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Golden standards and modern technology

Decades ago, the giants of modern endodontics put together the standards of root canal treatment, and we have been following them ever since. At the time, they had only ideas and rather simple research techniques and yet managed to formulate golden standards for a whole field of therapy.

Shaping and cleaning the root canal system (as proposed by Schilder) is a key phrase from Seltzer and Bender: it is more important what we take out from the root canal system than what we put into it (even today, with the warm vertical technique of obturation).

Images obtained with simple methylene blue dye showing the complexity of the system was their precursor of our sophisticated micro-CT scanning, and yet it was them who opened our eyes to the root canal system complexity. And such examples are many.

Today, we need to ask ourselves—especially when new, marketing-driven concepts are promoted to us—what are we doing to our patients and are we still following those concepts? It is true that with new tools we are able to work faster and potentially safer; it is also true that we managed to add to those concepts or modify them a bit—nevertheless, we still work in the spirit of those guidelines.

At the end of the day, we need to see one simple thing—with all the great studies and publications serving the same purpose—the outcome of the root canal treatment that we perform in our chair for our patient. This is where we need to focus. What kind of service are we offering to our patients and what is the viability of our treatment? Are we putting our skills and knowledge to the test? Are we recalling our patients in order to check if what we did is still standing true and healthy?

It is definitely a difficult task, and takes huge effort from our staff and from our patients, especially when they say, “I am fine and I am busy, I don’t feel a thing and maybe I cannot manage to pass by the clinic for a follow-up.” It has to be a joint effort (maybe even included as a clause in the consent form the patient signs, to make sure the patient understands that they need to come for regular check-ups on a yearly basis). Hopefully, we will then be able to publish more data and learn from what we see from the recalls—and use real-life clinical experience to introduce change to some of our protocols.

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Being actively involved as a founding member and president of several endodontic societies, Dr Ibrahim Abu Tahun has experienced the changes in the field significantly over the last decades. DTI had the opportunity to speak with Tahun, who is an associate professor in the Department of Conservative Dentistry at the University of Jordan, about the most influential developments in the specialty and how these advances are changing the way endodontics is practised.

Dentistry is changing rapidly, with new materials, devices and treatment protocols being introduced constantly. What is the situation in endodontics in particular? What are the major developments currently?

At the beginning of the 21st century, we have greater understanding of the pulp biology, pathophysiology and its powers of healing. The field of tissue engineering has exploded during the last decade, and extensive reviews on dental applications are available, producing a critical mass of knowledge and methods that are likely to answer the challenge issued decades ago.

Various animal and human studies have shown high success rates for vital pulpal therapy. These investigations have demonstrated that the amputated pulp can be repaired by itself or after application of bioactive materials.

Recent approaches to pulpal wound treatment have essentially followed two lines: one has continued the conventional path to seeking improved synthetic materials that provide better seals, resulting in a breakthrough in bioactive materials, while another line has taken a biological approach with the hope of identifying a biologically based strategy for treatment of clinical conditions.

What are the advantages of new treatment modalities compared with conventional root canal therapy?

The potential benefits to patients and the profession are groundbreaking. From a public health point of view, the recent advances in tissue management and wound healing, compared with the current form of root canal therapy, which is more of a mechanical and chemical process, should be reflected in our clinical management to develop more bio-compatible treatment modalities and increase tooth longevity.

In the past, it was unthinkable that the tissue in the periapical region of a non-vital infected tooth could regenerate. Case reports published during the last 15 years have demonstrated convincingly in humans that this type of environment may create the ideal clinical outcome if disinfection can be achieved, just as it is for the canals in the case of dental avulsion. These novel endodontic tissue engineering therapies offer the possibility of restoring natural function and improving the long-term outcome of teeth with a poor prognosis.

When it comes to implementing new treatment modalities in daily practice, do you think the endodontic community is somewhat divided or is the specialty as a whole on the verge of a major paradigm shift?

The debate on clinical technique and the concept of regeneration and revascularisation per se is not a product of modern medicine. The varying treat-
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ments for the tooth pulp during the last three centuries illustrate this clearly. Recently, various treatment concepts have been suggested using less-invasive approaches. Even though an optimal treatment protocol is lacking, however, many case reports and case series on pulpal therapy have been published.

Once considered taboo, vital pulpal treatment of symptomatic permanent teeth with mineral trioxide aggregate has been reported to be successful, and greatly improved prognoses for permanent retention are now possible.

A very recent study has found that regenerative endodontic treatment has the potential to be used to retreat teeth with persistent periapical periodontitis after root canal therapy.

More high-quality cohort studies would strengthen the evidence-based recommendations. However, the current best available evidence allows clinicians to provide these treatment modalities safely to patients.

Globally, what is necessary to implement this new approach to endodontic treatment?

A reparative, biological approach to pulpal therapy is not only welcome, but also absolutely essential. Ideally, the delivery of biologically based endodontic procedures must be more clinically effective than current treatments and the method of delivery must also be efficient, cost-effective and free of health hazards or side-effects for patients. A recent study has suggested that endodontic practitioners are supportive and optimistic about the future use of regenerative endodontic procedures.

Best practice guidelines must be updated to include guidance to maintain the self-respect of the dental profession and the trust of the patients we serve, as the fact remains that more biological endodontic treatment means endodontics that is more ethical than today.

In your opinion, what innovations will influence endodontists most in the years to come?

The tremendous and exciting new research on regenerative endodontics from Japan, the US and other countries has made the cultivation of potential in this field a strategic priority without undermining the efficacy of conventional endodontic therapies, but positioning practitioners at the forefront of this field.

We are changing protocols, towards going biological. This path to the future with various potential approaches based on clinical and scientific results presented in the professional literature will lead to predictable conservative treatment that may enable practitioners to fill a root canal with nature’s tissue instead of plastic materials or artificial surgical prostheses. The important challenge facing us now is to develop and adapt a safe, effective and consistent method for regenerating a functional pulp-dentine complex in our patients.

Thank you very much for the interview.

Editorial note: At the 19th Scientific Congress of the Asian Pacific Endodontic Confederation, which was held from 5 to 8 April in New Delhi in India, Tahun addressed current endodontic challenges and conflicting priorities between conventional therapies and new treatment modalities in his lecture “Can we do it forever?”.
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In the era of advanced technologies, patients’ expectations are multiply increasing. They want to have the least invasive treatment procedure with only minimal bleeding, more effective healing, greater precision and the least number of appointments.

For many years now, lasers have been proven to be an effective device for a minimally invasive treatment. Nevertheless, any dental office that wants to implement lasers in its daily practice has to keep in mind several issues. These issues are:

- Safety
- Employee education
- Marketing
- Revenue channels
- Advantages

Amongst the issues mentioned here, marketing is one that is very pivotal but in most cases not yet well prioritised. Although, current trends in practice do focus a lot on marketing. The winning edge of today’s practice lies in a formula saying: “I project who I am.” This philosophy brings forth the transparency of laser-based practice. Since the costs incurred to the patients are higher with laser treatments, the imperative as well as the benefits coming with lasers needed to be well known by the patients.

The Blue Ocean Strategy

Most corporations do smart things and also less smart things from time to time. In order to improve the quality of success, it is important to evaluate what has made the positive difference and understand how to replicate this in a systematic manner. It is also understood that the strategic move that matters centrally is to create blue oceans. The Blue Ocean Strategy challenges companies to break out of red oceans of conventional approaches and competition by creating uncontested market space that finally leaves any competition irrelevant.

The Blue Ocean Strategy in dentistry

As stated by Masahiro Fujita, President of Sony’s System Technological Laboratories: “The risk of not innovating is greater than the risk of innovating.”

The success of brands relies on cutting an edge in the existing market. The introduction of dental lasers is the most practical application of the principles of Blue Ocean Strategy in the dental business. Marketing and treatment protocols can be well shaped in lines of this principle. Even though laser can prove to be a high-end investment, the success and uniqueness that follows has been well researched and documented by several practitioners around the globe.

Investment above investment

The investment in laser devices for a company is an extra mile. Combining both hard and soft tissue lasers could add up to about 100,000 US$ to the total cost of investment. Even though this amount sounds substantial in the initial stage, the return on investment with lasers can range between 280 to 600 per cent. These kind of returns are possible when we successfully combine technological benefits with appropriate marketing strategies.

Changing patients’ trends

The patients walking into the practice these days are “drone patients”. Prior to their consultation, they like to read about possible procedures, optional treatments and latest advances. Since patients are partly aware of the technology, stating further benefits enhances their knowledge. Hence, decisions are made more easily and naturally in favour of lasers.
Benefits of lasers

The usage of laser in the daily dental practice is undoubted. From a practitioners point of view there are several benefits which basically can be divided into intangible and tangible benefits. Intangible benefits refer to the high technological status of lasers and the subsequent referrals that its reputation generates. Lasers do make the procedure easier and more comfortable for the patient. Almost all hard tissue procedures can be done without using anaesthesia. This certainly reduces the stress for the patient who normally relates dentistry with needles and drills. The most important factor in private practice is “time management”, which ranks amongst tangible benefits. With lasers, multiple restorations can be performed in the same appointment as there is no numbness involved. Additional procedures like hygienist appointment and exam schedule with specialists can be also accommodated at the same time. This directly adds on to saving time and increasing profitability.

More benefits of laser usage in the dental practice are:

Fear factor control
Most patients walking into the practice have dental fears or phobias for various underlying reasons. Their fears could be caused by negative past experiences, a shared experience from someone close or just the anticipation of needles and drills. With lasers, the approach to dentistry becomes different. The need for anaesthesia is either completely ruled out or substituted by only a few drops of intergingival infiltration.

More certain prognosis
When it comes to the treatment of endodontically compromised teeth, lasers work quite accurate in combination with conventional treatment approaches. A recent approach of combining diode and erbium lasers has given vast success rates in grossly decayed teeth with peri-apical infections.

No drill dentistry
Since laser is a non-contact procedure, there is no pressure or touch sensation involved; this increases the patients’ acceptance of the treatment.

No antibiotics after minor procedures
It has been a common trend to prescribe antibiotics after any kind of surgical intervention or in endodontically compromised teeth. With laser there is no scar formation, tissue healing is faster, site of interventions is more sterile; hence, the need of antibiotics has decreased.

Marketing fundamentals

Dr Philip Kotler defines marketing as “the science and art of exploring, creating, and delivering value to satisfy the needs of a target market at a profit. Marketing identifies unfulfilled needs and desires.”

Marketing, in simple terms, is a management process through which goods and services move from concept to customer. It includes the coordination of four elements called the four P’s of marketing:
1. Identification, selection and development of a product,
2. determination of its price,
3. selection of a distribution channel to reach the customer’s place, and
4. development and implementation of a promotional strategy.

Changing trends
Over the years, marketing has evolved through three stages: Marketing 1.0, 2.0 and 3.0.

Marketing 1.0 was selling the factory’s output of products to all who wanted to buy them. The products were quite basic and designed to serve a mass market. The goal was to standardise productions’ costs so that goods could be priced lower and made more affordable to buyers. This marketing strategy was part of the product-centric era.

Marketing 2.0 is the principle attached to marketing in current times which is information age where the core is information technology. Thereby, the job of marketing no longer stays simple. The golden rule of marketing 2.0 is: “Customer is king.” Customers are better off as their needs and desires are prioritised.

Marketing 3.0 denotes a “value driven” era. This concept of marketing uplifts into the arena of human aspirations, values and spirits. It believes that consumers are complete human beings whose complete needs and hopes should never be neglected. Therefore, this principle complements emotional and human spirit marketing.

Lasers as a tool for Marketing 3.0

Marketing 3.0 incorporates lasers pretty well as it keeps in consideration the benefits to the patients, the producers credentials, and the high-end technological status. The current age also follows the new wave technology which enables connectivity and interactivity of individuals and groups. This enables the customers and the dentists to be well aware of the advances in lasers availability.
FDA approval for dental laser marketing

Applications for and research on lasers in dentistry continues to expand since their introduction to the dental profession. Dental laser systems are cleared for marketing in the United States via the Food and Drug Administration (FDA) Premarket Notification (510(k)) process. The review team determines whether the product under review meets relevant criteria for “substantial equivalence” to a predicate device (the term “predicate” is used to describe any device that is marketed for the same use as the new device, even if the actual technologies are not the same).5

There are three key points in the marketing of dental lasers:
1. Efficiency: In a dental practice, efficiency is one of the key factors that draw the thin line between growth and failure. Efficiency is based on the application of technology. The more we succeed in incorporating the latest advances, the more we ensure that our practice is increasing revenues, enhancing patient experiences and expanding referrals. Efficiency in a practice accounts to increase the happiness quotient of both patient and dentist.
2. Reduced chair time: Speed is another major variable to consider when choosing the dental laser. Lasers are certainly a bit slower than the conventional drill, but this lapse of time does get well compensated with the fact that there is no waiting period of numbing involved.
3. Improved patient experience: Drill-free and no anaesthetic procedures are always more welcoming to the patients. Dental lasers create a virtually pain-free experience, which is a definite game changer for the vast majority of patients.

The above mentioned points can be easily used as key markers in promoting dental lasers. Since there are unquantified and data supporting these facts, patients can also be encouraged to search around online before booking in their appointments. Relevant information can be communicated by different forms of media:
- Social media such as Facebook, Twitter, Snapchat, Instagram
- Advertisements through radio or TV channels
- School screenings: information leaflets on lasers can be included along with the school dental reports. This makes information reach home and triggers the first step of curiosity to get to know more and use the service if or when required.

Laser marketing and practice

Dental lasers add a lot on the functioning of dental practices. They not only boost up the revenues, primarily due to the cost differences between laser and conventional treatments, but also improve the actual functioning of the practice in several manners.

Significant decrease in missed appointments

Pain is certainly an abstract phenomenon and its perception changes from one patient to another. Having lasers in the dental practice with their added advantages certainly decreases the perception of pain to a large extent. Patients are no longer afraid to sit in the chair and receive the care they need. This helps decreasing the number of missed appointments.

Increased new patient volume

Satisfied patients add a lot to any practice. Dental lasers give dentists the opportunity to increase new patient referrals because of the unique experience lasers enable for existing patients. Patients feel so positively motivated that they talk about their experience to family and friends, thereby spreading the name of practice by word of mouth.

More referrals

Being unique projects the practice as a cut above the rest. This helps increasing the referrals from other practices and also from colleagues in the same practice. When the practice comes to be known as laser specialty practice, it becomes a known referral base for specific procedures and also for those who are technology-friendly.

New procedures

Laser equips the dentist to perform a wide variety of procedures that could not be handled otherwise. The lack of anaesthesia, blood, sutures and minimal postoperative discomfort enables dentists to perform procedures such as labial and lingual frenectomies, fibroma removals to exposures, crown lengthening and much more. New procedures get added to a dentist’s repertoire that would previously have been referred out or untreated. Many of these procedures can be performed during the same visit; thereby, increasing revenue growth without having to add a second appointment.

Conclusion

There has been a long road between the times when lasers were taken as the adjunct only for high-end practices and procedures, to the current times, where laser is used as a regular armamentarium. In the world of marketing, lasers have brought dentistry to Blue Ocean. The frequent use of a laser by offices has resulted in a higher level of patient comfort, increased case acceptance for routine care, larger cases, and improved doctor productivity.7

Following the principles of the Blue Ocean Strategy, practices that offer compassionate care using advanced technologies such as lasers will be the offices that experience the largest influx of new patients in the future...
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Completely disinfecting the canal system is challenging when all factors are considered. If we are looking at the nano level there are approximately 76,000 dentinal tubules per square millimetre of dentine. Each of which can harbour a colony of bacteria. Then there may be inaccessible anatomy such as lateral canals, apical deltas or fins. These are factors that need considering outside of canal curvatures that may or may not be entirely visible in the plane of the radiograph. It is clear that outside of the contact our files make with the walls of the root canal there needs to be chemical disinfection to further reduce bacterial load. Irrigants disinfect as well as lubricate instruments and they dissolve the pulp. Sodium hypochlorite has been the mainstay irrigant for decades.

During the 1980s, Bystrom and colleagues investigated the effect of mechanical instrumentation with and without adjunctive use of hypochlorite. They found, unsurprisingly so, that when compared to pure mechanical instrumentation, the use of hypochlorite in combination with hand filing significantly reduced bacterial load. As such chemomechanical instrumentation was shown to be crucial for endodontic success. They compared irrigation with saline, 0.5 % and 5 % hypochlorite over a sequence of 5 appointments. Interestingly they found no difference in the reduction of bacterial load between 0.5 and 5 % hypochlorite. Despite what was likely to be a comprehensive protocol for these teeth, 7 of the 15 specimens in this study still had bacteria that could grow at the end of treatment. The presence of cultivable bacteria does not necessarily mean we have failure—it merely means that there may be a cohort of bacteria that have resisted treatment. Mechanical instrumentation does reduce bacterial load by itself—this is by way of physical removal of tissues where bacteria reside, while also facilitating the dispersal of the irrigant into the canal. Siqueira and colleagues found that enlarging the canal from size 30 to 40 resulted in a significant decrease in endodontic pathogens.

It seems that irrigation and instrumentation are both highly inter-related in canal disinfection. Take washing your car for instance, purely covering it with soapy water and rinsing won’t remove the motorway bugs and bird produced projectiles. A good scrubbing with a sponge is needed, or if you are really serious about cleaning, a pressure washer! This begs a further question—how would your patients feel if they knew that, more or less, the same or very similar liquid they use to clean bathroom suites is the same that we use to clean the inside of their teeth? On recent evidence of a dentist to the “stars” appearance on national TV not much—he advocated using charcoal to whiten teeth, which you may be able to buy from your local petrol station for barbecues.

Hypochlorite is an effective bactericidal but does not remove the smear layer. The smear layer is a mix of organic material (protein, pulp remnants, saliva, microorganisms) with an inorganic components consisting of minerals from the dentine. The smear layer prevents bacteria residing in the dentinal tubules from being exposed to the irrigant as well as reducing the contact between the dentine and sealant during obturation. Hence, utilising EDTA to remove the smear layer prior to obturation but after completion of preparation and instrumentation is sensible. A penultimate rinse with EDTA then a final rinse with hypochlorite prior to drying has been advocated heavily in the literature.

Bacteria and the biofilms

Unlike what we once thought, bacteria do not tend to just sit alone and remote from each other. If only they were this antisocial and could be picked off one by one! Bacteria join forces and create symbiotic groups, share resources and protect each other from external influence. This is commonly known as a “bio-
The goal of obturation is to seal the canal system to prevent any reinfection and entomb any bacteria not eradicated by chemomechanical debridement. If the obturation is through the apex, this can have significant implications. GP through the apex can carry bacteria outwith of the canal and exacerbate symptoms. A foreign body reaction could also develop.

We also have to remember that a beautiful obturation of a canal achieved without rubber dam and utilising saline or local anaesthetic irrigation is sub-standard treatment. It can be difficult to assess the "quality" of treatment when a radiograph of a "failed" tooth is examined in this context. Indeed, an obturation that is short of the radiographic apex having been treated under rubber dam and with copious amounts of irrigation is more likely to be successful than the previous scenario. Attributing too much significance to the radiographic appearance of the obturation is short-sighted. Indeed, Katezbadeh and colleagues in the late '90s witnessed healing in the absence of obturation where teeth where instrumented and irrigated optimally under isolation. Sealants are also antibacterial and aide filling the voids between the GP and the canal system. One further option would be to provide a sub-seal to each of the canal orifices. This can be achieved by removal of 1 mm of GP and packing a good thick mix of IRM packed with a plugger.

Covering the cusps

The provision of a coronal restoration (if provided optimally) can improve the coronal seal while also structurally protecting the underlying tooth tissue. Due to endodontic treatment, resulting in reduction of tissue bulk and stiffness the risk of fracture increases. Where both mesial and distal margins have not been breached and the access cavity is confined to the occlusal surface, a crown restoration may not be required. Once a margin is breached the tooth is more likely to flex and result in cracks or fractures. Commonly asked question, "When should the crown be provided? Soon after the root canal treatment or when the treatment has proven to be successful?"

If the success of endodontic treatment is significantly in doubt then this should be communicated to the patient and a well compacted direct restoration may be the best option, otherwise an onlay or if tooth tissue is significantly reduced, a crown should be provided soon after completion.

Conclusion

Bacteria are public enemy number one in dentistry. Disinfecting the root canal system by irrigating in combination with mechanical instrumentation is key to success in root canal therapy. Preventing further re-infection or persistence of residual bacteria after the formal stages of treatment through dressing initially and a quality coronal seal subsequently is as important as the root canal therapy.
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As usual in the human anatomy, root canals come in all forms and sometimes develop in very random structures. Luckily, pre-bendable nickel titanium (NiTi) files allow us to prepare and clean the canal in next to no time. In this article, we will compare three different endodontic cases, you will quickly find that a thorough and efficient root canal preparation is easy with the right set of instruments—regardless of the shape of the canal itself.

Reading endodontic case reports, you sometimes get the impression that root canals always spot an extreme, double curved morphology. With the latest technology and treatment auxiliaries the endodontic world has to offer, you should, of course, feel confident to take on even the most unusual shapes of canals. Would not it be nice though to have a universal, flexible NiTi file system that allows you to prepare all sorts of canals, whether they are S- or J-shaped or lead straight down to the apex? In Italy, we say “tutte le strade portano a Roma”. For a well-versed endo expert “all root canals lead to the apex is just as true—you only have to know how to use your equipment the right way”.

**Case 1: Straight down to business**

A 48-year-old female patient introduced to our surgery complaining of pain caused by chewing in the maxillary left side. We quickly found that the necrotic pulp of tooth 24 caused the complaint. The pre-operative radiograph showed a deep caries as well as a medium-sized periapical lesion (Fig. 1).

The root canals were positioned in a comparatively straight, almost parallel way with hardly any curvature. Quick preparation with a reduced sequence of NiTi files consequently should be possible in that particular case, as there were no contraindications to a root canal therapy in general.

To provide a clean and dry operating field, dental dam was applied to isolate tooth 24 for the following treatment. First of all, we handfiled the main canals up to ISO 10 size. We were thus able to create a suitable glide path, before the actual preparation took place.

In our endodontic practice, we normally use the latest generation of nickel titanium files by Swiss dental specialist COLTENE for cleaning and shaping the canal. As the name already indicates, the HyFlex EDM is a “highly flexible” NiTi file, which proves to be incredibly fracture resistant. In close cooperation with leading universities and international endo-specialists, the renowned research department of the innovative provider of endo equipment developed a literally sharp solution for their instruments. To come up with a new, powerful tool they employed a clever idea that is widely used in other industry branches to dentistry. The abbreviation “EDM” stands for a specific manufacturing process named “electrical discharge machining”. Spark erosion improves the cutting performance of the instrument as it produces a unique surface in the file. You can compare this kind of refinement with the serrated
edge of a kitchen knife you use for cutting bread to make bruschetta (Fig. 2). Due to its special material properties, the file is virtually unbreakable and predestined for dentists who require fast and reliable results using a reduced file sequence.

With the HyFlex EDM, we were able to prepare the root canal system in the blink of an eye. Access was quickly gained with the HyFlex 25/.12 Orifice Opener (Fig. 3). For the main procedure we used only one universal file that saved a lot of time during the treatment. For a quick and thorough preparation, a size 25 file with variable taper was applied in the common single length technique. The shaping took only a couple of minutes and we were able to navigate the instrument swiftly through the canal in a soft pecking motion (Fig. 4). Even when a bit more pressure was put on the file it neither blocked nor got stuck in the dentine.

To obtain the ideal chemomechanical cleansing we then irrigated the canal several times for a total of at least 30 minutes. Following the classic irrigation protocol, we used intracanal heated sodium hypochlorite (Iandolo technique), 17 % EDTA solution and 2 % chlorhexidine digluconate solution to remove all debris and possible irritants from the canal. After eradicating the infection, we dried the canal with the corresponding paper points size 25. The last step was to create a proper seal to prevent microorganisms from reentering the root canal system and thus protect the root from future
recontamination. A bioactive 3-in-1 obturation material was applied in a special technique as described in the following case to ensure that all lateral and side canals were filled. The postoperative radiograph after the treatment most notably showed a lateral canal in the apical third as well as an isthmus between the main canals, which got both filled safely (Fig. 5). The result was a tight, durable seal of the whole root canal system, as the final radiograph reflected (Fig. 6).

Case 2: 3-D obturation technique

In our second case, a 65-year-old female patient was referred to our practice with chief complaint of pain in the right side mandible. The radiograph showed defects in two teeth: in tooth 45, an insufficient former root canal treatment had led to a peri-apical lesion. In the neighbouring molar, a deep restoration was clearly visible. Tooth 46 was therefore diagnosed with a necrotic pulp (Fig. 7). Again, the HyFlex EDM helped us to shape the canal effectively without transporting or changing the natural path of the root canal. After gaining access with the orifice opener, we once again used the HyFlex OneFile to get to the apex. A few finishing touches were provided with the help of a 40/.04 EDM file.

Obturating all portals of exit turned out to be particularly challenging in our second case, therefore a modified three-dimensional obturation technique was applied using GuttaFlow bioseal. The 3-in-1 obturation material combines fluid gutta-percha with a suitable sealer at room temperature and bioceramics in an automatix syringe (Fig. 8). This composition results in an easy to handle material with excellent flow properties and working times of 10 to 15 minutes. What we call three-dimensional obturation technique is, in fact, an efficient and reliable way to fill even complex root canal structures.

First, we warm the gutta-percha using system B heat source. For our purpose, we decrease the temperature to 130 degrees from the average 200 degrees, as this totally suffices. Penetration depth is reduced to 3 seconds as well compared to the usual 5 seconds with a heat carrier to 4 millimetres from working length. This way the GuttaFlow does not set, but keeps a sticky consistency, which allows us to push it further down the canal with a plugger, if necessary. However, with our new technique the gutta-percha itself does not have to get inside the accessory canals, as the bioceramic sealer will already flow into any hidden canals. In previous test settings, you can see that the modified obturation technique allowed the sealer to advance deeper inside lateral canals in comparison to a traditional single cone technique (Fig. 9). Inserting the obturation material with more speed also generates higher pressure: you do not have to reach the desired working length in one go, but can use another stroke until you reach the desired length. The sealer sets only around 2 minutes earlier than normal with the reduced heat settings and fast penetration. Thanks to 3-D obturation, you let the sealer do its job in areas which are hard to reach, while it gets pushed further.
down into the canal by the slightly melted gutta-percha on top.

The fine white line in the postoperative radiograph of tooth number 45 showed the obturated small lateral canal leading away from the main canal (Fig. 10). Moreover, in the follow-up session, we noted that healing of the affected teeth 45 and 46 had already taken place. The bioactive components of the obturation material further added to the regeneration process, as they stimulated the rebuilding of bone and dentine tissue, which was a favourable side effect to the actual sealing of the canal (Fig. 11).

**Case 3:**

**Severe double curvature to finish off**

Last but not least, we come to the extraordinary S-shaped canal as mentioned in the introduction. With strong curves it is always good to know that NiTi files with a so-called "controlled memory" (CM) effect can be bent like classic stainless steel files, but do not bounce back. Using their unique material properties, you can work comparatively stress-free, even under difficult conditions.

This time, the patient with the rather challenging canal anatomy was a 40-year-old female patient with complaints in her right side mandible. In our analysis, the clinical diagnosis revealed an irreversible pulpitis in tooth 47. The radiograph indicated that we needed to get around a very sharp angle in the mesial root (Fig. 12); endo specialists know how distant molars are notorious for their winding root canal system!

We used the following sequence to get to the length very quickly without straightening the canal at all: HyFlex EDM 25/.12, 10/.05 and the afore-mentioned HyFlex EDM OneFile 25/~ (Figs. 4, 13, 14). The flexible files can even find their way around tricky anatomies and are virtually unbreakable. They move perfectly in the centre of the canal, therefore I have never come across any perforations or ledges during my numerous treatments so far. After using "CM"-treated NiTi files, they can be quickly regenerated by autoclaving and are ready for their next application until they reach the end of their life cycle by displaying an uneven, bent shape. As long as they are not unwound they can be re-used safely, otherwise they have to be discarded.

After drying and successfully obturating the canal, we were able to dismiss the patient with a very promising prognosis. The immediate postoperative radiograph showed the naturally formed, filled mesial canal with its striking double curvature at the end (Fig. 15). We are very glad that even in more challenging cases like the present one we can rely on the versatility of the latest generation of rotary instruments.

**Conclusion**

The latest generation of nickel titanium files adapt easily to all shapes of root canals thanks to their flexible design and unusual cutting power. Whatever way you choose to reach the apex, pre-bendable NiTi files like the HyFlex EDM help you to follow the natural path of the root canal and quickly remove debris for chemical cleansing and long-term obturation of the various root canal structures. The extremely fracture resistant files are literally "cutting edge" technology, which make an excellent travel companion on virtually every road.

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**contact**

**Dr Alfredo Iandolo** was awarded Doctor of Dental Medicine by the University of Naples Federico II in 2006. As Professor A.C. he has continued speaking on endodontic courses at his home university since 2014. Iandolo is a certified member of the ESE (European Society of Endodontics) as well as an active member of the SIE (Italian Society of Endodontics) and AIOM (Italian Academy of Microdentistry). As winner of the "Riitano Award" 2016 for best research in Endodontics Iandolo is a regular speaker at national and international congresses. The inventor of the Iandolo Gauging File (IG-File) and a new protocol in irrigation activation is widely published both nationally and internationally.

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**Fig. 14:** HyFlex EDM 10/.05.
**Fig. 15:** Postoperative radiograph case 3 showing a severe double curvature in the mesial root.
Management of a non-vital central incisor with an open apex

Using a novel MTA-based repair material in a young patient

Authors: Drs Mario Luis Zuolo & Arthur de Siqueira Zuolo, Brazil

Traditionally, calcium hydroxide has been the material of choice used to induce the formation of an apical hard tissue barrier before placing the permanent filling.1 Although many studies have reported favourable outcomes when this treatment is used,4–7 disadvantages have also been reported. The use of calcium hydroxide apical barriers has been associated with some problems, such as unpredictability of apical closure,8 risk of reinfection due to leakage of the provisional filling9 and risk of root fracture as a result of the long-term application of calcium hydroxide.10, 11 Furthermore, poor patient compliance has a negative influence on the prognosis of conventional apexification procedures.12

With the advent of the mineral trioxide aggregate (MTA), a calcium silicate-based, biocompatible, non-absorbable material, another treatment option was proposed.13 This material has the ability to set in a short period and in the presence of moisture. It solidifies into a hard structure in less than three hours.14 This property, along with its capability of inducing cementum-like hard tissue when used in the periradicular tissue,15 allows its use in the immediate obturation of an open apex.16–18

Several studies show that apexification with MTA has a high success rate with fewer visits and less time to completion.19–21 Also, in a study that compared clinical and radiographic results of apexification with MTA or calcium hydroxide, all of the cases sealed with MTA healed, whereas in the calcium hydroxide cases, two out of 15 did not heal.9 However, MTA has some disadvantages too. Because of its consistency, its manipulation and placement in the site of repair can be challenging.22 Additionally, its use can cause discoloration of the tooth, and it should be used with caution in aesthetic zones.23 A novel material, MTA REPAIR HP (high plasticity; Angelus), was recently introduced with the intention of improving some of those characteristics.24 This new formula retains all the chemical and biological properties of the original MTA; however, it changes its physical properties of manipulation, resulting in greater plasticity, thereby facilitat-
Case report

A 12-year-old male patient with a non-contributory medical history presented for examination with the chief complaint of pain in tooth #11. Clinical examination found that the tooth had been restored with a temporary filling and responded with pain to percussion and palpation and presented with a discrete oedema in the area. There was no probing defect or sinus tract stoma. According to the patient, root canal therapy had been started in the tooth approximately 12 months before. In the radiographic examination, a radiopaque material inside the canal a few millimetres short of the apex could be observed. Also, on the radiograph, it could be seen that the apex was not completely formed and presented with a periradicular lesion (Fig. 1). A clinical diagnosis of a pulpless tooth with unsatisfactory previously initiated therapy and symptomatic periradicular periodontitis was established.

The treatment plan was to first perform the cleaning and shaping of the canal and to place a calcium hydroxide dressing. Then, after one to two weeks, with the regression of the symptoms, we would recreate an apical barrier with a new MTA-based material, obturate the tooth and restore it. The treatment plan was presented to the patient’s parents, who agreed to it.

After the consent form had been signed, 1.8 ml of local anaesthetic (2% lidocaine with adrenaline 1:100,000) was administered, the restorative material was removed, and endodontic access corrected. After rubber dam isolation, the material inside the canal was removed under thorough irrigation using a 2.5% sodium hypochlorite solution (Fórmula & Ação) and a CPR-7 ultrasonic tip (Obtura Spartan Endodontics). After the removal of the material from the canal, #2 and #3 Largo burs were used to prepare the first two-thirds of the canal. Then, the apical foramen was located with the aid of an apex locator (RAYPEX, VDW), and the working length was established at 0.0 and confirmed with a radiograph. Instrumentation proceeded using stainless steel K-type hand files in a crown-down technique until a #80 hand file achieved the working length. Between each file change, copious irrigation with 2.5% sodium hypochlorite solution was performed (approximately 100 ml throughout the entire treatment).

During the procedure, passive ultrasonic irrigation was performed for one minute several times to ensure complete removal of the old material and to maximise the irrigation technique. After the completion of instrumentation, the canal was irrigated with 5 ml of 17% EDTA (Fórmula & Ação) for three minutes and a final rinse with 5 ml of saline solution. A calcium hydroxide-based paste was placed in the canal as an inter-appointment dressing, and the tooth was temporarily restored (Fig. 2). After ten days, the patient came to the clinic for conclusion of treatment. The tooth was asymptomatic, and the area was no longer
swollen. The temporary filling was removed, and the calcium hydroxide paste was removed from the canal using a 2.5% sodium hypochlorite solution and passive ultrasonic irrigation as previously described. The #80 hand file was used again to working length. The canal was then irrigated with 5 ml of 17% EDTA for three minutes to remove the smear layer, and 5 ml of saline solution was used for the final rinse. The canal was dried with paper points, and MTA REPAIR HP was manipulated according to the manufacturer’s instructions and placed with the aid of pluggers (BTL Biotech) in the last 3 mm of the root canal, forming an apical plug. After ten minutes, the material had set, and the tooth was obturated using BC Sealer (Brasseler USA) and gutta-percha cones with the lateral condensation technique (Figs. 3a & b).

The pulp chamber was cleaned with a sponge soaked in 70% alcohol, and the access cavity was restored using composite (Figs. 4a & b). A high-resolution CBCT scan of the patient was requested immediately after treatment so that it could be used for comparison later in the follow-up.

The patient presented for recall one month later without any symptoms. Postoperative radiographic and clinical evaluations were performed at three, six and nine months. The tooth was asymptomatic, and the area did not have any signs of inflammation. After nine months, another CBCT examination was conducted. Comparison of the CBCT images was performed, and bone healing and apical closure of the open apex could be observed (Figs. 4a & b, 5a & b).

Discussion

Previous clinical studies in humans have demonstrated that an apical barrier of MTA can be used with success in the technique of apexification of teeth with open apices. El-Meligy and Avery ran a clinical trial comparing the use of calcium hydroxide and MTA in 30 teeth of 15 patients who had lost pulp vitality through caries or trauma. The conventional technique of apexification with calcium hydroxide was performed in one tooth, whereas the barrier technique with MTA was applied to the other tooth in the same patient. The teeth were then followed up for three, six and 12 months. Two of the teeth filled using calcium hydroxide failed, while none of the teeth filled with MTA showed clinical or radiographic signs of pathology. Simon et al. carried out a prospective clinical trial in 57 teeth of 50 patients with open apices treated with MTA plugs and definitive filling of the canal and observed success in 81% of the cases.

In this case report, the use of a modified MTA (MTA—bioceramic-based high-plasticity reparative cement) achieved a good clinical result over the short follow-up period. Comparison of CBCT images just after placement of the MTA barrier and after a nine-month period demonstrated bone formation and apical closure by hard tissue. It should be noted that a radiolucent area too could be seen at this time. Such a healing pattern could be classified as incomplete healing, according to Molven et al.

From a clinical perspective, the handling and placement of the MTA REPAIR HP was easier than with the conventional MTA. According to the manufacturer, the difference between MTA REPAIR HP and the original Angelus MTA is the replacement of distilled water with a liquid that contains water and another organic plasticiser that gives the new product high plasticity (Fig. 6). The manufacturer claim that the new MTA does not promote dental discoloration could not be studied in this case, since the material was placed in the apical portion of the canal.

The importance of case reports is the demonstration of what is possible in our patients using scientific clinical treatment protocols. Reports from clinical practitioners have played important roles in the field of dentistry, but should be validated through proper laboratory and clinical research studies. In conclusion, the clinical protocol using the new MTA REPAIR HP, as described in this case report, enabled the successful apexification of a central incisor in a young patient.

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Blue light laser-assisted crown lengthening in restorative dentistry

Authors: Dr Philipp Skora, Dr Dominik Kraus, PD Dr Jörg Meister & Prof. Matthias Frentzen, Germany

Abstract

Basic investigations of the laser-tissue interaction of a new type of laser device with a wavelength of 445 nm—the blue light spectrum—promise considerable advantages in comparison with infrared laser systems due to the known optical parameters of oral soft tissue. The procedure for a comprehensive laser-based gingivectomy before restorative treatment using this new type of laser is presented in the following case report. Due to the outstanding haemostasis with the blue light laser, both gingivectomy and adhesive filling treatment were possible in only one session. The follow-up examination showed the rapid healing of the wound with no complications and with no postoperative gingival recession. The treatment led to a very good aesthetic result at a moderate effort.

Introduction

Blue light-emitting diode lasers present an innovative alternative to the already established diode laser systems with wavelengths within the infrared spectrum. Due to the strong absorption of blue laser light in oral soft tissue, the cutting capacity is improved when comparable laser parameters are used. Blue light lasers have very powerful coagulation effects that enable blood-free work. In addition, the high antimicrobial effect of blue light has been demonstrated in many fundamental studies. Due to these specific characteristics, blue light lasers are extremely suitable for corrective periodontal surgery in terms of gingivectomies. In contrast to electrosurgery, laser-assisted plastic-aesthetic periodontal surgical procedures do not cause problems of electro-magnetic
interactions that could in turn present a contraindication in the case of patients with symptoms of cardiac disease. In the case of multimorbid patients who are frequently prescribed anticoagulants, the danger of secondary haemorrhage can be minimised. In addition, in these cases, a bloodless surgical field can be created ad hoc, so that moisture-sensitive restorative measures (adhesive dentistry) can be carried out.

In general, for multi-morbid patients it is important that restorative procedures can be carried out in a short time and that the use of anaesthetics should be reduced to a minimum. Excision wounds should heal in a short time period. A dry environment is advantageous, in particular when a dental rubber dam cannot be used.

In case of extended subgingival loss of dental hard tissue, e.g. as a result of carious defects, it is always necessary to enable a visual inspection of the preparation margin before the restoration can be placed. Furthermore, a bloodless, clean, and dry adhesive surface must be guaranteed before application of restorative material. Here, laser-assisted procedures provide a fundamental advantage in comparison to classical surgical procedures. Adequate haemostasis after soft tissue excision with the scalpel, scalers and cuvettes is often not achievable by styptics.

This case study presents a treatment protocol for restorative and endodontic treatment of patients with extensive subgingival carious lesions in the anterior tooth area.

Case report

A 72-year-old patient visited the Dental School of the University of Bonn to obtain a dental consultation regarding prostodontic aspects. The medical history was unremarkable. The patient did not suffer pain. Among other things, insufficient composite restoration in the anterior tooth regions of the upper jaw were noticeable at the initial examination. In addition, subgingival probing showed defects in dental hard tissues at 11 and 21. For tooth 11, a fistula and an apical radiolucency were found in the vestibular marginal area in the X-ray image (Figs. 1a–e). Teeth 12 and 21 reacted positively to a sensitivity test, in contrast to tooth 11. The probing depths of the teeth 11 and 21 were 4–5 mm.

The treatment plan was explained thoroughly to the patient. In the first session, tooth 11 was trepanated as part of an emergency procedure. After exposure of the root canal, it was rinsed with NaOCl and calcium hydroxide was applied. Ahead of this emergency endodontic procedure, the carious lesions on 11 and 21 were excavated incompletely and treated temporarily with glass ionomer cement.

The patient came for further treatment five days later. The fistula on 11 had closed, clinical symptoms were no longer present (Fig. 2). After an infiltration anaesthesia (1.8 ml UDS), the subgingival carious defects in teeth 11 and 21 were visualised in a gingivectomy (Fig. 3). For both teeth, approximately 4 mm of soft tissue had to be removed to expose the af-
The gingivectomy was carried out using a 445 nm diode laser (Sirona K-Laser blu, Sirona) with a power output of 1.5 W in cw mode and an application tip with a diameter of 320 μm. This device is a pre-serial model equivalent to SIRO Laser Blue (Sirona). The resection was carried out in six minutes. The surgical procedure was performed with no pain. After finishing the gingival excision, the surgical field was bloodless and dry (Fig. 3), so that the temporary fillings at 11 and 21 could be removed and the caries completely excavated under visual control. The defects were treated with adhesive restorations with a composite material in a multi-layer technique (Herculite®; A3,5). Figure 4 shows the situation after the restoration had been completed, including finishing and polishing of the aesthetically complex restoration. After laser treatment, haemostatic measures were no longer necessary for all subsequent treatment steps. In the postoperative recall after seven days (Fig. 5), the patient reported that there was no postoperative pain. After the procedure, the patient did not find it necessary to use the analgetics that had been made available.

After 14 days (Fig. 6), the excision wounds had healed to a very great extent. There was still slight redness in the marginal area. No swelling occurred in the entire postoperative phase. At this time, endodontic treatment was also performed for the devitalised tooth 11. After preparation and sealing of the root canal, the trepanation cavity was closed using a composite material (Figs. 7a–c). Three months after the operative procedure, the endodontic treatment of tooth 11 resulted in no further clinical symptoms. In the treated area, the probing depth was 1.5 mm. No bleeding was found during probing. No further recession of the gingival margin was found after the primary healing, approximately two weeks after treatment or at the follow-up inspection after three months. Gingival colour and surface texture (gingival stippling) corresponded to a healthy appearance (Fig. 8). To ensure long-term good oral hygiene and to prevent approximal gingival recession at 11/21 in a further step a frenectomy (laser-assisted) should be performed.

**Discussion**

The presented treatment protocol for laser-assisted gingivectomy enabled the badly destroyed teeth 11 and 21 to be restored in an aesthetically satisfactory manner. Due to the safe procedure and the drying of the surgical field after laser-assisted excision, adhesive fillings were placed in the same session and exhibited no discoloration in the marginal zone, even after three months. This indicates a good bonding between the restorative material and the dentin. There was only little discomfort for the 72-year-old patient which derived from this complex therapy. After an emergency treatment, definitive rehabilitation, including adhesive restorations and endodontics, was carried out in two sessions. The patient did not report any discomfort related to the laser treatment. The patient’s aesthetic appearance in the anterior teeth of the upper jaw was restored with moderate means. This treatment procedure improves the patient’s compliance, because it allows the patient to partake in a systematic care and treatment concept, which enables the continuation of additional necessary treatment measures.
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Objective

This study was designed to examine the influence of temperatures ranging from 37 to 65 °C on the cell morphology of DPSC (dental pulp stem cells) via light and electron microscopy, a synthesis of Heat Shock Proteins (HSP) with fluorescence-marked antibodies and vitality via the Live/Dead Fluorescence Kit.

Material and methods

DPSCs were cultivated at 37 °C and 5% CO₂ in sterile cell chambers (MiniCeM, JenLab GmbH). The cells were irrigated with pre-heated culture medium (Eagle's MEM, Gibco BRL; 37 °C) with 20% FCS, 2 mM L-Glutamin and 100 µM L-Ascorbate-2-Phosphate in order to remove cellular debris previously to the temperature trials. Filling the chamber with the culture medium followed and a preheated water bath of different temperatures was introduced. Up to an incubation temperature of 46 °C, the experiments were conducted with temperatures rising every 2 °C and 0.5 °C in the sensitive temperature scale of 46 °C to 58 °C. In addition, trial series were carried out at 60 °C and 65 °C. After a total of 15 min of thermal treatment, the cells were cooled down in the incubator at a temperature of 37 °C for one hour.

Some of the cells which had undergone thermal treatment were examined with the Live/Dead Fluorescence Assay (Molecular Probes) in order to assess vitality via fluorescence microscopy and Axiovert 200 (ZEISS) after incubation. A mixture of 2 µM Calcein AM and 4 µM Ethidium-homodimer-D1 was added to the cells which were slowly cooling down at 37°C in the incubator either 1 h or 24 h after thermal treatment and incubated for 10'. Vital cells exhibited a green fluorescence caused by calcein, while lethal cells showed a red core fluorescence (Ethidium-homodimer-D1 and coupled DNA). 100 cells of each type were enumerated.

In order to examine the synthesis of HSP, the cells having undergone thermal treatment were processed as follows:

- Opening of the chamber and removal of the cover-slip containing the cells

<table>
<thead>
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<th>Temperature</th>
<th>Lethality %</th>
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<td>65 °C</td>
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Table 1: Live/Dead Assay one hour and 24 hours after thermal treatment.
· Suction of the nutritive medium, two rinses with PBS (isotonic: 67 mM phosphate buffer pH 7.2–7.4, 0.5 % NaCl)
· 12' fixation in 2 % paraformaldehyde in 0.1 M cacodylate buffer pH 7.2; Rinse: 3 x PBS, 2 x TBS (Tris buffered saline, 50 mM Tris-HCl buffer, 1.25 % NaCl)
· Parting of the coverslip with Pap-Pen pen (oil pen), possibly correct with paraffin
· Incubate one half of the coverslip overnight at 4 °C with 1:500 diluted antibody AK HSP25, Rabbit (Biomol), diluting solution: fish gelatin 1 %, Triton x 100 1 % in TBS)
· Cover the other half of the coverslip exclusively in diluting solution (without AK)
· Wash in TBS for 3 x 10'
· Conjugate with the second antibody AK Anti-Rabbit-Alkaline Phosphatase for two hours at room temperature (Ziege, dilution: 1:50 with fish gelatin 1 % and Triton X 100 1 % in TBS)
· Wash in TBS for 3 x 10'
· 15’ Alkaline-Phosphatase verification with 3 mM Levamisol in Chedium (induces blue-brown colouring according to Seidel).

In order to perform examinations with scanning electron microscope, the cells were processed as follows:
· Washing of the cells in cacodylate buffer (0.1 M)
· Fixation with 2.5 % Glutaraldehyde in cacodylate buffer for 20'
· Washing with cacodylate buffer for two times, followed by two washings with Aqua dest.
· Dehydration with increasing alcohol concentration: 20 %, 30 %, 50 %, 70 %, 90 %, 2 x in 100 % EtOH for 10’ each
· Further processing of the samples at the Centre for Electron Microscopy (Critical Point Drying and sputtering with gold; SCD 005, BAL-TEC AG)
· Microscope: Zeiss EM 902A.

Examinations with the transmission electron microscope were conducted:
· Washing of the cells with cacodylate buffer (0.1 M) with 6.8 % Sucrose
· Fixation of 30' with 1 % glutaraldehyde
· Washing with cacodylate buffer

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**Fig. 1:** Vitality test of thermally treated DPSC.

**Fig. 2:** HSP-detection caused by an antibody colour reaction.
Contrasting with 1% Osmiumtetroxyde and 1% potassium ferrocyanide for two hours.  
Rinsing with cacodylate buffer for three times as well as with Aqua dest.  
Dehydration with increasing alcohol concentration: 20%, 30%, 50%, 70%, 90%, 2x in 100% EtOH for 10’ each  
Embedding in Epon (epoxy resin), polymerisation for four days at 60 °C  
Ultramicrotomy, ultra-thin sections (70 nm; Leica Ultracut S, Leica Mikrosysteme GmbH)  
Dyeing of the sections with 1% Uranyl acetate in methanol and 1 drop of acetic acid for 10’  
Microscope: Zeiss EM 906

**Results**

**Light microscopy and vitality test**

The cells received thermal treatment at temperatures ranging from 37 °C to 60 °C and varying intermediate temperature levels. Light microscopy examinations showed significant morphological changes at temperatures from 46.5 °C ± 0.5 °C.

At temperatures from 37 °C to 45 °C, all cells exhibited a green calcein fluorescence. At temperatures of 46 °C and above, lethal results were detected in some of the cells that had undergone thermal treatment. The number of lethal cells increased in correspondence to a rise in temperature.

At temperatures of 46 °C to 56.5 °C, the number of lethal cells had almost doubled 24 h after thermal treatment in comparison to the number of lethal cells one hour after thermal treatment (Table 1, Fig. 1). Starting at 56.5 °C, this phenomenon ceased, with about the same number of lethal cells. This temperature of 56.5 °C corresponded to the LD50 value (50% lethality). No cell survived thermal treatment at 58 °C.

**Fig. 3:** Control cells exhibited a normal appearance at 37 °C under REM. Cell processes, microvilli-like structures on the cell surface (their numbers seem to depend on the level of cell activity) as well as the elongated cell shape are clearly visible.

**Fig. 4:** REM: Thermally treated DPSC showed external signs of cellular damage at 46.5 °C. The cell usually changes its elongated shape and starts to round. At 50 °C, an increased rounding can be observed. The cell seems to contract so fast that a part of the cytoplasm processes tears off (arrows). The surface structure of the cells is effected as appearance and number of microvilli change.
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HSP production
Examinations with regard to the production of HSP via light microscope or transmission laser microscopy showed a slight, unspecific colouring of the cells after incubation of 37 °C (control, Fig. 2). An increase in HSP production (intense colouring) was noted at a temperature of 50 °C, while thermal treatment at 60 °C again resulted in slight, unspecific colouring of the cells.

REM
Scanning electron microscopy showed a typical flat, long distribution of the control cells (37 °C cells, Fig. 3). These cells exhibited many processes and microvilli-like structures. In addition, cell-to-cell connections with neighbouring cells were observed.

The successive rise in temperature resulted in the first critical temperature level of 46.5 °C ± 0.5 °C. From this level onwards, significant initial changes of the cells were registered via light and electron microscope, especially an initial deformation and rounding of the cells. The cell structure (microvilli-like structures) was reduced. However, microvilli were observed at temperatures of up to 50 °C (Fig. 4). At 50 °C (chance of survival > 70 °C according to Live/Dead Assay), the cells left distinct cytoplasm protuberances on the base of the coverslip (Fig. 4, arrow), probably caused by a rapid contraction or rounding.

TEM
The fibroblast-like DPSCs (Fig. 6) exhibited long, extended mitochondria (M) within the 3-D network of the cell at 37 °C (control). The nucleus (K) appeared to be undivided and to have a normal nuclear envelope (arrows). ER/RER, free ribosomes as well as the Golgi apparatus did not show any anomalies. A significantly expressed cytoskeleton (Z) whose filaments were aligned parallelly to the longitudinal axis (probably microfilaments) was observed. The cells featured a number of inclusions.

At 50 °C, cell rounding became irreversible (Fig. 7). Mitochondria (M) exhibited structural changes, especially an inflation which concurred with the destruction of the cristae alignment, the parallelism of which got lost. There was no longer a three-dimensional network. The Golgi apparatus was significantly deformed and hardly any vesicles were constricted. The cytoskeleton was partially disintegrated and could no longer be detected. The cell membrane appeared to have increases vacuolisation. The nucleus (K) appeared to be damaged irreversibly. The nuclear envelope was inflated and partially disintegrated (*). The nuclear plasma condensed at the chromatin, resulting in a reduction of the euchromatin-areas which condensed at the heterochromatin. The nucleus exhibited segmented chambering (arrow).

Contrarily, the external shape of DPSCs incubated at 60 °C (Fig. 8) remained mostly intact. However, cytoplasm was hardly detectable. Mitochondria (M) were destroyed, membranes and cristae were partially wound up (arrows). Golgi apparatus and cytoskeleton were not detected. The euchromatin areas were reduced at the nucleus (K) and condensed at the heterochromatin (*). The nuclear membrane was significantly vesiculated.
Discussion

The first indications to a temperature-related damage of the DPSC were seen in the Live/Dead Assay. Calcein is able to penetrate the membrane and is only converted to a fluorescent colouring agent inside of an intact cell. If the cell membrane becomes permeable as a result of damages, calcein will not remain inside the cell. As a consequence, Ethidium-homodimer-D1 will enter the cell in exchange. This substance is not permeable for intact membranes and will fluoresce red when combined with DNA.

Interestingly significant thermally-induced damages were only observed at temperatures ranging from 46.5 °C ± 0.5 °C. Starting at this temperature, cell membranes are destroyed apparently. Temperatures from 56.5 °C ± 0.5 °C form another threshold at which the 50 % lethality limit was reached.

If the vitality test was conducted 24 h after thermal treatment, almost twice as much lethal cells as observed 1 h after incubation were seen at temperatures from 46.5 °C to 56.5 °C. It appears that repairing processes cannot eliminate the thermal damage. Contrarily, thermal treatment will result in a lethal reaction even 1 h later.

Starting at 56.5 °C, most cells died immediately, probably due to denaturation of the proteins (coagulation). Usually, a temperature level of 62 °C is given as the starting point for coagulation in the literature.

However, the Live/Dead Assay does not allow any conclusions on the effects of the damages on the cell organells, compartments or physiological reactions such as protein production. Consequently, HSP tests and electron microscopic examinations of the ultrastructure were conducted additionally.

Heat Shock Proteins (HSP) were detected very well at 50 °C by an antibody reaction. The cells were distinctly coloured, which implies a significant reaction of the cell on the temperature-related stress. These cells were still able to synthesise the proteins and to survive for some time. Controls only showed only a light colouring, which may be the result of an unspecific reaction of the antibody with different proteins.

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Fig. 6: TEM: Control cells at 37 °C. K: Nucleus; ER: endoplasmatic reticulum; RER: rough endoplasmatic reticulum; M: mitochondria; Z: cytoskeleton; arrows: markers of the nuclear membrane.

Fig. 7: TEM: Due to thermal treatment at 50 °C, the cells are rounded and the cell membrane forms vesicles (left). Mitochondria exhibit a disrupted structure of the cristae, while the nuclear plasma starts to condense and the nucleus (K) itself often appears to be uncharacteristically flapped (arrow). The nuclear membrane (*) seems to be partially inflated or dissolved.
study temperature-related damage of the DPSC

Similarly, a temperature level of 60 °C only lead to light colouration, which can be explained by the immediate lethal effect resulting in a missing time scale for the biosynthesis of HSP. In general, it should be noted that the first HSP examinations did not exhibit the expected intracellular resolution due to a low specificity.

The results of REM and TEM at the different guide values of 37 °C, 46.5 °C, 50 °C, 60 °C and 65 °C fit very well with the results from light microscopy. The effects of a sudden and massive heating to more than 46 °C on the exterior cell shape (rounding and partial reduction of external structures) are distinctly visible. The extremely fast contraction of the cells at temperatures around 50 °C might result in the observed tearing of cytoplasm-processes. Thermally-related membrane openings were not detected via REM even at temperatures of 60 °C and above. These high temperatures probably resulted in an immediate coagulation of membrane proteins and other intracellular proteins, which lead to a "conservation" or fixation of the cells in their current shape. While the external cell shape was maintained because of the lacking time window for morphological modification, irreversible damages to the organelles, nuclear membranes, nucleus and cytoplasm were detected electron-microscopically.

Starting at a temperature of 46.5 °C, a vacuolated cell membrane was observed via TEM in the rounded cells. Nucleus, organelles and cytoskeleton were subject to beginning morphological changes.

The cells reacted differently on heating, probably because their differences in physiological age, activity and cycle states influenced immediately visible effects. For example, the cells differed in the level of microvilli reduction.

If the survival of thermally treated cells will prevail for a time span of more than 24 h and if there are thermally-related damages of the reproductive behaviour remains to be examined by further studies. However, it may be postulated with caution that the presented data indicate a chance of survival of the examined DPSC up to a temperature of 46 °C. These results on the thermal damage behaviour of human dental pulp stem cells are important for the development of ultrashort dental laser systems.

Acknowledgements: The authors would like to thank Dr Walter Richter, Dr Iris Riemann and Mr Helmut Hörig (Clinical Centre of FSU Jena, Germany) for their support in producing electron microscopic and light microscopic images.

Fig. 8: TEM: Thermal treatment at 60 °C. Parts of the cytoplasm are damaged or dissolved as can be seen by the mitochondria (M) with inflated or wound-up cristae (arrows). The nucleus (K) shows severely condensed areas (*).

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Lighting in dental surgeries—frequently neglected requirements of the standard on illumination

Author: Antonín Fuksa, Czech Republic

Proper illumination plays an important role in most of our activities, as we acquire more than 80 per cent of information by sight. Precious values such as health and well-being are intrinsic in healthcare.

Lighting in dental surgeries is governed by EN 12464-1:2011 standard specifying minimum lighting requirements for workplaces. National versions of this harmonised standard are made mandatory by country regulations in EC countries. The current standard is effective as of 2011. Some of the illumination systems designed according to the previous edition (2002) are therefore no longer compliant. The requirements of the standard should be understood as the absolute hygienic minimum, as they are a compromise between average physiological needs and average economic potential.

According to ergonomic research, most people prefer their workplaces to be illuminated to 1,000 lx or more, while the standard-prescribed minimum is 500 lx. The standard prescribes the maintained illumination $E_m$. When the real average illumination $E$ falls under $E_m$, maintenance is to be performed: luminaires to be cleaned up, lamps to be replaced, walls to be repainted, etc.

Adequate illumination of the operating area is vital to perform surgical tasks. The standard for dental operating lights requires the operating field illumination to be in the range of 8,000 to 20,000 lx in ellipsis of size 50 × 25 mm (visual task area); but only 60 mm up from the centre of the ellipsis, a maximum of 1,200 lx is allowed to prevent the patient from being dazzled.

Constant re-adaptation of the eye between very bright and dark areas leads to eye fatigue, and finally to overall fatigue for the dentist. A powerful luminaire above the chair meets or exceeds the minimum prescribed illumination of the patient, which is 1,000 lx (co-responds to immediate surrounding area of the visual task: a stripe at least 0.5 m around visual task area). Lower contrast means better visual comfort for the dentist.

Cold tones of light are preferred as peripheral vision is more sensitive to the blue component of light. This leads to a decrease of perceived contrast. The standard requires light with high colour rendering index $R_a \geq 90$. Patients looking directly into the luminaire prefer matt luminous surfaces.
The model surgery has dimensions 5 x 6 m and ceiling height of 2.8 m. The luminaire above the chair is suspended in the height of 2.2 m above the floor. Positions of the additional luminaires are a compromise between functionality and aesthetics.

Besides the visual task in the mouth cavity, many other facets exist in the dental surgery that need to be illuminated in order to carry out tasks: instrument trays, controls and displays of diagnostic instruments, material preparation areas, PC table, filing cabinet, etc. Illumination requirements have to be fulfilled at all these places, too. A minimum overall room illumination of 500 lx has to be maintained as well.

One of the principal items in the updated standard is the background surrounding the dentist’s workspace, which is a stripe aligned to the surrounding area of the dentist’s workspace, at least 3 m wide, within the size of the room. According to the standard, this has to be illuminated 1/3 of the illumination of the surrounding area. Installations according to the older standard rarely meet this requirement. A luminance of 5,000 lx directed at the patient can be measured under a powerful luminaire. The background lighting in this case would be 1,670 lx, which is quite expensive to achieve. This requirement has not been met in any of tens of surgeries measured where a powerful directional pendant luminaire was placed above the chair. The updated standard helps us to understand the room as a whole, not just a set of task areas. Not only the illumination of the patient, but also the uniformity and acceptable contrast in the whole space is important.

The focused beam of the operating light provides illumination of about 15,000 lx that is necessary for the dentist’s task in the mouth cavity. The high-output directional/indirectional panel luminaire above the chair provides illumination of the task background area of about 3,000 lx, providing a 1:5 contrast, which is already an acceptable level. Colder tones of light further improve the perceived contrast to about 1:4. Besides illuminating the patient, the high-output directional/indirectional panel luminaire serves as an ergonomic aid to ease the visually demanding task of the dentist.

Measurements carried out in dental surgeries across some Eastern European countries clearly show that

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Meaning</th>
<th>Purpose</th>
<th>Overall illumination</th>
<th>Patient illumination</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\mathcal{E}_m$</td>
<td>Maintained Illuminance</td>
<td>Adequate level of light</td>
<td>500 lx</td>
<td>1,000 lx</td>
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<tr>
<td>UGR</td>
<td>Limit of Glare index UGR</td>
<td>Glare limitation, acceptable contrast</td>
<td>19</td>
<td>–</td>
</tr>
<tr>
<td>$U_o$</td>
<td>Minimum illuminance uniformity</td>
<td>Acceptable distribution of light</td>
<td>0.6</td>
<td>0.7</td>
</tr>
<tr>
<td>$R_a$</td>
<td>Minimum general colour rendering index</td>
<td>Required colour discrimination</td>
<td>90</td>
<td>90</td>
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<tr>
<td>–</td>
<td>Special requirements</td>
<td>According to selected task or area</td>
<td>Light should not dazzle the patient</td>
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Table 1: Comparison and evaluation of very basic parameters of illumination.

Table 2: Requirements on lighting in dental surgeries, according to table 5.48 of the standard.
even the very basic requirement of task illumination is often neglected. Also task background and overall illumination are often far too low, which has both eye and overall fatigue implications. As little as 30 lx have been repeatedly measured on the material preparation areas and computer desks. Many surgeries installed in existing buildings kept the original (office) luminaires, not quite following the lighting project. These systems were often projected according to an old standard that required as little as 300 lx for office work. Savings on lighting tend to generate much larger expenses later. The need for light grows with age.

Other parameters of lighting like uniformity, glare, colour rendering or non-visual effects of light and lighting control will be discussed later in a dedicated article.

Lighting the surgery with office luminaires only is not sufficient to fulfil basic requirements. Lighting using a single, powerful central luminaire provides enough light in the visual task area, but may easily fail to meet additional requirements. That is why additional luminaires are needed to provide background area illumination and uniformity.

References


Antonín Fuksa graduated (MSc) in 2000 at the Czech Technical University in Prague, Faculty of Electrical Engineering in the field of study Measurement and instrumentation. He currently works as a developer of intelligent luminaires, smart lighting systems and chronobiological phototherapy devices in NASLI.
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VDW: Endodontics with a system

Every dentist wants to perform safe and efficient endodontic treatment to preserve patients’ teeth for as long as possible, but can root canal therapy be easily integrated into general everyday practice? With almost 150 years of experience in endodontics, VDW provides perfectly coordinated solutions for the four key stages of endodontic treatment: preparation, irrigation, obturation and post-endodontic care.

“We offer new solutions that save time, simplify procedures and ensure the long-term success of treatments. We have adapted all of these innovations to VDW’s entire system solution approach,” said Arjan de Roy, Commercial Development Director of VDW. “We demonstrate that endodontics as a system solution pays off.”

Simple preparation perfectly combined

No dentist wants to deal with the hassle of an instrument breaking—for his or her own sake and above all that of the patient. Reasons for a fracture can be many and varied, including a complicated root canal anatomy, incorrect preparation techniques or poor processing of materials. Especially with severely curved root canals, a broken-off file can be removed only with a great deal of patience and skill. However, the alternating motion of reciprocating instruments, such as RECIPROC, significantly reduces the risk of file breakage. With RECIPROC blue, VDW went one step further: the latest generation of the single-file system is particularly flexible owing to a revolutionary production process. The result is a significantly reduced risk of fracture and even greater safety for the dentist and patient. With the RECIPROC blue, VDW provides the most effective tool for preparing all canals.

No endo without an endo motor

In modern treatment, wireless endodontic motors for reciprocating and rotating file systems have proved to be reliable. The handling of VDW’s motors is extremely simple: fully rotatable contra-angle handpieces with small heads allow easy access, excellent visibility and quick change of rotation. For optimum use and patient information, there are now also apps available with many functions, including preset programmes and a file library. Different file sequences and precise torque specifications allow safe operation while the dentist can also inform and best advise the patient. The innovative VDW.CONNECT Drive wireless motor combines all of these advantages for opti-
mum endodontic workflows, and the VDW.GOLD RECIPROC classic motor even has an integrated apex locator as a two-in-one solution.

**Successful endo means thorough cleaning**

Often under-estimated and yet crucial, proper irrigation and disinfection improve the likelihood of successful endodontic treatment. However, irrigation has so far posed a major challenge for many practitioners. General dentists and endodontists do, indeed, use different means of cleaning canals efficiently and preparing them for obturation. However, there is always a compromise in terms of either effectiveness or preservation of tooth substance. VDW offers a simple and clever solution for everyday practice that provides highly-effective cleaning of the root canal with minimal effort: the EDDY irrigation system. Using acoustic streaming and cavitation effects, the sonic-activated irrigation tip of the EDDY ensures efficient cleaning of the complex canal system, leaving no tissue residue or dental chips. The tip is made of polyamide, which is softer than dentine. Recent studies have proved that sonic activation with EDDY is at least as efficient as ultrasonic activation, but significantly safer owing to the polyamide.

**Obturation easier than ever**

Only a homogeneous, solid root canal filling prevents the risk of recontamination and ensures the long-term success of the treatment. With GUTTAFUSION, VDW has been offering a simple system for several years that combines single-post technology with warm 3-D obturation. The warm gutta-percha condenses into all isthmuses and ramifications, resulting in a homogeneous filling that can easily be prepared. The specially designed handle allows precise placement using tweezers, even in the molar area, and it can be detached easily without additional instruments. Obturation with GUTTAFUSION saves a great deal of time, in contrast to lateral condensation, as practitioners can apply the warmed gutta-percha more easily. A further advantage is that root fractures are virtually eliminated.

**Correct post-endodontic care**

The long-term prognosis of an endodontically treated tooth with a badly damaged clinical crown ultimately depends on the quality of the root post securing the crown to the root canal. Furthermore, it is essential that the coating allow an optimum bond between the post and the luting composite. VDW’s DT ILLUSION XRO SL offers even greater safety for the practitioner and patients. The colour pigments of the quartz-fibre posts react thermally, making the posts invisible at body temperature, but clearly visible during treatment and especially in radiographs. Durability and fracture resistance are further advantages. Finally, the innovative Safety Lock coating enables a secure and lasting bond for all adhesive systems and composite cements.

**Combined solutions instead of individual products**

Where endodontic treatment used to be perceived as complicated, with its pursuit of “Endo Easy Efficient”, VDW heralds the start of a paradigm shift. Systems that are precisely coordinated provide dentists with greater safety and simplicity while reducing treatment costs and time. Those who want to preserve teeth successfully choose endodontics with a system. Endo is just as “easy” as that._

More information at: www.vdw-dental.com
In the field of dentistry, the opportunities of current technologies are very concrete, very tangible as the International Dental Show 2017 (IDS) in Cologne demonstrated. In this way, the visitors experienced substantial enhancements to established digital workflows—from imaging techniques through to 3-D printing. In addition, the exhibiting companies also presented innovations for traditional working methods in the laboratory and practice.

What form will the work in practices and laboratories take on tomorrow and how can dentists and dental technicians seize the opportunities that are already visible today?

This specifically applies to the digital processes. In the field of implantology, they have already significantly contributed towards exploiting the healing potential of the body to a maximum through optimised planning.

Implantology has long since been considered to be the flagship discipline for the implementation of digital technologies. How far these have pushed forward in the spectrum of dentistry is demonstrated in a field that some people initially considered to be rather difficult terrain: orthodontics. With virtual models for orthodontics not only can diagnostic issues be processed and a virtual set-up created, but also more and more often orthodontic appliances can be planned, such as, for example, fixed devices. Even the largest orthodontics challenge for digital technology is increasingly coming under focus: removable devices such as stretching plates, activators, etc.
3-D printing—which displays great future potential—is a production process that is already implemented in orthodontics, as well as in other disciplines. Alongside drilling templates, different splints, dental technology models, individual impression trays and plastic base casts for the metal cast will most probably depict the most frequent indications.

In general, speed plays an increasingly more important role in all sections of dentistry. For example, patients ideally want prosthetic treatments to be carried out in one session if possible or at least completed on the same day. Digital technologies make this possible more frequently than to-date.

**Practice and laboratory riding at high speed**

The increased speed is achieved through pure chair-side therapies or by accelerating the workflows across the entire process chain in the practice and laboratory, from A for activators to Z for zirconium oxide. Attractive optimisation options are arising now at all levels.

This begins with digital moulding. At IDS, a whole series of new intraoral scanners enriched the existing offer. Some of them can simply be carried from one treatment room to the next, almost as conveniently and inconspicuously as a pen in the pocket of the dentist’s coat. Beyond this, connecting it to the tablet facilitates the patient communication. Other intraoral scanners are consciously kept small to ensure high patient comfort and yet exploit the possibilities of voice and motion control.

A prosthetic restoration can subsequently be carried out in the practice more and more often. A milestone here is the production of bridges from zirconium oxide, which enables the dentist to carry out more than just single-tooth restorations. Dentures that are printed out of plastic in the practice using the DLP method (Digital Light Processing) are also almost within reach.

The process for classic production in the dental laboratory is being accelerated enormously. At the same time, the communications are becoming more intensified; the dentist and the dental technician are moving closer together. Technology in the laboratory—for example a new dental microscope with a 3-D mode—is assisting here. Besides quality control, it can be used for the direct exchange of digital images with the practice (screenshots, videos, split-screen function). Furthermore, it ensures a constantly relaxed, ergonomic posture.

But even the production steps themselves are becoming faster all the time. For instance, the guidance of instruments on curved shape tracks when process-
ing glass and hybrid ceramics promises great time savings in comparison to the conventional milling or sanding techniques. A fine structure feldspar ceramic infiltrated with polymer now offers an interior colour gradient with six layers in fine nuances in a time-saving and convenient process for patient-friendly aesthetics. The general trend is moving towards the more frequent production of monolithic restorations.

Interesting new surface finishing materials are appearing here. The dental technician sprays a thin layer of a transparent version on sintered zirconium oxide restorations; the spray diffuses during the firing process in the surface where it bonds intensively, homogeneously, non-porously and smoothly after the first firing without additional polishing.

In addition to milling and sanding the possibilities of the printing techniques are expanding considerably. A wide range of splints, models, drilling templates, indirect bonding trays, in the near future temporary and permanent dentures—almost everything can be printed. Laboratory systems now offer even bigger building platforms and convenient remote maintenance for network-compatible models. Meanwhile, the speed is picking up—just to get an idea of the magnitude: seven splints in one hour are definitely possible today.

Innovative software even enables a combined additive/subtractive production: where it comes down to the highest precision, the machine subsequently carries out an automatic milling process and thus creates overall a consistently high surface finish. Today, multi-material printers are perhaps visible on the horizon. For example, six plastics are mixed to make a new compound with the defined required properties; for instance, with specific colouring or interior colour gradients for a patient-specific design.

As an alternative to their own production, the laboratory can also outsource jobs to a central or industrial supplier. Models can be delivered within short lead times, prompt service is offered using digital technology.

Forward planning in endodontics

New digital technology is also available for endodontics; after planning tools initially established themselves in the field of implantology and more recently in orthodontics, a root canal treatment can now also be simulated in advance—its complexity more accurately estimated and ultimately planned step by step. A 3-D X-ray and innovative software form the basis here. This enables the dentist to follow the course of the canals on the monitor using dot markers through to the root tip. Subsequently he sees in (orthogonal) cuts (to the canal), at which points calcifications are present for example. He can also pre-test virtual filing. All of the information gained from the simulation is taken into account when carrying out the treatment, or in the case of a general dentist, if necessary a referral to the specialist is provided.

Part thermally treated filing assists in safely and hygienically preparing even strongly curved canals. The stiffer material at the shaft increases the tactile control when navigating through the root canals, whereas the tip of the instrument is particularly flexible.

If a root pin is attached before the crown is restored, models made of a fibreglass reinforced composite make canal extensions superfluous. Because such a pin can be extended across the entire root canal, it adapts to suit the natural anatomy and thus enables a substance-friendly treatment.

Gaining through combination: microscopy and diagnostics

Because endodontics always involves particularly small structures, further developed OP microscopes also offer interesting opportunities here. These are even becoming increasingly interesting for other dentistry part disciplines thanks to current innovations. For example, an integrated fluo-
rescence mode enhances one microscope, which enables the intraoperative check for tooth decay during the substance removal. The newly designed interface allows one-handed control. The opportunities of such systems range from endodontics through to preserving dentistry, periodontology and implantology.

Different functionalities are growing together in a different area too. Small lamps combine a lamp for the hardening of dental materials with fluorescence diagnostics. Both bacterial activities, such as the smallest leakages in the edges of fillings, become visible. However, this is more and more frequently avoided from the onset, among other things thanks to a constant reduction in polymerisation shrinkage with current values down to just 0.85%.

The terminal tooth always presents a special problem in filling therapy: the matrix cannot be wedged, and after its removal, distocervical surplus composites have to be laboriously filed away. The solution is a matrix that is produced in Germany in a completely manual process, which can be placed in one hand movement in four seconds and which automatically lies distocervically.

**Target figure = primary stability**

If a tooth is no longer worth preserving despite today’s endodontic and tooth preserving possibilities, implantology treatment is more and more frequently an option, which is now becoming even more interesting: new instruments with sharp working tips and a thin profile enable a tissue-saving extraction and thus often make elaborate bone augmentations superfluous.

New implant systems are appearing that considerably increase the primary stability through comprehensive further developments. Certain engines now dispose of a non-invasive stability measurement so that the optimal service life of an implant can accurately be determined.

Fibre-reinforced composites are used as superstructure material to provide a “shock absorber” effect, which offers a plus in durability and biting feeling. Corresponding CAD/CAM blocks can be processed chairside in the meantime even without separate firing processes.

When fixing implant prosthetic constructions using locators (often an alternative to full dentures) a high pivoting capacity now allows divergences of up to 40 degrees between two implants. And thanks to a special holding mechanism, the dentures can be extracted particularly easily using a hydraulic release system during the recall appointment.

If a conventional mucosa-supported full denture is chosen, cold curing resin with many of the material characteristics of heat curing polymer offer the dentist totally new possibilities. Such pink denture plastics are high impact, lie nicely on the gums of the patient and can nevertheless still be comfortably processed in the laboratory.

**Step towards the practice and laboratory of tomorrow**

New super-sharp scalers, new tiny mini implants, new ceramics for press technology processing, new embedding materials—this list is ongoing. The industry heads the ranks in many areas with both analogous and digital innovations. During their tour around IDS in Cologne the dentists and dental technicians took advantage of this to collect ideas for their practice and laboratory of tomorrow, based on well-founded knowledge thanks to the comprehensive offer of the exhibitors.

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*Editorial note: IDS (International Dental Show) takes place in Cologne every two years and is organised by the GFDI Gesellschaft zur Förderung der Dental-Industrie mbH, the commercial enterprise of the Association of German Dental Manufacturers (VDDI) and is staged by Koelnmesse GmbH, Cologne.*
International Events

2017

HK IDEAS—International Dental Expo and Symposium
4–6 August 2017
Hong Kong
www.hkideas.org

FDI Annual World Dental Congress
29 August–1 September 2017
Madrid, Spain
www.world-dental-congress.org

18th ESE Biennial Congress
14–16 September 2017
Brussels, Belgium
www.e-s-e.eu

9th Annual Congress of Czech Endodontic Society
23 September 2017
Prague, Czech Republic

Dental–Expo 2017
25–28 September 2017
Moscow, Russia
www.dental-expo.com

American Association of Oral and Maxillofacial Surgeons—99th Annual Meeting
9–14 October 2017
San Francisco, USA
www.aaoms.org

ADA 2017
19–23 October 2017
Atlanta, USA
www.ada.org/en/meeting

BDIA Dental Showcase
19–21 October 2017
Birmingham, UK
www.dentalshowcase.com

DenTech China
25–28 October 2017
Shanghai, China
www.dentech.com.cn

XXXVIII AEDE Annual Meeting
1–3 November 2017
Coruña, Spain
www.aede.info

GNYDM
24–29 November 2017
New York, USA
www.gnydm.com

ADF 2017
28 November–2 December 2017
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Questions?
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