A light at the end of the tunnel?

Professor Liviu Steier asks if there’s a future for bacteria-free dental devices such as implants

Why should a dentist be worried about bacterial contamination or even worse biofilms? And by this, I don’t just mean plaque. Let us have a look on the definition of “biofilm” by the University of Montana under the chairmanship of Dr David Costertone.

It says: “Biofilm forms when bacteria adhere to surfaces in aqueous environments and begin to excrete a slimy, glue-like substance that can anchor them to all kinds of material – such as metal, plastics, soil particles, medical implant materials, and tissue. A biofilm can form on any surface exposed to bacteria and some amount of water. Once anchored to a surface, biofilm microorganisms carry out a variety of detrimental or beneficial reactions (by human standards), depending on the surrounding environmental conditions.” (http://www.erc.montana.edu/CBEssentials-SW/6f-basics-99/basics-01.htm).

A dentist’s concern?

Now, why and how should this concern the dental practitioner? A prosthesis, an implant, or any device added to the oral cavity could be surrounded by biofilm once exposed to saliva. Virulence factors of bacteria surviving in biofilm differ heavily from planktonic ones. Infective processes can be in -

all include pumping the gas with energy. A spark in a gas will create a plasma. A hot gas passing through a big spark will turn the gas stream into a plasma that can be used. Plasma torches like that are used in industry to cut metals. The biggest chunk of plasma you will see is that dear friend to all of us, the sun. The sun’s enormous heat rips electrons off the hydrogen and helium molecules that make up the sun. Essentially, the sun, like most stars, is a great ball of plasma.’’ (http://education.jlab.org/qa/plasma_01.html).

Results are to be expected within the next five years. ‘Many patients will be benefit and have fewer problems after surgery relating to implant infections und healing delays,’ says Professor Katharina Landfeuster, director at the Max Planck Institute for Polymer technology.

Why should a dentist be worried about bacterial contamination or even worse biofilms? And by this, I don’t just mean plaque. Let us have a look on the definition of “biofilm” by the University of Montana under the chairmanship of Dr David Costertone.

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A dentist’s concern?

Now, why and how should this concern the dental practitioner? A prosthesis, an implant, or any device added to the oral cavity could be surrounded by biofilm once exposed to saliva. Virulence factors of bacteria surviving in biofilm differ heavily from planktonic ones. Infective processes can be induced, leading to as much as rejection of the incorporated device. Researchers at the Max Planck Institute in Mainz, Germany, started to research developing a surface coating to reduce or even prevent biofilm from forming on devices, prosthesis and implants. Dr Renate Förch, the spokeswoman of the research group, has outlined the future achievements on polymertechnology and the use of plasmatechnology (http://www.mpip-mainz.mpg.de/www/pages/aktuelles/pressemitteilungen/?year=2010&kap,72). Involved in this project, are research institutes from Spain, the United Kingdom, Switzerland and of course Germany, covered by a grant of the European Community. The biological attachment process of bacteria and the formation of biofilm are its main focus.

Daily practice

We deal with monomers and polymers in our daily practice. We use materials such as composites for restorations or veneering and help turn monomers into polymers. Polymers are chains of monomers, which offer new and unique properties. But do you remember what plasma is? Brian Kross, chief engineer at Jefferson Lab explains:

‘‘Plasma is the fourth state of matter...there are three states of matter: solid, liquid and gas, but there are actually four. The fourth is plasma. To put it very simply, a plasma is an ionized gas, a gas in which sufficient energy is provided to free electrons from atoms or molecules and to allow both species, ions and electrons, to coexist. The funny thing about that is, that as far as we know, plasmas are the most common state of matter in the universe. They are even common here on earth. A plasma is a gas that has been energized to the point that some of the electrons break free from, but travel with, their nucleus. Gases can become plasmas in several ways, but

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The Nobel Active implant

Dr Tidu Mankoo demonstrates the interdisciplinary restoration of six maxillary anterior teeth and a single Nobel Active implant

Abstract
This case illustrates the use of the Nobel Active (Nobel Biocare) implant for restoration of a failed maxillary central incisor, as part of the wider interdisciplinary restoration of the maxillary anterior teeth, in a 35-year-old female patient with a history of extensive treatment including previous crowns, multiple endodontic treatments and post cores.

There are a number of key factors in achieving inconspicuous aesthetic integration of an implant restoration, particularly in the case where a failed maxillary central incisor has led to considerable damage to the alveolar bone and compromised soft tissue volume.

The goal of any implant therapy in the aesthetic zone is to produce a restoration of the tooth (or teeth) that blends inconspicuously into the patient's smile and maintains stable soft-tissue form over time. It is understood that bone and soft tissue remodelling occurs around all dental implant restorations and while this remodelling has been attributed to a number of factors, it is now commonly accepted that it is probably due to the establishment of a “biologic seal”, commonly described as a “biologic width” between the free gingival margin to the crest of the peri-implant alveolar bone.

A number of factors have been proposed as playing a role in this process and in recent years, new implant designs have been suggested as being potentially helpful to reduce the impact of the remodelling process on the marginal bone; therefore creating enhanced stability of the marginal soft peri-implant soft tissues. While it is clear that the components alone are not the whole story, nevertheless most of the new designs serve to enhance the thickness of the soft tissue cuff around the implant-abutment complex.

The Clinical Case
In this example, a 35-year-old female patient with a history of extensive dental treatment required revision of her previously restored maxillary anterior teeth (canine to canine), as well as additional treatment in the posterior regions, which are not relevant to the article. The teeth had been previously crowned in a piece-

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The Nobel Active implant

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meal approach over some years, and the most of the teeth in question were root treated and restored with post crowns.

The overall aesthetic situation was compromised by the appearance of short clinical crowns, giving the teeth (particularly the central incisors) a rather ‘short and broad’ appearance (Fig 1). In addition, there were pre-existing endodontic treatments and post crowns in a number of the teeth and residual apical radiolucencies evident on some of the teeth (Fig 2).

These were asymptomatic (except for the failing left central incisor), the right lateral incisor and canine had been apicected and retrograde root filled a couple of years prior, the right central incisor had been previously root treated and contained a fibre post and composite core although the root filling was difficult to assess radiographically. However, as the tooth was stable and symptom free it was decided to accept the situation as re-treatment would be difficult, and lastly the radiolucency on the left lateral incisor had been symptomless and stable for a number of years and may have been a scar.

Nevertheless, it was clear that the prognosis of some of these teeth was uncertain and that further surgical endodontic treatment may be required in the future for the left lateral and possibly the right central incisor. The patient was made aware of this and the risk of possible future root fractures, particularly in the left lateral incisor where there was a large metallic post.

An additional point to note is that the presence of metallic post and cores and dark root substrate makes ideal colour of the gingival margins tissue difficult to achieve and has to be managed carefully when being restored with all-ceramic restorations to avoid affecting the value of the crowns.

The maxillary left central incisor needed surgical endodontic treatment, but had to be removed shortly after due to root fracture (Fig 5), and it was not possible to place an implant immediately due to the infection and damage to the labial bone.

Soft-tissue healing
A provisional metal-acrylic fixed-partial denture was fabricated and fitted at the time of tooth extraction and soft-tissue healing at six weeks post extraction.

Positioning the implant
The correct three-dimensional...
References

positioning of the implant is of critical importance in helping to achieve a lasting aesthetic result and here it is important to place the implant correctly, ie, three mm apical and two mm palatal to the final gingival margin desired on the implant restoration. In this case the teeth were to be crown lengthened, so it was necessary to recontour the cusp and establish the correct biologic width on the teeth (Figs 7, 9) prior to positioning the implant so that the final gingival margins will harmonise.

In effect, this meant that the implant was placed deeper than would have been in a case where no crown lengthening was required and facilitated a good housing of bone for the implant. Despite this, it was still necessary to augment the labial osseous and soft tissue contours for the purposes of achieving the correct soft tissue aesthetics.

A Nobel Active 4.5 x 13mm implant was placed after prepa-
ration of the osteotomy, achieving excellent primary stability, and bone augmentation was carried using the principles described in the previous publications by the author 25 using an organic bo-
vine bone mineral (Nu-Oss, Ace Surgical Co, Brockton, USA) and covered with resorbable collagen membrane (Bio-Gide, Geistlich AG) (Figs 9, 10).

A narrow healing abutment was placed, the bone augmenta-
tion carried out and the tissue on the crest of the ridge was deepi-
thelialised and rolled under itself to the labial to create an increase of the soft tissue volume on the labial of the implant healing abut-
ment and the flap sutured using 6-0 monofilament polypropylene sutures (Fig 11). This could be further enhanced with a connec-
tive tissue graft if necessary, but in this case, the roll flap created sufficient thickness. The bridge was re-cemented after adjust-
ment of the pontic to fit passively against the augmented ridge and healing abutment, and to allow for a slight tissue excess in the area of the implant.

The healing process begins

After three months of healing, the remaining crowns and pro-
visionals were removed and the teeth re-prepared to the new ging-
vival margins. The bridge retainers were relined and provisional crowns made and cemented provisionally to allow for tissue maturation to occur (Figs 12, 15).

After six months, final refine-
ment of the tooth preparations (Fig 14) and the achievement of good soft-tissue contours can be seen particularly on the labial as-
pect of the implant, where a thick collar of labial tissue is evident (Figs 15, 16). The final impres-
sions of the preparations and a transfer impression of the im-
plant were made and subsequent steps to try-in the abutment and biseque bake of crowns were car-
rried out. After all necessary adj-
justments were made the final Procera alumina crowns were finished and final cementation performed with a glass ionomer cement (Fuji I, GC) over a peri-
ods of a few weeks. It is essential that retraction cord is used when cementing the crown (whether provisional or final) on the im-
plant abutment to ensure that no cement excess travels into the sub-mucosal area as this can lead to peri-implantitis and therefore compromise the result.

A Procera Zirconia abutment was fabricated and Fig 17 shows an example of this, demonstrat-
ing the ideal contours of the abut-
ment with the scalloped margins resembling a tooth preparation. This enables crown margins to be ideally placed for cementation. The design of the Nobel Active implant components lend them-
Selves naturally to the creation of the transmucosal under-contour that facilitates a thicker trans-
mucosal tissue cuff and therefore greater stability.

Figs 18, 20 show the final crowns at two-month follow up. It is interesting to note the difficulty in achieving ideal soft tissue col-
our at the gingival marginal area of the teeth restored with metallic post crowns, but good colour is achieved around the implant.

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esthetic cases, particu-
larly complex cases. He is the current
President of the European Academy of Esthetic Dentistry.
Screw versus cement-retained, implant-supported prosthetic restorations

Professor Liviu Steier discusses passive-fit, cement hydraulics/overhangs and retrievability of implant-supported prosthetics

It was the year 1999 when Kim et al. stated that: ‘The use of cement-retained implant prosthesis is increasing because of improved occlusal anatomy, esthetics, and simplified laboratory procedures. Little is known about the biomechanics of cement retained implant prosthesis compared with that of screw retained implant prosthesis.’

While comparing, ‘cement retained versus screw retained implant restoration’, Michalakis et al. reviewed the literature in 2005. His research emphasised the following factors:

1. Ease of fabrication and cost,
2. Passivity of the framework,
3. Retention,
4. Occlusion,
5. Esthetics,
6. Delivery,
7. Retrievalability.

Weber et al. (2007) could not find enough evidence to prove any significant difference among restoration design and treatment outcome and Chee et al. (British Dental Journal 2006; 201: 501-507) summarised the differences they have identified:

- Screw-retained restorations are more easily retrieved and maintained
- Cemented restorations can accommodate more implant positions
- Screw-retained restorations are easier to manage when immediately loading implants.

Screw loosening is among the biggest post-loading problems. Cavazos et al. (1996) summarise reasons for screw loosening: ‘Screw stretch, less than ideal implant position, inappropriate occlusal scheme or crown anatomy, variations in hex dimension coupled with equalisation in the abutment counterparts, slight differences in fit and accuracy, tension on abutment and cylinder from ill-fitting restorations.’

Several approaches have been researched and suggested to avoid screw loosening, from silicon to resin sealing, from screw material innovation to coating techniques.

Fit variation

As early as 1961, Kurosu and Ide demonstrated that marginal fit of cemented restorations varies between 20 and 90 microns. Wilson et al. proved in 1990 the cementation procedure. Kim et al. (1999) measured the deformation of restorations with screw retention. Weber et al. proved in 2007 the fit of cemented restorations varied between 20 and 90 microns. As early as 1961, Kurosu and Ide described the differences in the screw-retained and the cement-retained implant crown transferred less stress to the implant fixture and supporting structure than the screw-retained and the permanent cement-retained implant crown transferred less stress to the implant fixture and supporting structure.
implant crown when a vertical force was applied.

Researching the literature, only one paper by Schwedhelm et al. (2003) has been identified addressing the cementation problem in implant-supported crowns. He suggested a lateral access screw to allow elimination of cement excess and reduce deflection/deformation of the prosthesis part as well nocivous forces to the implant.

A clinical case study

Missing tooth 46 was replaced by an implant: Internal Implant BTF, Laser-Lok 4.0 x 12mm, 4.5 Platform (Biohorizons UK, 17 Wellington Business Park, Dukes Ride, Crowthorne, Berkshire RG45 6LS). After adequate osseointegration time (three months after insertion), the second-stage surgery has been performed and the gum sculpted with a provisional.

References

The laboratory delivered the prepared abutment mounted into the transfer key. The PFM crown (high precious metal) guarantees a coronal access to the screw.

The abutment will be tightened according to the indications of the manufacturer using a torque control device. The impression as well as to be used as definitive abutment. The preparation of the abutment is performed by the technician. It is important to make sure that a nice prep margin is defined. This will ease the removal of the cement at the crown margins.

The author prefers a technique of cementation with coro- nal venting. The presented crown design addresses the following technology shortcomings:

- Cementation will easier pardon parodontal discrepancies.
- Coronal access will facilitate and allow screw retightening at any needed time.
- Coronal access will facilitate excess cement evacuation and clearly facilitate a better fitting.

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Conclusions
1. The crown will be seated using a luting cement, producing a very thin cement film, I favor active cemenation using vibrating approach to ease excess cement evacuation and avoid misfit and/or deflection or restoration.

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3. The laboratory delivered the prepared abutment mounted into the transfer key. The PFM crown (high precious metal) guarantees a coronal access to the screw.

4. The prepped abutment mounted into the transfer key.

The postoperative x-ray demonstrates the perfect fit of the abutment – restoration margin.

(2010). The tape will easily facili- tate future screw access and findings proved a less bacterial contamination manifested by bad smell.

5. The preped abutment mounted into the transfer key.

6. The laboratory delivered the prepared abutment mounted into the transfer key. The PFM crown (high precious metal) guarantees a coronal access to the screw.

7. The preped abutment mounted into the transfer key.

8. The preped abutment mounted into the transfer key.

9. The abutment seated in vivo using the transfer key.

10. The prosthesis was cementsed using the transfer key.

11. The postoperative x-ray demonstrates the perfect fit of the abutment – restoration margin.

12. The laboratory delivered the prepared abutment mounted into the transfer key. The PFM crown (high precious metal) guarantees a coronal access to the screw.

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The primary pathophysiologic vectors of pulpal disease and the myriad complexity of the root canal system had always been understood; as the century closed, clinicians were provided with new tools and technology to expand the boundaries and limitations of endodontic treatment procedures (Fig 4a, 4b).

Root canal infections are polymicrobial, characterised predominantly by both facultative and obligate anaerobic bacteria. The necrotic pulp becomes a reservoir of pathogens, toxic consequences and their resultant infection is isolated from the patient's immune response. Eventually, the microflora and their by-products will produce a periapical inflammatory response. With microbial invasion of the periapical tissues, an abscess and cellulitis may develop. The resultant inflammatory response will initiate either a protective and/or immun-

Figs 2a, 2b – Tooth #1.5 (4) was determined to be non-salvageable. It was removed, the socket stimulated to regenerate and in four month’s time an ANKYLOS® implant inserted, a sulcus former placed and the tissue closed over the site to allow for bone integration to occur.

Figs 2c, 2d – The choice of a natural tooth versus an orthobiologic replacement will increasingly be a powerful force in dental treatment plans. The temptation to choose one or the other based on expediency versus complexity, on marketing versus science is going to be the sine qua non of the standard of comprehensive care.

Figs 2g – Vertucci FJ – 1984. Two thousand four hundred human permanent teeth were decalcified, injected with dye, and cleared in order to determine the number of root canals and their different morphology, the ramifications of the main root canals, the location of apical foramina and transverse anastomoses, and the frequency of apical deltas.

Figs 3 – Fig 3 – The degree of complexity of the root canal system has been understood for most of the past century. The failure to negotiate the labyrinthine ramifications of the root canal system has purportedly been a function of technical limitation rather than comprehension and yet, it took until the mid 70’s to appreciate that thermolabile condensation of an obturating material could demonstrate a greater occlusive degree of the system than any other modality.

Fig 4a – Panel of anatomic preparations from the classic work by Professor Walter Hess of Zurich – The anatomy of the root canals of teeth of the permanent dentition, London,pag. John Bale, Sons & Danielsson.


The primary reflected what is now an anachronistic view of emergency procedures and the standard of care defining non-surgical therapy during that period; the second, done prior to the technologic advances of the last decade of the 20th century, was hallmarkbed by a dramatic decrease in leaving pulpless teeth open in emergency situations and a significant decline in the use of culturing prior to obturation. The report indicated that the concept of “debridement and disinfection” versus “cleaning and shaping” was now the focus of the biologic therapeutic imperative and the need for expansive microbial strategies was recognised as being of paramount importance (Fig 3). The primary patho-physiologic vectors of pulpal disease and the myriad complexity of the root canal system had always been understood; as the century closed, clinicians were provided with new tools and technology to expand the boundaries and limitations of endodontic treatment procedures (Fig 4a, 4b).

Root canal infections are polymicrobial, characterised predominantly by both facultative and obligate anaerobic bacteria. The necrotic pulp becomes a reservoir of pathogens, toxic consequences and their resultant infection is isolated from the patient's immune response.
opathogenic effect; additionally, it may destroy surrounding tissue resulting in the five classic signs and symptoms of inflammation: calor, dolor, rubor, tumor and pungere. Patient evaluation and the appropriate diagnosis/treatment of the source of an infection are of utmost importance.

Patients demonstrating signs and symptoms associated with severe endodontic infection (Table I) should have the root canal system filled with calcium hydroxide and the access sealed. In the event of copious drainage, the access can be left open for no longer than 24 hours, the tooth then isolated with rubber dam, the canals irrigated and dried and calcium hydroxide inserted into the root canal space and the access sealed (10). The antibiotic of choice for periradicular abscess remains Penicillin VK; however, recent studies have reported that amoxicillin in combination with clavulinate (1gm loading dose with 500mg q8h for seven days) was a more effective therapeutic regimen (11).

Systemic antibiotic administration should be considered if there is a spreading infection that signals failure of local host responses in abating the dispersion of bacterial irritants, or if the patient’s medical history indicates conditions or diseases known to reduce the host defense mechanisms or expose the patient to higher systemic risks. Antibiotic treatment is generally not recommended for healthy patients with irreversible pulpitis or localized endodontic infections (Table II).

Numerous studies with well-defined diagnosis and inclusion criteria failed to demonstrate enhanced pain resolution beyond the placebo effect (12, 13). The sophistication of endodontic equipment, materials and techniques has been steadily iterated and innovated since the second survey. The microscope first introduced to otolaryngology around 1950, then to neurosurgery in the 1960s, is now standard of care for the voyage into the microcosmic world of the root canal space. Recursions in the micro-processing technologies of electronic foramenal locators generated unprecedented accuracy lev-
Diagnosis

Of all the technologic innovations embraced by endodontics, digital radiography should have generated the greatest impact; however, its value remains limited in diagnosis, treatment planning, intra-operative control and outcome assessment. Flat field sensors still require three to four parallax images of the area of interest to establish better perception of depth and spatial orientation of osseous or dental pathology. These three-dimensional information deficits, geometric distortion and the masking of areas of interest by overlying anatomy or anatomic noise are of strategic relevance to treatment planning in general and in endodontics specifically. Cone beam computed tomography (cbCT) produces up to 580 individual projection images with isotropic submillimeter spatial resolution enhanced by advanced image receptor sensors; it is ideally suited for dedicated dento-maxillofacial CT scanning. When combined with application-specific software tools, cone beam computed tomography can provide a complete solution for performing specific diagnostic and surgical tasks. The images can be resliced at any angle, producing a new set of reconstructed orthogonal images and studies have shown that the scans accurately reflect the volume of anatomic defects. The limited volume cbCT scanners best suited for endodontics require an effective radiation dose comparable to two or three conventional periapical radiographs and as such are set to revolutionise endodontics.

Three dimensional pre-surgical assessment of the approximation of root apices to the inferior dental canal, mental foramen and maxillary sinus are essential to treatment planning. The ability of cbCT to diagnose and manage dento-alveolar trauma using multiplanar views, the determination of the root canal anatomy and the number of canals, the detection of the true nature and exact location of resorptive lesions and the discovery of the existence of vertical and horizontal fractures outweigh concerns about the degree of ionising radiation and the risks posed. Provided cbCT is used in situations where the information from conventional imaging systems is inadequate, the benefits are essential for optimisation of the standard of care.

Patel reported that periapical disease can be detected sooner and more accurately using cbCT compared with traditional periapical views and that the true size, extent, nature and position of periapical and resorptive lesions can be accurately assessed. Using a new periapical index based on cone beam computed tomography for identification of apical periodontitis, periapical lesions were identified in 59.5 per cent by radiography and 60.9 per cent of cases by cbCT respectively (P < .01). Simon et al compared the differential diagnosis of large periapical lesions with traditional biopsy. The results suggested that cbCT might provide a faster method to differentially diagnose a solid from a fluid-filled lesion or cavity, without invasive surgery. In spite of the presence of artifacts, the learning curve related to image manipulation and the cost, cone beam tomography will invariably be the accepted standard of diagnostic care and treatment planning in endodontics in the very near future.

Access

An improperly designed access cavity will hamper facilitation of optimal root canal therapy. If the orientation, extension, angulation and depth are inaccurate, retention of the native anatomy of the root canal space becomes precarious. The requirements of access cavity design can be achieved by conceptual and technical regression of the existing configuration to that which one would logically expect to have seen prior to the insults of restoration, function and aging.

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SWISS PREMIUM ORAL CARE
If tertiary dentin were perceived of as “irritational dentin” or dystrophic calcification considered “decay”, the chamber outline could be used to blueprint an inlay configuration for the access design that literally replicates the “virgin” tooth (Fig 7).

Removal of the existing restoration in its entirety and/or preliminary preparation of the coronal tooth structure for the subsequent full coverage restoration will identify decay, fractures, unsupported tooth structure and expose the anatomy of the underlying root trunk periphery which assists in discovery of the spatial orientation and morphology of the roots. The pulp chamber ceiling and pulp stones can be peeled away with a football diamond bur to grossly identify the primary orifices. Micro-etching (Danville Materials, San Ramon CA) the floor of the chamber, perhaps the most underused of all access tools, is invaluable in the exposure of fusion lines and grooves in order to identify accessory orifices. Troughing with ultrasonic tips of any design is used solely to trace fusion lines, not effect gross removal. The use of ultrasonics to “jackhammer” pulp stones is simply too risky as one approaches the root canal system. An acceptable alternative is to use incisal directed water jets to remove pulp stones and debris. Drying the operative field with ultrasonic tips will assist in the differentiation of restoration and tooth structure should re-entry be necessary.

Irrigation

The complex anatomy of the root canal space presents a daunting challenge to the clinician who must debride and disinfect the corridors of sepsis with absolute asepsis to achieve a successful treatment outcome (see Fig 10). In addition, the absence of a cell-mediated defense (phagocytes, a functional host response) in necrotic teeth means the microorganisms residual in tubuli, cul de sacs and arborisations are mainly affected by the redox potential (reduction potential) which reflects the oxidation-reduction state of the environment – aerobic microflora can only be active at a positive Eh, whereas strict anaerobes can only be active at negative Eh values) and availability of nutrients in the various parts of the root canal. While our knowledge of persistent bacteria, disinfecting agents and the chemical milieu of the necrotic root canal has greatly increased, there is no doubt that more innovative basic and clinical research is needed to optimise the use of existing methods and materials and develop new ones in order to prevent and/or treat apical periodontitis.

Varying degrees of sterility of the root canal space are achieved by mechanistic removal, the chemical reactivity and fluid dynamics of irritants and their introduction to the canal space;
however, the protocols used today cannot predictably provide sterile canals. As none of the elements of endodontic therapy (host defense system, systemic antibiotic therapy, instrumentation and irrigation, interappointment medicaments, permanent root filling, and coronal restoration) can alone guarantee complete disinfection, it is of utmost importance to aim at the highest possible quality at every phase of the treatment. In the classic study by Sjögren et al., 55 single-rooted teeth with apical periodontitis were instrumented and irrigated with sodium hypochlorite and root filled. Periapical healing was followed-up for five years. Complete periapical healing occurred in 94 per cent of cases that yielded a negative culture. Where the samples were positive prior to root filling, the success rate of treatment was just 68 per cent – a statistically significant difference. These findings emphasize the importance of completely eliminating bacteria from the root canal system prior to obturation. This objective cannot be reliably achieved in a one-visit treatment of necrotic pulps because it is not possible to eradicate all infection from the root canal without the support of an interappointment antimicrobial dressing.

NaOCl is the most widely used irrigating solution. It is a potent antimicrobial agent and lubricant, which effectively dissolves pulpal remnants and organic components of dentin thus preventing packing infected hard and soft tissue into the apical con- fines. Hypochlorous acid (HClO) is the active moiety responsible for bacterial inactivation. NaOCl is used in concentrations varying from 0.5 per cent to 5.25 per cent; the in vitro and in vivo studies differ significantly in terms of the effectiveness of the range of concentrations as the in vitro experiments provide direct access to microbes, higher volumes are used and the chemical milieu complexity of the natural canal space are absent than in the in vivo experimentation. A study by Siqueira et al. showed no difference (in vitro) between one per cent, 2.5 per cent and give per cent NaOCl solutions in reducing the number of bacteria during instrumentation. What has been shown is that the tissue dissolving effects are directly related to the concentration used.

Perhaps the most misunderstood aspect of NaOCl irrigation is the need for the quantities of irrigation required due to the morphologic and anatomic vari- ations in the volumetric size of the root canal system. Siqueira showed that regular exchange and the use of large amounts of irrigant should maintain the antibacterial effectiveness of the NaOCl solution, compensating for the effects of concentration. Numerous devices have appeared in the endodontic armamentarium to address this situation: EndoVac (Discus Dental) – a negative pressure differential device designed to deliver high volumes of irrigating solution while using apical nega- tive pressure through the office high vacuum evacuation system, Negative Pressure Safety Irriga- tor (Vista Dental, Racine WI) – device is similar to EndoVac, Rinseendo (Air Techniques, Cor- rona CA) uses pressure suction technology; 65ml of irrigant are automatically drawn from the attached syringe and aspirated into the canal (pressure created is lower than manual irrigation), Viperine (Bisco Canada, Rich- mond BC) – sonic flow technolo- gy facilitates enhanced irrigation through the myriad complexities of the root canal system (Fig 11).

NaOCl cannot dissolve in- organic dentin particles and thus prevent smear layer for- mation during instrumentation. Chelators such as EDTA and citric acid are recommended as adjuvants in root canal ther- apy. It is probable that biofilms are detached with the use of che- lators; however, they have lit- tle if any antibacterial activity. Several studies have shown that citric acid in concentrations ranging as high as 50 per cent was more effective at solubi- lization of inorganic smear layer components and powdered den- tin than EDTA. In addition, citric acid has demonstrated antbacte- rial effectiveness.

Technology and innovation will not negate the need for op- timal preparation (debridement and disinfection) to eliminate microbial content and its impact on a necrotic root canal system. We as a discipline need to be better; however, by the same token, endodontics has shown its com- mitment to endless reinvention. In time, that will restructure the role of natural teeth in founda- tional dentistry, currently di- minished by the market forces of implant driven dentistry. Or- thobiologic replacement is not a panacea as random clinical trials increasingly show; the se- verity of peri-implantitis lesions demonstrates significant vari- ability and as such no treatment modality has shown superiority. The pendulum will continue to swing as the endodontic implant algorithm becomes increasingly multivariate.

Part 2 in next issue, including references

About the author
Kenneth S Serota, DDS, MMS: graduated from the University of Per- to, Faculty of Den- tistry in 1973 and was awarded the George W Tart Award for excellence in Prosthodontics. He received his Certificate in Endodontics and Master of Medical Sciences Degree from the Harvard Forsyth Dental Center in Boston, MA. A recipient of the recipient of the American Association of Endodontics Memorial Research Board for his work in nuclear medi- cine screening procedures related to dental pathology, his passion is educa- tion and most recently e-learning and rich media. He was selected for Fell- owship in the Pierre Fauchard Academy and is a Fellow of the Academy of Dentistry International. As the author of more than sixty publications, he has lectured on Endodontics internationally. He is on the editorial board of En- dodontic Practice, Endodonic Tribune and Implant Tribune. The founder of www.tdsonline.org in order to promote the empow- erment digital technology to the dental team and the propagation of comprehensive care.