian Dental Association, Bulgarian Scientific Dental Association, Bulgarian Endodontic Society, Bulgarian Academy of Esthetic Dentistry, International Team for Implantology and Bulgarian Association of Oral Implantology. She can be contacted at gusiyska@yahoo.com.
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Long-term stable restoration of severely discoloured anterior teeth

Prof. Dr Daniel Edelhoff, Germany

Introduction

Severely discoloured endodontically treated maxillary incisors can have a considerable detrimental impact on aesthetic appearance and also present a particular challenge for the restorative team. When planning treatment, the focus is firmly on reconstruction of the biomechanical and visual properties of the affected teeth combined with minimal biological cost. In a well-coordinated approach, internal bleaching measures, the use of a fibre post (depending on the degree of destruction), selected adhesive build-up materials and a preparation technique tailored to the restoration material can be combined to achieve a satisfactory treatment result which, compared to classic full crown preparations, can significantly reduce the loss of hard tooth structure.

In the following case report, the restoration of two maxillary central incisors using bleaching measures, insertion of DT ILLUSION XRO SL fibre posts with direct composite build-ups and final restorative treatment with 360° glass ceramic-based veneers is illustrated and documented after a clinical service period of seven years.

Case report

Initial situation

A 28-year-old male patient presented with the demand to have his endodontically treated and severely discoloured maxillary central incisors restored. He stated that since undergoing an apicoectomy a number of years ago, he no longer experiences any symptoms on the two anterior teeth. However, he expressed his discontent with the appearance of the teeth and requested a treatment to improve their aesthetic. He had undergone endodontic treatment and composite build-ups several years ago, but the discolouration had not improved.

Fig. 1: Frontal view of initial situation. Seriously impaired aesthetic appearance due to extreme discolouration and malpositioning of the maxillary central incisors. Fig. 2: Palatal view of the initial situation. As well as micro-leakage around the margins, secondary caries is also evident under the composite fillings, which were placed more than five years ago.

Fig. 3: Post-preparation for the DT ILLUSION XRO SL Post (diameter 2.2 mm, blue). The marginal post section becomes translucent upon trying-in in the root canal as it is warmed up to body temperature. Fig. 4: DT ILLUSION XRO SL Post (diameter 2.2 mm, blue). The post is translucent when warmed up to body temperature, here in the apical third area after being handled.
of his teeth resulting from the considerable aesthetic imperfections (Fig. 1). After evaluating the clinical findings and the X-ray images, root canal fillings presented in compliance with the state-of-the-art were diagnosed on teeth 11 and 21. Root canal posts were not present. However, the extensive composite fillings in both teeth showed micro-leakage and secondary caries had begun to develop (Fig. 2). The patient explained that the fillings on the two affected incisor teeth had been placed more than five years ago.

The particular challenges presented by this initial situation arose from the patient’s demand for a prompt improvement of the aesthetic imperfections and, with this, restoration of an adequate tooth shade and position and, as far as possible, permanent stabilisation of the remaining hard tooth structure.

Treatment planning

Prior to planning the definitive treatment, the insufficient composite fillings in both anterior teeth were replaced and the secondary caries was removed. This was a key prerequisite to obtaining a good overview of the degree of destruction of the teeth and to rule out possible contamination of both root canals with microorganisms as a result of the insufficient and leaking fillings over the years. As both root canal fillings were sealed tight by separate adhesive fillings at the cement-enamel junction, there was no need to inspect the canals.

Following the initial laboratory and clinical analysis, the patient and treatment team opted for the following treatment plan:

Firstly, the malpositioning (crowding) and the existing tooth proportions were to be corrected with a diagnostic wax-up. During the pre-treatment phase, the affected teeth were to be lightened to a shade that harmonises with the adjacent teeth by means of internal bleaching measures. Given the pronounced nature of the defects, the adhesive technique was to be used for the post-endodontic structure with the aid of fibre-reinforced posts in the direct technique. For the final restoration of the severely damaged anterior teeth, adhesively placed 360° veneers based on glass ceramic were to be used.

Pretreatment and preparation

After cleaning the coronal pulp chamber, an additional seal for the root canal fillings was created on the level of the enamel-cement junction in order to rule out penetration of the subsequently applied bleaching agent into sensitive areas. Internal bleaching was performed

Fig. 5: Palatal view of try-in of both DT ILLUSION XRO SL posts on the prepared incisors. The marginal post section of the DT Post is already translucent upon trying-in in the root canal as it is warmed up to body temperature. Fig. 6: Palatal view of the built-up incisors prepared for the full veneers (360° circular veneers). The DT ILLUSION XRO SL Posts were translucent when warmed up to body temperature.

Fig. 7: Palatal view of try-in of full veneers (360° circular veneers) made of glass ceramic. The underlying abutment teeth could be masked extremely well even with a minimal layer thickness. Fig. 8: Transmitted light image of the maxillary anterior teeth following finalisation and insertion. Thanks to the combination of the DT Post with translucent build-up materials and glass ceramic veneers, light transmission was achieved, which corresponds to that of natural teeth.
using a mixture of sodium perborate powder and distilled water applying the walking bleach method. The palatal access to the coronal pulp chamber was sealed using a cotton pellet soaked in bonding agent and low-viscosity composite and the patient was requested to return in one week’s time. During this session, the bleaching agent was changed again in order to extend the exposure period by another week. After the second week of exposure, the shade of both abutment teeth was satisfactorily improved. In order to neutralise the bleaching agent, a calcium hydroxide preparation (CalciPure) was applied to the pulp chamber. Following this neutralisation phase, post-endodontic build-up of the abutment teeth could be commenced. To this end, the coronal seals on the root canal fillings were firstly removed and standard holes for fibre-reinforced posts (type: DT ILLUSION XRO SL, diameter 2.2 mm, colour at 21 °C: blue) were created (Fig. 3). The DT ILLUSION XRO SL Posts are coloured according to their size at room temperature; this colouring disappears following insertion and when warmed up to body temperature. If the post needs to be removed, the colouration can be rendered visible again by cooling gently, e.g. with an air spray (Fig. 4). The DT Posts were secured in place using a fully adhesive technique with a multiple-step dentine adhesive system (Fig. 5). The direct build-ups were created in two stages; after covering the posts with a low-viscosity (flowable) composite, a pre-warmed (54 °C) highly filled viscous composite of shade Bleach XL was used for the main volume of the build-up. The minimally invasive preparation was produced with the guidance of a template derived from the diagnostic wax-up (deep-drawn film); this template contained all the information for correction of the malpositioning and the outer contour of the subsequently definitive restorations (Fig. 6).

Temporary restoration
The temporary direct veneers were produced using a reusable diagnostic template and Bis-GMA-based temporary restoration material. After a four-week evaluation phase of the tooth shape and position determined in the wax-up by means of the temporary prosthesis, a precision impression of the prepared teeth and an impression of the opposing jaw were taken. These were sent to the laboratory together with the facebow, the maxillomandibular relationship record and a photo of the prepared abutment teeth.

Try-in and insertion of the glass ceramic veneers
After removing the provisional restorations, the preparation surfaces were freed from all remains of the bonding agent using cleaning brushes and a fluoride-free cleaning paste (Zircate, Dentsply Sirona). To check the shape and shading, the restorations were tried in with a coloured glycerine gel. As such, perfect masking of the abutment teeth was possible, resulting in a uniform appearance irrespective of the subsurface (Fig. 7).

For final insertion, the inner surfaces of the glass ceramic veneers were etched with hydrofluoric acid and then coated with a silane coupling agent. A multiple-step dentine adhesive system was used on the tooth side.

Conclusion
Thanks to the combination of translucent build-up materials with glass ceramic veneers, light transmission was achieved, which corresponds to that of natural teeth (Fig. 8). The final inspection of the functional and aesthetic parameters showed that all patient’s demands could be fulfilled. The tooth shade harmonised perfectly with the neighbour teeth. Alongside rectification of the extreme discoloration of the hard- and soft-tissue structures, malpositioning and tooth proportions were also satisfactorily corrected. The patient was fully satisfied with the aesthetically pleasing result and experienced no phonetic problems whatsoever due to the corrected positioning of the incisors. After a clinical wearing period of seven years, no loss of retention of the post, build-ups or veneers was evident nor were there signs of bonding problems in the X-ray image (Figs. 9 & 10).

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Bisphosphonate-related osteonecrosis of the jaw

Drs Claudia Dib, Sara Salloum, Edgard Jabbour & Philippe Sleiman, Lebanon

Introduction

Bisphosphonates are a class of drugs that prevent the resorption of bone by osteoclasts. These antiresorptive medications have become the principal mode of therapy for osteoporosis, Paget’s disease of the bone, bone metastasis, breast cancer and other conditions that display bone fragility disease. Their usage has continued to grow despite the concerns expressed recently regarding potential side effects, such as bisphosphonate-related osteonecrosis of the jaw (BRONJ). At the moment, it is unpredictable whether this interconnection can be traced back to a coincidence or to the existence of a true causal relationship. However, Marx et al. claimed in 2003 that bisphosphonates would lead to disrupted bone homeostasis by suppression of osteoclast function. An accumulation of non-vital osteocytes and microfractures would be the effect of the disturbance of the normal bone remodelling.

However, it should be declared that BRONJ might be a persistent condition. As a matter of fact, withdrawal of bisphosphonate treatment would not decrease the risk rate of BRONJ, since the drugs may persist in the skeletal tissue for years. Several studies have highlighted that, if bisphosphonates were prescribed temporarily or interrupted for a specific reason (e.g. completed or discontinued the course or taking a drug break), the patient would have to be considered at risk. To clarify, BRONJ symptoms such as delayed healing after a dental extraction or other oral surgery, pain and soft-tissue infection may appear after dental treatment. Accordingly, any necessary dental treatment should be done under strict safety conditions.

Setting aside the spinous questions of the aetiological mechanisms of BRONJ and the extent of bisphosphonates’ contribution to this process, it seems purposeful to reflect on recent clinical studies to seek the most effective treatment for BRONJ.

Case presentation

An oral oedema is considered to be the most common of symptoms caused by oral disease, and its cor-
rect diagnosis and successful management is most challenging.14

A 55-year-old female patient presented to a dental clinic with no pre-existing oral disease for urgent care. An extraoral examination showed one-sided facial swelling under the lower jaw that had followed implant placement (Figs. 1 & 2). The panoramic radiograph revealed an extensive osteolytic reaction surrounding the first implant on the left side (Fig. 3). Although the symptoms and the radiological signs from the examination could have indicated implant failure, a CT scan of the left part of the mandible was requested for better evaluation of the soft tissue and osseous involvement of the swelling. In addition, information gathered from the patient’s medical history showed that she had been treated with bisphosphonates. The cross sections of the scan exposed sclerotic lesions with cortical bone destruction. The necrosis of the bone with an open wound was determined from delineated focal lesions located at the first implant site (Figs. 4 & 5).15 Therefore, BRONJ was diagnosed. A treatment plan detailed the therapeutic interventions.

The patient was put on antibiotic treatment, a combination of 1 g of amoxicillin and 500 mg of metronidazole twice daily for ten days with a chlorhexidine-based mouthwash. The symptoms cleared and the patient was kept under control without any additional dental work. During this time, a tiny piece of bone that was showing through the gingiva was delicately removed and sent to a pathology laboratory, and the results confirmed that it was bone necrosis. After three months, the patient showed the same signs of swelling and again she was prescribed the same antibiotics. During the AB cycle, the patient felt that the implant was becoming very loose, so removing the implant was the only solution, as it was floating and a scan was taken to check the progression. Several weeks later, a piece of bone where the implant had been placed became so loose that it could be removed with a pair of tweezers. At the same time, the patient was experiencing pain arising from the mandibular anterior teeth; two of them were confirmed necrotic, and root canal therapy was performed using TF Adaptive (Kerr Dental) and most importantly negative pressure (EndoVac, Kerr Dental) for chemical preparation, as any irritation to the apical area would have had poor consequences. Two months later, a fistula discharging green pus was found under the mandibular anterior teeth. Correspondingly, the patient was prescribed another cycle of antibiotics (clindamycin) for ten days, as well as instructed to use a chlorhexidine-based mouthwash for several weeks. The antibiotic treatment decision was taken in consultation with her physician. That was the last episode of swelling that the patient had. Two years later, when no more symptoms occurred, the patient requested some aesthetic work to be done, only if it was safe for her (Figs. 9–13).

It was explained to the patient that, owing to her stable condition and since aesthetic work would not require any surgery or procedure involving trauma to the bone, it could be performed with a very mild anaesthetic without vaso-constrictors as a safety precaution. Mouthwash was prescribed for several days prior to any dental work and after it. The patient was very happy to have her smile back finally (Fig. 14).
Discussion

From a number of clinical studies, it is well substantiated that bisphosphonates cause drug-induced osteonecrosis.\textsuperscript{16–19} Osteonecrosis is a condition that occurs when there is loss of blood to the bone. Bisphosphonates inhibit the resorption of bone by osteoclasts and may have an effect on osteoblasts.\textsuperscript{20} By the same token, these two types of cells represent the origin of the bone remodelling cycle. Therefore, any cell dysfunction would influence the cycle, preventing bone formation and resulting in bone necrosis.\textsuperscript{21–23}

In dentistry, the association of osteonecrosis with bisphosphonate therapy is a matter of recent knowledge. Nevertheless, Schuster et al. suggest that, when the risk factors of the disease change, the intensity changes accordingly.\textsuperscript{24} The risk factors induced by bisphosphonates increase with the increase of the uptake and potency of this class of drugs. Science declares that the body is exposed to higher levels of drugs via intravenous administration than via the oral route.\textsuperscript{25,26} That is why it has been observed that osteonecrosis related to oral bisphosphonate therapy is less common than that related to intravenous administration.\textsuperscript{27}

Wood et al. showed that bisphosphonates can be classified into two groups as nitrogen-containing and non-nitrogen-containing bisphosphonates. Nitrogen-containing bisphosphonates pose a higher risk regarding BRONJ development.\textsuperscript{28}

Another factor that should be taken into consideration is the duration of therapy. According to a study, it was discussed earlier that oral bisphosphonates have lower bioavailability than intravenous ones, but the risks of BRONJ increase with the prolonged duration of administration.\textsuperscript{29–31}

Equally important, ceasing the use of bisphosphonates would not be considered safe, since the BRONJ risk might remain. Some practitioners still prefer stopping the drugs for six months to one year before and after a traumatic procedure. Bisphosphonates could be preserved in bone for months, even years, after the drugs have been used. According to some research, unfavourable effects from these drugs would not appear until three years after treatment ends, and after that time, the possibility of developing BRONJ remains very low.\textsuperscript{30,33}
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Furthermore, bisphosphonates have been shown to inhibit the proliferation of keratinocytes in the oral mucosa; thus, injury of the oral mucosa due to any dental procedure may increase the risk of BRONJ in bisphosphonate users. In most cases, dental procedures such as tooth extraction and surgeries were considered the initiator of the BRONJ. However, some papers have reported the spontaneous development of BRONJ without a prior invasive dental procedure.\textsuperscript{34}

Unfortunately, BRONJ is irreversible, meaning the bone cannot regenerate. There are no controlled studies on the long-term management of BRONJ.

Under these circumstances, making a treatment plan decision must consider the stage, or progression, of the disease. Ruggiero et al. identified four stages of BRONJ.\textsuperscript{31, 35, 36} Not so long ago, the stage of BRONJ was one of the most significant factors in choosing treatment options;\textsuperscript{37} however, a new protocol has recently been proposed. It is noted that one should ensure the completion of a dental examination before the commencement of bisphosphonate treatment. Any dental procedure concerning the patient should be done with two weeks preceding the administration of the medication.

Accordingly, patients are grouped into high risk and low risk.\textsuperscript{38} The factors in the high-risk category include intravenous administration of bisphosphonates, the intake of oral bisphosphonates with immunosuppressants and the existence of BRONJ in the medical history of the patient. The treating dentist should determine whether an extraction can be avoided. If so, root canal therapy and coronectomy can then be considered. However, if not, the dentist should discuss the case with an oral and maxillofacial surgeon.\textsuperscript{37}

The factors in the low-risk category include the oral administration of bisphosphonates. If an extraction is indicated and the patient has risk factors such as smoking or poor oral hygiene, before proceeding with the plan, the dentist should work on reducing the risk factors. If there are no threatening risk factors, the patient should be prepared for the extraction with the provision of 0.2 % chlorhexidine. Either an atraumatic or surgical extraction can be applied. If the latter is chosen, periosteal flaps and bone exposure should be kept to the minimum and antibiotics should be prescribed postoperatively. The wound is given a period of four to eight weeks to heal, and if healing does not occur in the given time, the dentist should refer to an oral and maxillofacial surgeon. It should be noted that treatments are intended to control the condition and resolve certain symptoms of osteonecrosis of the jaw.\textsuperscript{39}

Editorial note: A list of references is available from the publisher.

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A hidden champion in the field of medical technology, META BIOMED has exported its products to a European customer base through qualified distributors ever since its establishment in 1990. Recently, however, the company has redoubled its efforts to become an active force on the continent, establishing European headquarters in Mülheim in Germany in 2016. As the sole gold sponsor of the upcoming ROOTS SUMMIT—the premier global discussion forum for endodontics META BIOMED will be looking to further its brand recognition and presence in Europe, a key factor for the company’s continued growth.

META BIOMED in Europe
With more than 1,000 employees worldwide, META BIOMED is recognised for its emphasis on research and development, and its commitment to providing innovative, high-quality solutions for endodontics and restorative dentistry at low prices. Founded in South Korea, the company is perhaps best known for its i-ROOT electronic apex locator, EQ Master cordless gutta-percha obtur- rator, and EQ-V obturation gun and pen.

META BIOMED’s entry into the European market has allowed it to widen its customer base, as the company already has branches in Cambodia, China, Japan and the US. In February, Frank Wirtz was appointed the new Sales and Marketing Manager for META BIOMED EUROPE. With previous experience at METASYS, Morita Europe and the NWD Gruppe, Wirtz brings a wealth of first-hand industry knowledge to the position.

“Wirtz has over 30 years of national and international experience in marketing and selling high-quality dental products,” remarked META BIOMED Managing Director Ian Yun on the appointment. “With such experience in the dental industry, he is the perfect candidate to further expand and establish the META BIOMED brand in Europe.”

META BIOMED at the 2018 ROOTS SUMMIT
The ROOTS SUMMIT will be held in Berlin from 28 June to 1 July at the European School of Management and Technology, a historical site in the centre of the German capital. Over the past two decades, the biennial meeting has established itself as an open and inclusive learning forum for those interested in endodontic therapy, and approximately 500 visitors are expected at the upcoming event, including many global opinion leaders in endodontics.

“We are extremely proud and excited to be a gold sponsor at the ROOTS SUMMIT, and to celebrate we are going to do a prize draw at the welcome reception,” said Wirtz. “The winner of the draw will receive a free flight to the 11th IFEA World Endodontic Congress, to be held from 4 to 7 October 2018. What’s more, he or she will get an exclusive guided tour of the META BIOMED headquarters in Osong in South Korea on 8 October.”

“We look forward to meeting current and future customers at the ROOTS SUMMIT and discussing our wide range of products with them,” he concluded.

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Surgical microscopes

Seiler Alpha Air and Promise Vision 3D

Seiler Instrument & Mfg Co., Inc. has over 75 years of optical experience. As one of the world’s leaders in dental surgical microscopes, the company has continued to advance the technology in conventional microscopes. In 2017, Seiler introduced the new Alpha Air series, one of the lightest microscopes on the market and equipped with over 150,000 lux LED illumination, six steps of magnification, apochromatic lenses and superior movement.

The newest product offering from Seiler is its Promise Vision 3D surgical microscope, which is revolutionising dentistry, according to the company. With no need for a binocular head to use the microscope, the dentist can sit in an upright position and practise four-handed dentistry seamlessly. At 60 frames per second, there is no lag time, and the depth of field and field of view are superior to those of a conventional microscope.

www.seilermicro.com
Kohler Medizintechnik of Stockach in Germany has introduced updated and enhanced versions of the Lee MTA Pellet Forming Block and Lee MTA Carver. Although the Lee MTA Block has been available in the dental marketplace for several years, the Kohler version has several improvements. Following the recommendations of a number of European endodontists, Kohler has added two larger grooves (1.2 mm) to the block to allow for the dispensing of a larger volume of MTA. Also, each of the grooves now has laser-marked measurements (0.6 mm, 0.8 mm, 1.0 mm and 1.2 mm). This makes the block much easier to read and use.

The new ENDOBLACK® Lee MTA Carver is much more ergonomic than any version from other companies. It has a larger, more light-weight black PEEK handle (weighing only 12 g). It also has the Kohler ENDOBLACK® surface to provide for better visibility during use, as well as greatly reduced reflected light during procedures.

Combined, these two products are superior to older syringe or carrier devices, which have problems with too-large cannula sizes, excessive quantities of MTA being delivered, difficulty in delivery of MTA to some areas of the mouth, and clogging of and damage to those devices.

Especially for the orthograde revision of an endodontic treatment, guttapercha removers according to Dr. Yoshi Terauchi are very suitable. The instruments have been proven for years in their daily clinical use, yet there is nothing that cannot be made even better. Thus, manufacturer Kohler and Dr. Terauchi have modernised the removers. Now, micro-hooks boasting outstanding tensile strength and stability on the fine working ends ensure firm hooking into the guttapercha, and these are produced to the utmost precision.

The new handles are made of PEEK, a shape- and colour-stable high-performance plastic, and are extremely light, each instrument weighing only 12 g. Furthermore, the black surface of the handles reduces light reflection under magnification. The handle design combines the advantages of simple cleaning and sterilisation with outstanding grip.

The guttapercha removers are available in four versions, adapted to different clinical situations: with working ends of 30 mm or 18 mm in length, and hooks to the left or right or the top or bottom.

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**IFEA World Endodontic Congress 2018 Seoul**

October 4-7, 2018 Coex, Seoul, Korea

**Endodontics:** The Utmost Values in Dentistry

**Overview**

- **www.ifea2018korea.com**
- **www.facebook.com/ifea2018seoul**

**Confirmed Invited Speakers**

- **Paul Abbott**, Australia
  - Is there still a role for medicaments in endodontics?

- **Antonis Chaniotis**, Greece
  - Management of severe curvatures and complex anatomy with controlled memory files: A new approach

- **Samuel O. Dorn**, USA
  - Extraction-Replantation: An alternative surgical technique

- **Mo K. Kang**, USA
  - Pulp tissue regeneration: Challenges and new outlook

- **Sergio Kuttler**, USA
  - “Past, present and future of endodontic files”: Where science meets technology

- **Tara Mc Mahon**, Belgium
  - Does heat treated NiTi facilitate endodontic therapy?

- **Cliff Ruddle**, USA
  - Endodontic Disinfection: 3D Irrigation

- **Michael Solomonov**, Israel
  - Contemporary approaches to instrumentation of non-round root canals

- **Yoshi Terauchi**, Japan
  - Predictable and minimally invasive method to retrieve a separated file

- **Andreas K. Braun**, The Netherlands
  - Root resorption after dental trauma - findings and treatment possibilities

- **Gustavo De-Deus**, Brazil
  - The relationship among reciprocation, glidepath and canal scouting

- **Filippo Cardinali**, Italy
  - Solutions to simplify shaping and cleaning; improving the quality of the root canal treatment

- **Franck Diemer**, France
  - How asymmetric geometry and heat-treatment influence the behavior of rotary root canal instrument

- **Nick Grande**, Italy
  - The paradox of minimal invasive endodontics

- **Anil Kishen**, Canada
  - Nanomaterials in endodontics: A potential game changer

- **Gianluca Gambarini**, Italy
  - 3D endodontics: Shaping root canals in 3 dimensions

- **Syngcuk Kim**, USA
  - Long term prognosis of endodontic Tx vs. Implant Tx

- **Seung Jong Lee**, Korea
  - Are the viable cells the only predictor for delayed replantation?

- **Zvi Metzger**, Israel
  - Early diagnosis and biomechanics of vertical root fractures

- **Frank Setzer**, USA
  - Management of iatrogenic errors by non-surgical and surgical retreatment.

- **Asgeir Sigurdsson**, USA
  - Is it toothache? non-odontogenic pain presenting as dental pain

- **Martin Trope**, USA
  - The expanding role of vital pulp therapy

- **Yosef Nahmias**, Canada
  - How to prevent instrument breakage by creating a mechanical reproducible glide path (don’t rotate, reciprocate)

- **Hagay Shemesh**, The Netherlands

- **Ghassan Yared**, Canada
  - Management of second mesio-buccal, narrow and curved canals with only one reciprocating instrument.

Lecture titles are tentative and subject to change.
Welcome to the 3rd part of the series "Successful communication in your daily practice". The series that includes the most popular and challenging scenarios that might occur in your dental practice and teaches you, how to deal with them so that your patients always leave your practice feeling: "My dentist is THE BEST!"

Each individual article of this series will teach you a new specialised protocol that you can easily use, customise and adapt from the same day on to your own dental clinic’s requirements and needs.

Millennial patients

Let’s start with today’s challenging topic which is... how to attract, communicate and retain millennial patients, who are our present and future patients! I will show you 7 crucial steps to always have in mind when dealing with millennial patients.

First, who are the millennials? Millennials are those patients that were born between 1980 and 2000, in fact, the patients that are from 17 to 37 years old. Because patients that belong to this age group are our present and future clients, let's start examining how to attract them to come to our dental offices!

7 steps to attract millennials

In the following, I will teach you 7 steps of how to attract millennials to come to your dental practice.

Step 1: Have a unique and intense online presence

The world wide web is an essential part of the millennials’ life. With this in mind, you should spend some time in creating a unique and attracting website and actively serve your social media channels. The millennial patients are highly attracted by promo actions, they love to check...
reviews, read about your CSR (Corporate Social Responsibility) and your philanthropic activities. Also be aware to have a clear differentiation point and description of your services—they pay a huge attention to all these tools and points!

Step 2: Have a service-fighter
A service-fighter is a treatment, like for example home bleaching, which is offered at the lowest price in the market. This will help you to attract the interest of those for whom price is very essential.

Millennials want to identify themselves with their surroundings. This affects above all their health suppliers, amongst them you as their dentist! With loyalty programmes you can offer them the possibility to specially connect with your practice.

Step 3: Be honest and keep it short
While treating a millennial patient always remember to be honest, informative and brief! Millennials hate it when you fool around with them. Also be as informative as possible while in the same time keep it short. Millennials are used to getting concentrated information and thus they will double check what you are telling them. They may have already googled it before they came to you!

It is also helpful to use some trigger words like flexible, community, dynamic, friendly, stimulating, environment. For example, you can say: “Our clinic is environmentally friendly.” They will respect and appreciate that because they are highly environmentally conscious themselves!

Step 4: Have a millennial employee
If you do not belong to the millennials’ age group, it is of advantage to have at least one employee of your team who does. You will see: Your millennial patients will feel more comfortable to ask him or her possible questions instead of you—and this is a fact!

Step 5: Use loyalty programmes
Millennials want to identify themselves with their surroundings. This affects above all their health suppliers, amongst them you as their dentist! With loyalty programmes you can offer them the possibility to specially connect with your practice. Thereby, it is a good idea to add your clinic’s loyalty programme to your clinic’s mobile application (if you have one). They will just love it as their mobile phones are their whole life and something they always carry with them!

Step 6: No face-to-face communication to follow-up
After a successful treatment, avoid to make a lot of follow-up appointments with face-to-face communication. Millennials rather love it short and simple, as we have already learnt above. So better send them an e-mail, SMS, WhatsApp or messenger with a brief but at the same time detailed message about their current health status and further treatment options.

Step 7: Be fast
When you respond to your millennial patients, be fast! Since they have grown up in a world where information is available in only short time, being fast is notable and very important for them!

Just do it!

Imagine working for the next years and still have a “full house” clinic because you know how to deal with your millennial patients! Isn’t this just fabulous?

In the next issue of roots magazine, I will present to you the fourth part of this unique new series of communication concepts that will teach you how to promote a service and/or technology before you apply it in practice—6 unique steps that will guarantee the increase of your patients’ interest!

Until then, remember that you are not only the dentist of your clinic, but also the manager and leader. You can always send me your questions and request for more information and guidance at dba@yiannikosdental.com or via our website www.dbamastership.com. Looking forward to our next trip of business growth and educational development!

contact

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Dr Fred Weinstein, DMD, MRCD(C), FICD, FACD, who passed away 15 October 2017, at the age of 78, is pictured in Anaheim, Calif., at the California Dental Association meeting, CDA Presents the Art and Science of Dentistry, in 2012. A retired endodontist from Vancouver, British Columbia, Weinstein often travelled to dental meetings to keep his knowledge of the specialty current and to visit with his many friends. (Photo: Fred Michmershuizen)

“He brought a world of enthusiasm and knowledge to the global endodontic community”

Fred Michmershuizen, DT US

“What a remarkably kind and insightful individual he was—always inquiring about me and others and never letting on about himself,” Glickman remembered. “He brought a world of enthusiasm and knowledge to the global endodontic community. I will miss him dearly.”

“Fred was that special kind of person who would do anything he could to help out when needed. He cared for everyone and was a dear friend,” said John J. Stropko, DDS, of Prescott, Ariz. “Fred was a teacher, always encouraging others to use the latest technology to deliver better treatment results for their patients. During the process, he went to great lengths to clearly communicate his beliefs in an easy-to-understand manner. Our specialty has lost one of its great members.”

“I knew Fred for more than 25 years, and I always found it entertaining to be in his company,” said Anne Lauren Koch, DMD. “We went to hockey games, basketball games and endodontic meetings together. Fred was a character, but in the best sense of the word. He was entertaining, charming and unpredictable. That was Fred. But to those of us who knew and loved him, he was much more than that. He was a loyal friend who made a maximum effort to understand each of us in a personal and supportive way. Really, at the end of the day, Fred was a mensch. He will be very much missed.”

Weinstein was born in 1939 in Winnipeg, Manitoba. He graduated from the University of Manitoba at the age of 22 with a degree in general dentistry, and then he went on to study endodontics.

In a print ad published in the August 2007 issue of Endo Tribune, Dr Fred Weinstein dressed as a Royal Canadian "Mountie" to promote the IFEA meeting, held that year in Vancouver, British Columbia.
at the University of Pennsylvania School of Dental Medicine in Philadelphia, under the tutelage of Dr Louis Grossman, known as the “Father of Endodontics”. After receiving his Certificate in Endodontics from the University of Pennsylvania in 1969, he moved his family to Vancouver and established an office in the Fairmont Medical Building, where he would go on to practice for more than 40 years.

“He loved his patients, and he equally enjoyed teaching and lecturing throughout the world to advance the learning within dentistry,” his family wrote in an obituary published in the *Vancouver Sun*.

Weinstein’s accomplishments within the profession were notable. He served as an assistant clinical professor at the University of British Columbia and was a past President of the Canadian Academy of Endodontics, the British Columbia Society of Endodontics, the Interspecialty Society of British Columbia and the International Federation of Endodontic Associations (IFEA). He was a member of the Royal College of Dentists, and he was a fellow of the American College of Dentists and the International College of Dentists.

He served on advisory boards for several leading dental manufacturers, and he lectured extensively throughout the world. He also served as a volunteer endodontist at the 2010 Vancouver Winter Olympics, and performed root canal treatment on world boxing champion Sugar Ray Leonard in the 1980s.

He was especially proud to have served as the general chairman for the 2007 IFEA World Congress in Vancouver. To drum up excitement for that meeting, he dressed as a Royal Canadian “Mountie” at several events leading up to it—something that friends and colleagues remembered for years.

“Fred always had a smile and was known as ‘the Canadian Mountie’ for his outfit that he wore at every dental meeting to promote the IFEA meeting in Vancouver in 2007,” remembered Samuel O. Dorn, DDS. “He was truly dedicated to the Canadian Academy of Endodontics and its place in global endodontics. His passion for endodontics and his friendship will never be forgotten.”

“I cherish my photo of us with him dressed as a Mountie when he was President of IFEA,” said Dr William Ben Johnson. “Fred and I started out as endodontic colleagues, then became friends. So much so he would go snow skiing with me even when he didn’t care for skiing, and I would drink wine with him when I preferred scotch. I’ve lost a friend.”

After his retirement from practice, Weinstein continued to travel to dental meetings to keep his knowledge of the specialty current and to visit with his many friends.

For many years, Weinstein was editor in chief of *roots magazine*, the international C.E. magazine of endodontics, published by Dental Tribune America.

“Above all of Fred’s accomplishments and titles, his family remained his number one priority in his life, always,” his family wrote in the *Sun*. “He had a gentle heart of gold, compassion and sincerity and a smile that would illuminate a room.”

Dr Fred Weinstein with “Queen Elizabeth II” at the IFEA meeting in 2007. *(Photo: Fred Michmershulzen)*

Dr Fred Weinstein with “Queen Elizabeth II” at the IFEA meeting in 2007. *(Photo: Fred Michmershulzen)*

Dr Fred Weinstein in Hamburg, Germany, in the summer of 2017. *(Photo: Haye Hinrichs)*

Dr Fred Weinstein with “Queen Elizabeth II” at the IFEA meeting in 2007. *(Photo: Fred Michmershulzen)*

Dr Fred Weinstein in Hamburg, Germany, in the summer of 2017. *(Photo: Haye Hinrichs)*
International Events

**HKIDEAS**
24–26 August 2018
Hong Kong
www.hkideas.org

**FDI World Dental Congress**
5–8 September 2018
Buenos Aires, Argentina
www.world-dental-congress.org

**Dental-Expo**
24–27 September 2018
Moscow, Russia
www.dental-expo.com

**BDIA Dental Showcase**
4–6 October 2018
London, UK
www.dentalshowcase.com

**IFEA 11th World Endodontic Congress 2018**
4–7 October 2018
Seoul, Korea
www.ifea2018korea.com

**DenTech China – Exhibition & Symposium**
31 October – 2 November 2018
Shanghai, China
http://www.dentech.com.cn

**Expo-Dentária**
8–10 November 2018
Porto, Portugal

**JADR Annual Meeting**
17–18 November 2018
Hokkaido, Japan
http://jadr66.univ.jp

**GNYDM**
25–28 November 2018
New York, USA
www.gnydm.com

**ADF**
27 November – 1 December 2018
Paris, France
www.adfcongres.com
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Please note that all the textual components of your submission must be combined into one MS Word document. Please do not submit multiple files for each of these items:

- the complete article;
- all the image (tables, charts, photographs, etc.) captions;
- the complete list of sources consulted and
- the author or contact information (biographical sketch, mailing address, e-mail address, etc.).

In addition, images must not be embedded into the MS Word document. All images must be submitted separately, and details about such submission follow below under image requirements.

Text length

Article lengths can vary greatly—from 1,500 to 5,500 words—depending on the subject matter. Our approach is that if you need more or less words to do the topic justice, then please make the article as long or as short as necessary.

We can run an unusually long article in multiple parts, but this usually entails a topic for which each part can stand alone because it contains so much information.

In short, we do not want to limit you in terms of article length, so please use the word count above as a general guideline and if you have specific questions, please do not hesitate to contact us.

Text formatting

We also ask that you forego any special formatting beyond the use of italics and boldface. If you would like to emphasize certain words within the text, please only use italics (do not use underlining or a larger font size). Boldface is reserved for article headers. Please do not use underlining.

Please use single spacing and make sure that the text is left justified. Please do not centre text on the page. Do not indent paragraphs, rather place a blank line between paragraphs. Please do not add tab stops.

Should you require a special layout, please let the word processing programme you are using help you do this formatting automatically. Similarly, should you need to make a list, or add footnotes or endnotes, please let the word processing programme do it for you automatically. There are menus in every programme that will enable you to do so. The fact is that no matter how carefully done, errors can creep in when you try to number footnotes yourself.

Any formatting contrary to stated above will require us to remove such formatting before layout, which is very time-consuming. Please consider this when formatting your document.

Image requirements

Please number images consecutively throughout the article by using a new number for each image. If it is imperative that certain images are grouped together, then use lowercase letters to designate these in a group (for example, 2a, 2b, 2c).

Please place image references in your article wherever they are appropriate, whether in the middle or at the end of a sentence. If you do not directly refer to the image, place the reference at the end of the sentence to which it relates enclosed within brackets and before the period.

In addition, please note:

- We require images in TIF or JPEG format.
- These images must be no smaller than 6 x 6 cm in size at 300 DPI.
- These image files must be no smaller than 80 KB in size (or they will print the size of a postage stamp!).

Larger image files are always better, and those approximately the size of 1 MB are best. Thus, do not size large image files down to meet our requirements but send us the largest files available. (The larger the starting image is in terms of bytes, the more leeway the designer has for resizing the image in order to fill up more space should there be room available.)

Also, please remember that images must not be embedded into the body of the article submitted. Images must be submitted separately to the textual submission.

You may submit images via e-mail, via our FTP server or post a CD containing your images directly to us (please contact us for the mailing address, as this will depend upon the country from which you will be mailing). Please also send us a head shot of yourself that is in accordance with the requirements stated above so that it can be printed with your article.

Abstracts

An abstract of your article is not required.

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The author’s contact information and a head shot of the author are included at the end of every article. Please note the exact information you would like to appear in this section and format it according to the requirements stated above. A short biographical sketch may precede the contact information if you provide us with the necessary information (60 words or less).

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