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In patient or on paper?

During the evolution of humankind, revolutionary discoveries (like gravity from Newton with the apple tree), new techniques and medicines came from the field and from life experience. That is how we learnt about plants and their various benefits in our life, and this gave us some of the drugs we use today.

Recently, this modality of learning has been changing, it seems, and we are starting to see a big gap in the treatments we are using between what works on paper according to marketing materials, and what works for our patients in practice. It may be because while research is being conducted, the human factor or actual environment in which the potential future products will be used is not taken fully into consideration; it is not always easy to replicate the clinical environment in the laboratory. Therefore, we need to be reminded that it is not accurate to consider the laboratory results sufficient to start manufacturing, promoting and eventually using some products that may later be discovered to have some major deficiencies.

Denying the simple rules of treatment just for the sake of marketing is not right. Our only goal should be to deliver the best treatment for our patient, bearing in mind that a miracle product is not yet (and may never be) available and that each product has its limitations and indications. Doctors should understand this, and companies as well.

Clinical results should be our gold standard for any treatment, since what may work on paper and in statistical analysis may, sadly, fail in a patient.

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Dynamic real-time surgical navigation

Digital imaging, diagnostics and impressions, and the use of computer-aided design/computer-aided manufacture (CAD/CAM) for prosthesis fabrication and lasers for soft and hard tissue augmentation are altering the developmental framework in dentistry.1-5 Nowhere is this more prevalent than in the foundational pillar of endodontics. The magnification and illumination properties of surgical operating microscopes enhance the accuracy of freehand navigation access cavity preparation and microsurgical osteotomy. This has engendered a transformational shift to conservative, more restricted endodontic access cavity preparation.6 This preserves coronal and radicular tooth structure by optimising the long-axis entry point, the drill angulation and the glide path to the terminus of the root canal space.

Limitations

In spite of these advances, there are limitations in endodontic clinical scenarios where canals sclerotically regress in a coronal-apical direction and surgical access is space restricted. While the clinician’s experience is a positive factor, altered vertical and lateral angulation of the long-axis orientation of the endodontic access cavity presents iatrogenic risk. In endodontic microsurgery, a small bone volume or a misdirected osteotomy can injure the inferior alveolar nerve or perforate the maxillary sinus and other critical anatomical structures.7,8

The advent of cone beam computed tomography (CBCT—DICOM files) and 3D printing has transformed pretreatment planning. DICOM files are converted into stereolithic files,
which are used to create static navigation stents (CAD/CAM-fabricated). The stents direct the access cavity preparation and microsurgical orientation, thus avoiding removal of unnecessary tooth and bone structure (Figs. 1a & b).

Dynamic navigation offers new prospects for computer-guided endodontic protocols. Enhanced accuracy owing to real-time feedback diminishes the complex impact of access cavity preparation of calcified canals, retreatment and microsurgical procedures.\cite{9-11}

Each navigation protocol has disadvantages. With freehand navigation used for dentoosseous access and surgery, clinical judgement is the pilot. Freehand navigation depends upon visualisation of the anatomical scenario from information provided by casts and radiographs. Significantly more time is required with a freehand navigation technique in contrast to a guided technique. Determining the canal path position is more complex.

Stereolithic stents (static navigation) require a medium field of view CBCT scan. Polyvinylsiloxane impressions of

**Fig. 3:** The screen is divided into (1) panoramic view, (2) 3D reconstruction, (3) axial view, and (4) buccolingual and (5) mesiodistal section views. **Fig. 4a:** The planned axis angulation and orientation of the virtual drill are exacting in targeting calcified canals. (Courtesy of Dr Bobby Nadeau) **Fig. 4b:** The red virtual pathway reflects an off-angle positioning. (Courtesy of Dr Bobby Nadeau) **Fig. 4c:** Piezotome planning. (Courtesy of Dr Bobby Nadeau)
the arch to be treated are poured and a digital 3D scan of the stone model merged with the patient’s DICOM files. The use of an intra-oral scanner is preferable.

In the case of dynamic navigation, virtual planning of the endodontic access preparation or the osteotomy can be affected by the resolution of the CBCT scan. Flaws in the process of fiducial integrated stent fabrication can result in inaccurate image acquisition.

Innovation navigation

Dynamic navigation facilitates real-time computer guidance technology using an imported CBCT data set. This is analogous to the use of GPS and satellite navigation. An innovative computer-guided technology, Trace and Place (TaP), has been developed by the Canadian company ClaroNav. TaP obviates the need for a fiducial stent, with the resultant increase in the accuracy of dentoosseous penetration. An optical tracking device (Fig. 2) tracks a Jaw-Tracker, the optical tracking tag connected to the patient’s jaw, and a Drill-Tag, which is the optical tracking tag connected to an instrument specific to the procedure. The tip is superimposed on the CBCT scan, which is mapped to the patient’s jaw.

The heightened level of accuracy of TaP technology enhances the facility of treatment for restricted access cavity preparation and minimises the size of cortical window osteotomies (high-speed; Piezotome, ACTEON). Ultrasonic tips used for root end retro-preparation can also be tracked by dynamic navigation software.

TaP workflow planning and trace registration

Estimates place the global population over 65 at 615 million. Years of dentate and periodontal disease can impact on the pulp, the periapex and the periradicular tissues. With longevity will come increasing numbers of a mosaic of endodontic procedures, as age and treatment induce sclerotic changes in the root canal space. As such, the use of dynamic navigation will prove to be of significance in a myriad of endodontic treatment protocols.

Prior to the appointment

The first stage of TaP workflow is the importation of the patient’s CBCT data set (as DICOM file) into the dynamic navigation planning software to reveal the dentition. The screen shows the streaming video, panoramic view, target view, depth indicator, and buccolingual and mesiodistal section views (Fig. 3). The access point of entry, the axis orientation/angulation and the depth of the access cavity are planned. For microsurgical procedures, the Piezotome pathway is based on the dimensions of the osseous pathology surrounding the root apex (Figs. 4a–c). The planning stage can be done at any time prior to the procedure, provided the CBCT scan is consistent with the current dentate condition. As a preliminary step prior to the trace registration, three to six trace starting points (landmarks) are chosen and marked on visible and accessible teeth.
When the computer mouse is positioned over the 3D model, a 2D cross-sectional view appears. The red cross-hair sticks to the landmark, its centre on the surface (Fig. 5). The software advises the clinician if it suspects that the landmark is in an incorrect position.

Trace registration

The Jaw-Tracker (mandible or maxilla) or Head-Tracker (maxilla) is securely fastened to the jaw to be treated (Fig. 6). It should be noted that the Jaw-Tracker can be positioned at a distance from the rubber dam, unlike a Jaw-Tracker attached to a fiducial stent, which is more positionally restricted. Once the three landmarks have been determined, the optical tracking sensor tracks the Tracer-Tag/Tracer-Tool as it is brushed around the landmarks on the facial, lingual and occlusal surfaces in a manner similar to applying etching or bonding solutions. The software shows the number of points contacted as a percentage (Fig. 7).

Calibration of the drill

The Drill-Tag is attached to the handpiece, and the drill axis and drill tip are calibrated. The optical tracking sensor continuously tracks the Drill-Tag, and the software shows the position of the drill or Piezotome. The software will issue a warning if the Drill-Tag or the Jaw-Tracker is out of view of the camera (Figs. 8a & b).

Dentoosseous real-time navigation

The navigation screen is active when the system identifies the calibrated instrument as it approaches the patient’s jaw. The target view measures the distance between the instrument’s tip and central axis of the designated access penetration point, the glide path or the osteotomy. The central axis length of the planned procedure is represented by the centre of the static white target, and the tip of the drill is indicated by the moving black cross following the drill tip movement. The real-time direction of the drill is represented as a cone in the head of the handpiece (Figs. 9a & b).

During the drilling, the moving cross and cone are tracked. The cone will turn green when the instrument tip is within 0.5 mm and has an angulation of less than 3° to the planned glide path or osteotomy. When the drill tip reaches a distance of 1 mm from the apical or horizontal extent of the planned depth landmark, the depth indicator turns yellow.

Conclusion

Dynamic navigation is an additional value chain in digital workflow sequencing. Minimally invasive protocols are the trajectory of dentistry’s future. Dynamic navigation is proving to be both the pilot and co-pilot of this new milestone in patient-centric care. All innovation requires seminal exploration of both the incentives for and barriers against prior to acceptance of a new technology as a contributing protocol. Early adoption is osmotic; general acceptance occurs by diffusion. Improvements in the resolution of computer screens, optical markers and the reference array will herald an unprecedented level of accuracy in endodontic procedures. Digital has replaced analogue as the societal norm. The transition in the dental profession is in process.

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

about

Dr Kenneth Serota obtained his DDS from the University of Toronto Faculty of Dentistry in Canada in 1973 and received his Certificate in Endodontics and Master of Medical Sciences from the Harvard–Forsyth Dental Center in Boston in Massachusetts in the US. Active in online education since 1998, he is the Founder of the ROOTS endodontic forum (started in 2000) and the NEXUS interdisciplinary forum. Dr Serota is an adjunct clinical instructor in the University of Toronto postdoctoral endodontics department. He has been a contributor to and author of clinical articles for the roots magazine since its launch in 2004.
Many years ago already, the anatomy of root canals was described as showing variability and being of a complex nature. According to Vertucci, the mandibular first premolar has one canal at the apex in 74.0% of teeth, two canals at the apex in 25.5% and three canals at the apex in 0.5% of teeth.

Case report

A 63-year-old female patient was referred to my UK practice for root canal therapy of tooth #44. The tooth did not respond to the cold sensitivity test and was slightly tender on percussion. The patient complained of previous episodes of swelling of the buccal gingiva. From analysis of the periodical radiograph, a wide occlusodistal cavity and a J-shaped radiolucency in the apical area of this tooth were noticeable (Fig. 1). The root canal was visible until 8 or 9 mm from the apex and then disappeared. This kind of disappearance is often present in teeth with a Type V anatomy, where one root canal leaves the pulp chamber and divides shortly before the apex into two separate and distinct root canals with separate apical foramina (Vertucci classification). This kind of root canal was very difficult to shape with the first generations of nickel-titanium files and required extensive removal of sound dental tissue in order to gain straight access to the canals.

The pulp chamber was opened with a high-speed handpiece and a round bur, and the root canal system rinsed with 5% sodium hypochlorite and then scouted with a pre-bent ISO size 10 C-PILOT file (VDW). The buccal canal was easily scouted. Orientating the tip of the C-PILOT file lingually, the lingual canal was explored with difficulty and the file came out bent at 10 mm from the tip (Figs. 2 & 3). Preliminary working lengths were immediately established using an apex locator (VDW.CONNECT Locate, VDW) and the C-PILOT file and these were 20.5 and 21.0 mm.

In cases with abrupt curvature in the coronal or middle third, it is recommended to use flexible instruments very resistant to cyclic fatigue. The resistance to cyclic fatigue was...
depends on the alloy used to produce the file and the core of the file. For those reasons, I decided to shape this tooth with the basic sequence of the VDW.ROTATE system (VDW). The blue alloy confers to this file great resistance to cyclic fatigue and permits easy bending of the tip in order to facilitate introduction of the file into an abrupt curvature in the middle third (Fig. 4). The shaping started with the first two files of the basic sequence: the 15.04 and 20.05 were used with a pecking motion in accordance with the manufacturer’s instructions regarding the torque limit and the revolutions per minute. All the shaping was carried out using the VDW.CONNECT Drive (VDW) connected to the apex locator under continuous working length control. In the lingual canal, the files were pre-bent and then introduced manually into the curvature. After that, the file was easily connected to the hand-piece thanks to its very small head.

A radiograph to confirm the final working lengths was carried out with an endodontic ring holder and the VDW. ROTATE 15.04 and 20.05 files (Figs. 5 & 6). The last instrument at the apex was the 25.04 file owing to its flexibility and reduced core (compared with the 25.06 file) using the same strategies as in the previous steps.

Final rinses with EDTA solution and sodium hypochlorite were followed by activation of the solution with a pre-bent EDDY tip (VDW, Fig. 7) for 20 seconds. The canals were
then dried and filled with AH Plus (Dentsply Sirona) and two gutta-percha cones matching the VDW.ROTATE instruments (VDW) and made of a more heat-conductive gutta-percha with a lower melting temperature using the continuous wave technique up to the bifurcation.

A radiograph was taken (Fig. 8) to check the root canal fillings and then a fibre post and core build-up were carried out. The final radiograph showed good filling of the root canals with small extrusions of the sealer through the buccal foramen and a lateral canal (Fig. 9). The patient was referred to her dentist for permanent restoration of the tooth. Six months of follow-up was planned in order to control the outcome of the treatment.

Conclusion

Martensitic files are easily bendable and, if pre-bent, permit the clinician to bypass ledges and shape very curved Type V canals mechanically. In addition, these files are more resistant to cyclic fatigue. The VDW.ROTATE system offers files of different ISO sizes and the finishing files have two different tapers: the .04 can be used safely in very difficult anatomies because having a reduced core increases cyclic fatigue resistance.

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

about

Dr Vittorio Franco graduated in dentistry in 1990 from the Sapienza University of Rome in Italy. He works in Rome and London in practices limited to endodontics.

Dr Franco is the author of scientific articles on endodontics published in national and international journals and of chapters in books dealing with endodontics. He won the Riccardo Garberoglio Award for Research of the Italian Society of Endodontics (SIE) in 2006 and 2016, and the prize for the best presentation at the 2010 ROOTS SUMMIT. He is a reviewer for many national and international journals and served on the scientific committee of the Giornale Italiano di Endodonzia (Italian journal of endodontics). During his career, he has given pre-congress courses, workshops and presentations at many national and international meetings and lectured in a number of university courses.

Dr Franco is President of SIE and an active member of the Accademia Italiana di Odontoiatria Microscopica (Italian academy of dental microscopy). He is Specialist Member and Treasurer of the European Society of Endodontology (ESE).
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Endodontic follow-up in strongly curved root canals

Dr Thomas Rieger, Germany

Introduction

The lasting success of any root canal therapy is always only apparent after long-term observation. In this article, based on a case study, the author demonstrates how a strongly curved canal in the posterior maxilla was prepared using pre-bendable nickel-titanium (NiTi) files, ensuring that a bacteria-proof seal is created that can last for as long as six years after the procedure. Here, the use of a reduced file sequence is just as important as the advantages of a flowable obturation material.

A curvature of close to 90° is far more common among roller coasters than in the human anatomy. The following patient case illustrates that such “breakneck” bends in endodontics do not necessarily lead to the same adrenaline rush at the practice of the treating dentist. Owing to modern NiTi file systems, competent, long-term, reliable preparation succeeds even with strongly curved canals—without going off track.

Initial situation

A 36-year-old patient presented with acute pain in tooth #26 to our practice in October 2012. Radiographic diagnostics showed a deep carious defect distally (Fig. 1). On the basis of these clear findings, we recommended a root canal therapy. The patient agreed to the treatment. After application of the rubber dam, the affected tooth was first built up with composite for greater stability, and then a diamond drill was used to create the appropriate access. The pulp chamber was then opened. All crown pulp tissue was removed from the infected tooth in the process. Canal clearance was checked with a 10/.05 glide path file.

COLTENE’s HyFlex EDM NiTi file system with its modular design and comparatively simple handling was used for the actual preparation of the canal. The sequence more or less functions according to a modular system: depending on the indication and the respective anatomical conditions, the dentist can select from a large number of different file sizes and special files. The HyFlex EDM greatly simplifies the process, especially for beginners in mechanical preparation, owing to its special material properties. The abbreviation “EDM” stands for “electrical discharge machining”, a specifically developed manufacturing process which creates a unique surface structure (Fig. 2). The rough, textured surface increases the cutting performance and makes the instrument particularly...
fracture-resistant. This makes the NiTi file predestined for dentists who want to achieve reliable results quickly with a reduced sequence.

**Nature-like preparation with only a few files**

Another feature of the file system used in this case is the controlled memory (CM) effect. NiTi files with this CM effect can be pre-bent in a similar manner to classical stainless-steel files and remain reliably in this pre-bent form even after insertion into the canal. If the distal molars are difficult to access or if the root canals are unusually curved, such a feature of the otherwise extremely flexible file may well prove helpful (Figs. 3 & 4). In addition, the file moves safely in the centre of the canal and adapts to the natural profile of the canal. This avoids any straightening, zipping or similar unwanted effects. The risk of causing iatrogenic damage cannot be neglected if the procedure is too invasive, particularly in the case of challenging anatomical conditions.

Furthermore, endodontic experts continue to argue passionately about the ideal file sequence. In the search for the ultimate simplification of the workflow, the sequences presented by the industry have been consistently shortened for years. Especially in the case of canals that deviate greatly from the textbook anatomy (in so far as they actually exist), the question inevitably arises as to whether preparation with a few files is possible or even meaningful.

In the case study, the focus was on working with a universal EDM file of ISO size 25 (Fig. 5). Using this instrument was perfectly adequate for preparing the canal anatomically correctly to working length in only a few minutes. The NiTi file completed a curvature of almost 90° without blocking when introducing the file gradually into the canal in dabbing up and down movements. Only a 40/.04 file (or palatal with a 50/.04 file) of the HyFlex EDM or CM series was necessary to provide the final touch.

Of course, executing the classical rinsing protocol contributed significantly to the effective cleaning of the canal. It is advisable in practice to ensure that sufficiently long rinsing phases are adhered to during preparation.

**Follow-up after six years**

GuttaFlow 2 was used for the long-term sealing of the canal. The two-in-one obturation material combines
flowable gutta-percha with a suitable sealer at room temperature. The biocompatible material exhibits almost no solubility, thus providing a long-term stable filling. The filled areas are clearly visible in the final radiograph (Fig. 6). On the one hand, this exemplifies how anatomically perfectly the natural canal profile was followed. On the other hand, one can see the advantages of a flowable filling material that reliably penetrates up to the apex and thus provides the best basis for a long-lasting restoration. Of course, such extremely curved root canals, as in the patient case described, are the exception; nevertheless, the example shows that even complex canal profiles can be prepared safely with the standard files of a modern NiTi system.

After two years and as part of follow-up, the radiographic check confirmed the reliability of the obturation (Fig. 7). The situation in the root canals was unchanged and the patient was evidently still free of complaints. In the past year, that is six years after treatment of the tooth, a further recall image again showed no abnormalities or changes to the final findings (Fig. 8). The long-term prognosis seems to be pleasingly positive despite the strong curve of the mesial root.

Summary

Cavities with difficult access and unusually curved canal profiles place particular demands on the craftsmanship of the endodontic expert, as well as on the flexibility and fracture resistance of the instruments used. Modular NiTi systems allow natural, lifelike preparation with only a few files. Pre-bendable files with the CM effect, such as the HyFlex EDM, can be navigated easily through the centre of the canal. The long-term follow-up impressively demonstrates the longevity of a cleanly prepared canal structure.

about

Dr Thomas Rieger completed his dental degree at the University of Munich in Germany in 1992. Thereafter, he was an assistant dentist in private practice and then a research assistant at the University of Zurich in Switzerland. He has been in private practice in Memmingen in Germany since 1996. In 2009, Dr Rieger founded TEC2, which provides specialist endodontic training, in collaboration with the University of Pennsylvania, USA, and is managing director and curriculum organiser. He has a long history of involvement in national and international training and teaching. He is author of the book Kiss, Workbook of Endodontics, and co-author of the book Endodontics Simply Successful, a case history study of endodontically treated teeth. He is a certified member of the German Association of Dental Implantology, AIE and German Board of Oral Implantology.

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Tooth-preserving endodontic surgery—A retrospective survival study from the general dental practice

Drs Robert Teeuwen & Monika Kriner, Germany

Introduction

Endodontic surgery includes incision and drainage, cortical trephination (TR), periradicular curettage (PC), root end resection (RER) and hemisection. TR is performed for prophylaxis or therapy for endodontic pain.\textsuperscript{1–3} Some authors have tested a possible postoperative pathology of teeth that have undergone TR versus teeth that have not after root canal filling (RCF).\textsuperscript{4–6} Sargenti\textsuperscript{7} and others\textsuperscript{1, 8} used TR systematically in their endodontic therapies.

The extension of TR is PC, in which granulation tissue surrounding the root tip is removed after creation of a bone window. In this manner, a direct view to the root tip is guaranteed. Morse questioned PC, claiming that the granulation tissue remains in situ with non-surgical root canal therapy (RCT) as well.\textsuperscript{2} Velvart states that PC is not necessary per se.\textsuperscript{9} The problem is the root canal to be treated. As the periradicular granulation tissue normally does not contain any bacteria, Rud and Andreasen concluded that it does not have to be removed.\textsuperscript{11} Instead, they proposed intense canal preparation in order to achieve a reduction of canal bacteria mechanically. Byström and Sundqvist proved in their tests that mechanical canal cleaning and preparation alone can reduce bacteria to 20–43%.\textsuperscript{12} According to Wu et al., 50–90% of the especially complex third of the apical root with its side canals, tubules and ramifications is settled by bacteria.\textsuperscript{13}

The classic treatment in endodontic surgery is RER, through which approximately 3 mm of the root tip is removed after opening and PC. RCF is either orthograde or retrograde; when indicated, orthograde and retrograde RCF are combined. Whether orthograde RCF actually leads to a better RER result if performed pre- or intra-operatively is debated. Malmström et al. observed an RER healing rate of 87.9% after preoperative orthograde RCF and of only 63.6% after intra-operative RCF.\textsuperscript{14} Hepworth and Friedman analysed 12 RER studies with simultaneously executed orthograde RCF and 22 studies without simultaneous RCF.\textsuperscript{15} The first group had a failure rate of 7%, and the latter a failure rate of 19%.

Elemam and Pretty evaluated four surgical studies and found the best survival rate when RCF and surgery were carried out at the same time.\textsuperscript{16} Friedman too found a combination of RER and orthograde RCF to be the most successful therapy.\textsuperscript{17} He suggested that application of root tip filling seems to improve the prognosis, whereas, according to Rapp et al., root tip filling has no influence on the success of an apicectomy.\textsuperscript{18} According to Friedman, the rate of complete healing after RER reported in the seven studies included in the review was widely spread, from 37% to 91%, while 80–94% remained in function asymptotically and 5–42% of the healed cases developed a recrudescence of the periapical periodontitis (PP) from the fourth year.\textsuperscript{19} Bergenholtz stated in 2016 that the PP rate had not improved within the last 25 years despite better endodontic procedures.\textsuperscript{20} The Swedish Agency for Health Technology Assessment and Assessment of Social Services highlights the lack of scientific literature as a decision aid for apical trepanation, analgesic and antibiotic administration, and partial or complete RCT in case of toothache.\textsuperscript{21}

Hülsmann and Schäfer report that they consider apical trepanation in particular cases, as they do not consider this therapy as being proven scientifically.\textsuperscript{22} The significant decrease of TR invoicing in West Germany from 13,300 in 1984 to 4,100 in 2016\textsuperscript{23} reflects this statement. The volume of RER invoicing increased 3.6-fold from 1984 to 2016. Using data from an insurance pool for analysis of RCT/RER, Lazarski et al. found that 25–40% of the teeth treated with RER by general practitioners had to be extracted in the observation period of an average of 20 months; however, only 7–11% of those treated by
The present study deals with the analysis of survival of non-vital anterior teeth and premolars treated with RER or TR in the dental practice of the first author. The anonymous treatment cases were recruited from 1975 to 1999. They were followed up until November 2016. The cases from 1985 to 1999 have already been the subject of a publication, but with a shorter follow-up period (until 2005) and evaluation of the radiographs by three experts, whereas this present evaluation was done exclusively by the first author.

Excluded from the analysis were cases without radiographs after RCT, cases with additional retrograde RCF or intentional replantation, as well as patients who did not return to the practice after RCT. Recall did not take place. Thus, 1,308 teeth treated with RER and 762 teeth treated with TR remained for the analysis. Orthograde RCT was done according to the Sargenti N2 method: relative drying with cotton rolls, intense canal preparation—up to ISO 90 in wide canals—with reamers, no canal rinsing, N2-RCF by lentulo, and Gutta-percha point consolidation.14 RCF followed local anaesthesia 20–30 minutes after TR or RER was done. After opening, the bone in the periapical area

### Materials and methods

The present study deals with the analysis of survival of non-vital anterior teeth and premolars treated with RER or TR in the dental practice of the first author. The anonymous treatment cases were recruited from 1975 to 1999. They were followed up until November 2016. The cases from 1985 to 1999 have already been the subject of a publication, but with a shorter follow-up period (until 2005) and evaluation of the radiographs by three experts, whereas this present evaluation was done exclusively by the first author.25

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<tr>
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<td>Yes; TR</td>
<td>159</td>
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<td>30</td>
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</tbody>
</table>

RCF = root canal filling; RER = root end resection; TR = cortical trephination; PP = periapical periodontitis

Table 1: Examined variables.
was trepanated for TR using an elongated turbine bur (H1 018, Brasseler). The trepanation opening was enlarged to a bone window owing to overfilling and for execution of RER, thus allowing resection of the root tip, as well as PC. A drain was inserted and the incision wound was sutured, and the sutures were removed after five to ten days. Generally, the teeth treated with endodontic surgery were immediately provided with a definitive filling. Patients were provided with a painkiller, some with antibiotics. The decision for a control check-up was left to the patients. This study is based on data from files and radiographs.

The radiographs prior to RCT were evaluated according to the following criteria:
1. apex without pathological findings;
2. apex presumably without pathological findings;
3. PP < 25 mm;
4. PP = 25–50 mm; and
5. PP > 50 mm.

The survival data of this study was calculated independently from incomplete follow-up radiographs and under consideration of various determining factors (Table 1) for descriptive statistics. The patient’s last appointment or the date of a possible reintervention, such as extraction, retreatment, TR or RER, was judged as the final point of survival. The use of antibiotics was taken into consideration.

The descriptive data evaluation was done by absolute and relative frequencies for all categorial variables and by mean value, minimum, maximum and median for metric sizes. Statistical relationships between categorical variables were checked according to the chi-squared test. Mean comparisons between two groups of metric variables were checked using a t-test. Survival times were presented in Kaplan–Meier curves and compared by the means of a log-rank test. Cox regressions were performed to determine the influence of several variables on survival time. All statistical tests were based on a significance level of 5 %.

### Results

The analysis included a total of 2,070 endodontic surgical treatments in 1,514 patients. The anamnestic factors that led to an RER or TR treatment are provided in Table 2. The treatments were divided into 1,308 RERs (63.2 %) and 762 TRs (36.8 %). Among those, the survival of 30 (1.49 %) ended in an acute exacerbation, 50 % (n = 15) of which occurred within 46 days of endodontic surgery, and 76.7 % (n = 23) within three months.

Within the first seven days, 27 discomfort cases (pain, oedema, haematoma) were noted, which had to be treated, and 19 untoward events (extraction, repeated RER, bleeding), which had to be treated. The survival of a further 46 cases was terminated because of a repeated endodontic surgery (33 RERs and 13 TRs), although the retreatment did not mean the physical end of the teeth involved. Survival was terminated mainly due to extractions, 350 of which were performed.
Of the patients, 47.7% were male and 52.3% female. Male patients had a significantly higher extraction rate (18.6%) versus female patients (15.3%; p = 0.044). The average age was 30.4 years (8–84 years) and the median 26 years. The age group of < 30 years was the largest, at 59.1%, followed by the age group of 30–49 years at 28.4% and the age group of ≥50 years at 12.5%.

The probability of extraction increased significantly with age (p < 0.001), from 11.5% in early age to 22.1% in the 30–49 age group and finally to 30.6% in patients aged ≥50 and older. The log-rank test revealed a significant difference in survival until extraction between the individual age groups (p < 0.0001). The older the patient, the lower the tooth survival time (Fig. 1).

The practice's senior dentist executed 1,302 treatments (62.9%): 722 RERs (55.2%) and 580 TRs (76.1%). The remaining 768 cases were treated by the practice's assistant physicians. Eighteen acute exacerbations (13 TR cases) were cases treated by the senior dentist and 12 (nine TR cases) by the assistant physicians. During the observation period, 230 extractions (17.7%) were performed by the senior dentist and 120 (15.6%) by the assistant physicians (p = 0.232).

The senior dentist administered antibiotics in 215 cases (29.8%) after RER and in 133 cases (22.9%) after TR. The assistant physicians administered antibiotics in fewer cases: 155 (26.5%) after RER and 26 (14.3%) after TR. Only for RER was a significant difference (p = 0.012) derived from these different administration behaviours, but not for TR (p = 0.184) or in total (p = 0.111).

Regarding insurance coverage, 58.3% of the patients had working class insurance, 28.8% employee insurance and 10.6% private insurance, and 2.3% were insured in some other way. The lowest socio-economic class had a significantly higher extraction frequency (p = 0.026), of 18.7% (n = 226), versus the higher socio-economic class patients (14.4%; n = 124).

Of the cases, 82% were maxillary treatments. The maxillary incisors were the most represented, at 57.1%. The maxillary central incisors were subject to the lowest extraction rate (9.8%). The maxillary canines had the highest extraction rate (31.4%). Overall, during the observation time, premolars had the highest extraction rate (19.7%) versus anterior teeth (16.2%). The difference was not statistically significant (p = 0.096).

<table>
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<tr>
<th></th>
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<th></th>
<th>TR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>n</td>
<td>%</td>
<td>n</td>
</tr>
<tr>
<td>Di 1</td>
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<td>14.6</td>
<td>52</td>
</tr>
<tr>
<td>Di 2</td>
<td>202</td>
<td>15.4</td>
<td>60</td>
</tr>
<tr>
<td>Di 3</td>
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<td>63</td>
</tr>
<tr>
<td>Di 5</td>
<td>279</td>
<td>21.3</td>
<td>106</td>
</tr>
<tr>
<td>Total</td>
<td>1,308</td>
<td>28.3</td>
<td>214</td>
</tr>
</tbody>
</table>

Di = diagnosis, RER = root end resection, TR = cortical trephination

Table 3: Antibiotic administration and extraction rate in relation to the initial diagnosis.
Twenty-seven canal instruments fractured during conservative RCT. Seventeen fractured instruments were immediately removed by an RER, and ten remained in situ. Follow-up of the sinus tracts (18 for RERs and six for TRs) did not reveal any flare-up, and with only two extractions, a clear evaluable difference between RER and TR could not be shown.

Twelve via falsa cases were subject to TR, and eight to RER. Four via falsa cases were followed by acute exacerbations and seven by extractions. Eight posts contributed to a disastrous appearance of a via falsa. Via falsa doubled the extraction rate versus cases without a via falsa (p = 0.030).

Table 3 relates the initial diagnosis to the frequency of antibiotic administration and extraction. Initial diagnoses 1 and 2 are based on the initial finding of “apex without pathological findings” and “apex presumably without pathological findings”, respectively. The cases with initial diagnoses 3, 4 and 5 (68.4% of RERs and 46.5% of TRs) included a pathological apex with an increasing number of periapical lesions. In case of PP, the practitioners preferred an RER—up to 85% for diagnosis 5. The extraction rate did not show any statistical peculiarities (p = 0.514 for RER and p = 0.581 for TR), even though diagnosis 5 featured the lowest extraction rate (14.9%).

Administration of antibiotics depended on the initial diagnosis: p = 0.001 for RER and p = 0.025 for TR. Diagnosis 5 cases were subject to antibiotic administration most often (37.9%; p < 0.001), but diagnoses 1–4 more seldom (23.2%).

The TR technique was mainly used by the senior dentist (76.1% of the TRs) versus the assistant physicians (23.9%). The single-appointment treatment was favoured for TR in 457 cases (60%), whereas 644 RERs (49.2%) were performed in single-appointment treatments. The difference in number of appointments between RER and TR was statistically significant (p < 0.001). Of the 969 multiple-appointment treatments, 410 (42.3%) were finished within seven days. The number of appointments did not influence the extraction rate (p = 0.469). An accompanying antibiotic therapy doubled for multiple-appointment treatments versus single-appointment treatments (Table 4): p < 0.001 for RER, for TR and in total.

Retreatments were done by either RER (n = 234; 17.9%) or TR (n = 116; 15.2%). There was no significant difference in the choice of treatment. The 350 retreatment cases ended in 65 extractions (18.6%): 48 (13.7%) for RER and 17 (4.9%) for TR. The difference in extraction rate between RER and TR was not statistically significant (p = 0.185). The 1,720 primary cases without retreatment ended in 285 extractions (16.6%). The chi-squared test proved that there was no correlation between the extraction rate and retreatment/no retreatment (p = 0.362). A statistically significant difference (p = 0.009) was found for retreatment cases regarding antibiotic administration (p = 0.009). Antibiotics were administered for 55 RER retreatment cases (23.5%) and 16 TR retreatment cases (13.8%).

In 115 cases, an abscess led to a surgical intervention in the form of removing the necrotic pulp tissue and provision with coronal and apical drainage by means of an RER or TR. Orthograde RCF was followed by 67 RER treatments (58.3%) and 48 TR treatments (41.7%). The percentage difference was of no statistical significance (p = 0.260). In 55 cases (82.1%), RER was due to the initial diagnoses 3, 4 and 5, and so was TR in 27 cases (61.4%). Five RER treatments and four TR treatments were done in one and the same appointment on the day of abscess diagnosis, followed by another 20 RER treatments and 28 TR treatments for abscess therapy within the next seven days. This was accompanied by administration of antibiotics in 43 RER cases (64.2%) and in 35 TR cases (72.9%). In summary, regarding both therapy forms, 30 extractions (26.1%; p = 0.007) and

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<th>RER</th>
<th>%</th>
<th>No. of failures</th>
<th>RER</th>
<th>%</th>
<th>No. of failures</th>
<th>RER</th>
<th>%</th>
<th>No. of failures</th>
<th>RER</th>
<th>%</th>
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</thead>
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<td>129</td>
<td>36.9</td>
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<td>40</td>
<td>29.4</td>
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<td>91</td>
<td>26.0</td>
<td>9</td>
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<td>24</td>
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</tbody>
</table>

RER = root end resection, TR = cortical trephination

Table 5: Main reasons for extraction, as well as the number of failures.
78 cases of antibiotic administration (67.8%; \( p < 0.001 \)) were documented in the follow-up period of the 115 abscesses.

In 118 cases, treatment with endodontic surgery was started \textit{alio loco}; 19 patients (16.1\%) presented to the surgery with abscesses. In 67 cases (56.8\%), the problem was solved by RER in 51 cases (43.2\%) and by TR in 27 cases (22.9\%). For 13 RER cases and 14 TR cases, survival was ended by an extraction. The 1,952 cases without \textit{alio loco} pretreatment were followed by 323 extractions (1.5\%). Seventeen RER and 12 TR cases were treated with antibiotics (\( n = 29; 24.6\% \)). Eighty-nine teeth were treated without antibiotics.

Thirty-five failed non-surgical treatments were treated using RER and 37 using TR. Of these 72 endodontic surgery treatments, 44 (61.1\%) were executed within seven days of the failure of conservative therapy. Fifteen (20.8\%) extractions were done: nine after RER and six after TR. Perioperative antibiotic administration completed RER in 13 cases (37.1\%) and TR in nine cases (24.3\%).

In the data files, 965 notes of the existence (\( n = 778 \)) or non-existence (\( n = 187 \)) of a preoperative pathology could be found. Antibiotics were administered in the case of non-existent pathology for 26 cases (13.9\%) and in the case of existing pathology for 278 cases (35.7\%; 41.7\% of RER cases and 29.9\% of TR cases). The difference in frequency regarding antibiotic administration between RER cases and TR cases in the case of pathology was significant (\( p < 0.001 \)). Thirty cases of non-existent anamnestic pathology (16\%) ended in extraction, compared with 139 cases of preoperative pathology (17.9\%), indicating no significance (\( p = 0.556 \)).

The extraction rate for non-homogenous RCF quality was 19.9\% (46 cases) and for homogenous RCF quality was 16.5\% (304 cases). The difference was not significant (\( p = 0.258 \) for RER; \( p = 0.557 \) for TR). Antibiotic administration was independent of RCF quality, but significantly (\( p = 0.0002 \)) higher for RER (\( n = 370; 28.3\% \)) versus TR (\( n = 159; 20.9\% \)).

RCF was graded in four categories: –2 to –5, –1 and 0, –1 and +2, +3 to +5. Heavily overfilled teeth were the most represented (36.7\%), followed by the RCF grade –1 and 0 (24.3\%) and slight overfilling (22.6\%). The overfilled cases overall represented the largest group (\( n = 1,227; 59.3\% \)), but had the lowest extraction rate (15.2\%; \( n = 187 \)). Underfilled teeth (–2 to –5) were the least represented (\( n = 339; 16.4\% \)), but had the highest extraction rate (21.2\%; \( n = 72 \)). The 504 teeth classified as RCF grade –1 and 0 had an extraction rate of 18.1\% (\( n = 91 \)). The differences in extraction rates were significant regarding the various RCF grades (\( p = 0.024 \)).

### Table 6: Extractions over time and the effect on survival.

<table>
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<th>Survival</th>
<th>CI</th>
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</thead>
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<td>TR</td>
<td>RER</td>
<td>TR</td>
</tr>
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<td>762</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>5</td>
<td>652</td>
<td>427</td>
<td>77</td>
<td>44</td>
</tr>
<tr>
<td>10</td>
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</tr>
<tr>
<td>35</td>
<td>12</td>
<td>7</td>
<td>0</td>
<td>4</td>
</tr>
</tbody>
</table>

\( RER = \text{root end resection}, \ TR = \text{cortical trephination}, CI = \text{confidence interval} \)

### Table 7: Cox regression with regard to extraction.

<table>
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<th>Subgroup</th>
<th>p-value</th>
<th>Hazard ratio</th>
<th>95% CI</th>
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</thead>
<tbody>
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<td>Age (years)</td>
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<td>–</td>
</tr>
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<td></td>
<td>30–49</td>
<td>0.003</td>
<td>1.45</td>
</tr>
<tr>
<td></td>
<td>(\geq 50)</td>
<td>&lt; 0.001</td>
<td>2.35</td>
</tr>
<tr>
<td>Restoration type</td>
<td>Filling (reference)</td>
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<td>–</td>
</tr>
<tr>
<td>Crown w/o post</td>
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<td>&lt; 0.001</td>
<td>0.22</td>
</tr>
<tr>
<td>Crown with post</td>
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<td>&lt; 0.001</td>
<td>0.32</td>
</tr>
</tbody>
</table>
ferent RCF grades had no influence on the frequency of administration of antibiotics ($p = 0.830$). A total of 350 (16.9%) extractions was performed: 214 (16.4%) for RER cases and 136 (17.8%) for TR cases. The reasons for extraction varied. The main reasons are provided in Table 5. Eighty-four of the teeth extracted (24%) exhibited radiographic or clinical failure. However, this failure was the reason for extraction of only 54 of these. Twelve teeth were extracted within the first year of RER (survival rate of 98.9%), and ten teeth after TR (survival rate of 98.5%). The median survival time until extraction was 29.8 years after RER and 31.4 years after TR. There was no difference in survival between RER and TR regarding extractions, as proved by the log-rank test: $\chi^2 = 0.1$ with df = 1 and $p = 0.814$. Extractions over time are presented in five-year intervals in Table 6.

Lastly, restorative measures (filling, crown with a post, crown without a post) were subject to analysis. The RER and TR values did not show significant differences, so these could be summarised in one group. Of the 2,070 cases, 1,168 (56.4%) were provided with a filling and 902 (43.6%) with a crown (382 with posts and 520 without posts). There was a statistically significant connection between restoration type and health insurance type ($p = 0.004$). Seventy-five of the 220 private patients (34.1%) were provided with a crown without a post—the total of this restoration type amounted to 25.1%. The lower-income patients had the poorest provision of crowns without posts (22.6%) and ranked scarcely above the filling total of all patients at 59.1%.

Of the teeth filled, 231 (19.8%) were later extracted ($p < 0.001$). One hundred and nineteen extractions (13.2%) were due to crown restoration. The difference in extraction rate for crowns with posts and crowns without posts proved to be statistically significant: 17.5% versus 10.0% ($p = 0.0009$). In 104 cases (24.6%), the patient was provided with a post and RCF in one and the same appointment. The timing of post insertion had no influence on the extraction rate.

A Cox regression model was generated to determine the influence of the variables tested so far on the time until extraction (Table 7). Only the factors of age and restoration type proved to be of significant influence. In the final model, the $\geq 50$ age group had a 2.3-fold risk versus the reference group (< 30 years), and the 30–49 age group had a 1.4-fold risk. Crowned teeth without or with inserted posts bore an essentially lower extraction risk versus teeth provided with a filling only. The hazard ratio of 0.22 shows a lower extraction rate for crowns without posts versus a hazard ratio of 0.32 for crowns with posts.

In the frame of endodontic surgery, we followed up on the question as to the extent to which antibiotic ad-
administration has an impact on the extraction rate. For this reason, we divided the case pool into four time periods. The administration of antibiotics decreased from 48.6% (52.9% for RER and 43.5% for TR) in 1975–1980 to 25.5% in 1981–1985, to 23.7% in 1986–1990 and to 13% (13.3% for RER and 12.6% for TR) in 1991–1999. Figure 5 illustrates this trend.

Of the 2,070 endodontic surgery cases, 529 (25.6%) were treated with antibiotics, followed by 91 (17.2%) extractions. These were divided into 370 RER antibiotic cases with 61 extractions and 159 TR antibiotic cases with 30 extractions. Regarding the 1,541 cases that did not undergo antibiotic treatment, 259 of those teeth (16.8%) were extracted. The extractions showed no statistical significance in relation to antibiotic treatment.

The average antibiotic administration decreased from 25.6% before 1985 to 18.3% since 1986. However, in some clinical situations, antibiotics were still administered generously from 1986: in the case of abscess (66.7%), diagnosis 5 (31.8%) and pathology (26.8%). From 1986, antibiotics were administered for abscess treatment nearly five times more often than for cases without abscess. In cases with initial diagnosis 5, antibiotics were administered to nearly double the number of cases than...
with most other diagnoses. In the case of pathology, antibiotics were administered nearly three times more than for cases of no pathology. Statistical significance (p < 0.001) regarding antibiotic administration was found, compared with cases with no abscess, no symptoms and a diagnosis other than diagnosis 5.

Discussion

Comparing the success of endodontically treated teeth is problematic, as studies differ in many ways. Influencing factors are to be considered such as case selection therapeutic procedure, practitioner, observation time, apical rarefaction and periodontal disease.

Success rate studies have been executed based on radiographs or clinical inspection or as survival studies with the sole criterion being extraction or occurrence of untoward events, such as RER, TR or retreatment. Friedman writes: “In many studies [...] the radiological appearance is used as the only outcome measure. This strategy possibly overestimates the success rate by not noting teeth that could be radiologically normal, but symptomatic.”

According to Bohay, radiographic appearance should not be considered the gold standard. Morbidity is underestimated when relying on radiographic appearance only. Under this presumption, the result of the Goldman et al. study is questionable. In this study, the lowest failure rate was found using radiographic interpretation by just one researcher, who treated many of the cases he reviewed. In contrast, the radiologist diagnosed eight times more failures. From this, it can be deduced that radiographic interpretation yields a strong bias.

Consequently, the authors of the present study did not want to be subject to a bias regarding radiographic diagnostics and refrained from diagnosis of the radiographs at hand. In this respect, the analysis was done to determine to what extent various variables influence retention of the treated teeth in symptomless function as far as this could be read from the file data. File data revealed that 109 patients did not present to the practice in the first seven days after removal of the sutures. Forty-six cases of discomfort and events were registered in this week. Of those, most cases did not need any therapy. With 2,070 treated teeth, one could regard 2.2% of teeth being affected by events and discomfort within the first post-operative week as being of minor importance. It has to remain a matter of speculation as to the extent to which the actual endodontic surgery and/or the following discomfort/event contributed to the patients affected never presenting again after the first postoperative week. Seymour et al. report in their study that pain after RER is only short term and is greatest in the first 24 hours. Painkillers were not administered by the surgeons. However, two-thirds of the patients—and more women than men—used painkillers. According to Christiansen et al., pain after periapical surgery is low and peaks after three hours, and postoperative swelling after one day.

According to a pain score, women feel pain more keenly than do men. Reference has revealed that women are
more sensitive to pain or are more impatient.\textsuperscript{25,29,30} The present study, which found a significantly higher extraction rate in men versus women, cannot confirm this finding. Nist et al. examined 50 patients regarding their sense of pain after RCF and after TR.\textsuperscript{31} TR was performed in 25 patients and the other 25 patients received a mock TR. All of the patients were given ibuprofen and a combination of codeine and paracetamol. The patients who underwent real TR took less ibuprofen, although this was not statistically significant. However, they took statistically significantly less of the codeine–paracetamol combination versus those who received the mock TR.

In the present study, a slightly higher number of extractions resulted for the cases treated by the senior dentist versus the assistant physicians. However, the percentage difference was not statistically significant. It has to be noted that the senior dentist treated the more difficult cases himself, leaving the young patients to his younger assistant physicians. The \( \geq 50 \) age group had a nearly three times higher extraction rate compared with the youngest age group. According to the higher extraction rate, a lower survival rate was observed in older patients. Raedel et al. differentiate survival depending on the age group;\textsuperscript{25} for example, 87.2\% survival rate for the 18–24 age group and 77.3\% survival rate for the 65–74 age group. The average observation period amounted to 1.4 years, and the cumulative survival rate after three years to 81.6\%. In the present study, the survival rate regarding extraction was 94.8\% for RER, compared with 95.7\% for TR, after three years. One may attribute more frequent tooth loss among the older generation to an increase in periodontopathies and advanced destruction of tooth substance in older patients.

While cross-sectional studies document the endodontic situation of the patients examined (and thus the quality of the endodontic achievements of the dentists involved) as one-time snapshots, this long-term survival study considers the development covering a certain time span, accepting the fact that possible periapical pathologies were not recorded. Torabinejad et al. report that survival studies, with and without interventions, allowed less biased statements, but these were less informative.\textsuperscript{32} Regarding the literature\textsuperscript{25,29,30} the authors write: “The older endodontic literature recorded the highest overall quality rating […]. Changing in treatments that have occurred over time may have introduced biases favoring the discipline with the most recent papers”. According to this statement, only few current studies comparable to the present study could be found during the literature search—and not one from a general dental practice. According to the Swedish Agency for Health Technology Assessment and Assessment of Social Services, little is known about how effective modern endodontic treatments in the general dental practice actually are.\textsuperscript{21} The results

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{f9a.png}
\caption{Case 3.}
\end{figure}
of controlled clinical studies cannot be generalised and cannot be transferred to a general practice. The practice in the current study used established techniques in endodontic surgery. A surgical microscope was not available.

Extraction serves as a hard criterion for the termination of survival. Untoward events, such as repeating RER, TR and RCF, terminate survival as well. However, the affected teeth are preserved, a plus for patient satisfaction. This study shows an increased extraction rate of the lower Classes and differences related to the restoration provision among the socio-economic classes. Filling therapy results in a statistically significantly increased extraction rate versus crowns without posts, but less versus crowns with posts. The ethical problem of a lower financial budget among this patient class should not be underestimated in this regard.

Regarding the post build-up, it has to be remarked that not the post build-up, but the problems related to insertion, such as insufficient remaining RCF (too short, insufficient thickness) or placement with a via falsa, cause a shortened survival time. This study found double the extraction frequency in the case of a via falsa versus cases without a via falsa.

Since via falsa and an improperly inserted post have to be seen as iatrogenic, the practitioner is to be blamed for an insufficient RCF. A sufficient RCF is the basis for a successful endodontic treatment. The first author only regarded 11.2% of the cases as being of insufficient thickness—these had a slightly higher extraction rate—versus homogenous RCF. Regarding RCF length, there was a clear prevalence of overfilled teeth, which had a statistically significant extraction frequency of 15.2%. The teeth that were not overfilled amounted to 19.3%. It is traceable that overfillings require substantial canal preparation with intensive canal wall cleaning and more extensive elimination of bacterial colonisation. Leaving of the overfilled material prolongs the healing of the periapex. Friedman claims that there are only insufficient studies regarding RCF length.17 According to some studies, too short or too long RCFs are favourable. Barone et al. reports good experiences with inadequate RCF lengths (too short or too long) regarding healing rate.33 They judged 74% as being healed and 94% as being functional after four to ten years. Of the 165 teeth treated with RER, 31 (18.8%) were extracted at the time of examination.

In her dissertation, Wiemer evaluated 132 RERs performed at a specialised practice one to eight years post-operatively.34 Of these, 88.9% underwent orthograde RCF. At the time of research, 17 teeth had been extracted. All extractions were attributed to failure. After five years, 90% of the treated anterior teeth and 86% of the treated posterior teeth were still in situ. The present study had a survival rate of 91.5% after five years. More than half of the RERs and more than three-quarters of the TRs were performed by the senior dentist. The percentage difference between RER and TR regarding extraction was not significant. The Kaplan–Meier analysis proved that the median survival time for RER and TR similarly amounted to 30 years. The Wang et al. study, which found a median survival time of 92.1 months in 154 first-time surgeries, serves as comparison.35 Furthermore, they found that practitioner and type of tooth have a significant influence on survival. In particular, anterior teeth survived significantly longer than premolars did, as also documented by Raedel et al.25 The practitioner did not play a role in the present study and anterior teeth survived premolars—not significantly though.

PP was present in 68.4% of all RER and 46.5% of all TR cases. The results of this study show that RER is preferable in the case of PP, and TR otherwise. Of the most extensive periapical lesions (diagnosis 5), 85% were treated with RER. The extraction rate was extremely low for cases with initial diagnosis 5—14.9%. Possibly, this is connected to the high antibiotic administration rate of 37.8%, whereas diagnoses 1–4 had an antibiotic administration rate of 23.2%.
A similarly severe clinical situation was the diagnosis of abscess, 58.3 % of which cases were treated with RER and 41.7 % with TR. During follow-up, 26.1 % of the teeth affected by anamnestic abscesses were extracted, and 68.7 % of the abscess-affected patients were treated with antibiotics.

The long survival time of approximately 30 years suggests that whether RER or TR is used for RCF of a non-vital tooth is not relevant to survival regarding extractions. The practitioner may rather consider the fact that TR is the easier treatment and that the time needed for TR—according to the first author’s own practical observation—amounts to only 38 % of the time needed for RER. However, health insurance covers only about a third of the dentist’s fee. The patient will be pleased with a speedy treatment and lower postoperative discomfort.

A multiplicity of factors were checked regarding the dependence of the extraction rate on antibiotic administration. The examined variables partly show high antibiotic administration rates. According to the findings of a poll reported on by Goepel and Hülsmann, 82 % of the dentists surveyed said that they administered antibiotics in the case of a periapical abscess and 53 % in the case of pulp necrosis with acute PP and swelling. From this, we established that the results reported in the present study are in the average range of antibiotic administration: 67.8 % for abscess, 37.9 % for diagnosis 5 and 35.7 % for pathology. However, a connection with the extraction rate could not be proved with statistical significance. Even the doubled antibiotic administration rate for multiple-appointment treatment versus single-appointment treatment did not influence the extraction rate. The Wang et al. statement can be supported in that antibiotic administration has no influence on tooth survival. Friedman states that “the use of systemic antibiotics should not be considered to influence the outcome of surgical endodontics”. Pallasch stresses that the risk of anaphylactic shock is higher than the prevention of endocarditis in the case of prophylactic antibiotic administration. Antibiotic prophylaxis serves as prevention of lawsuit rather than the prevention of endocarditis.

Conclusion

Regarding extraction, RER and TR serve as equivalent therapy options for endodontic surgery based on the conditions at the general dental practice involved in this study. The median survival time amounted to 30 years with both therapies alike. Corroborating the findings in the literature, the data of this study shows that antibiotic administration does not improve therapy outcomes for endodontic surgery.

Editorial note: A list of references is available from the publisher.
Diverse applications of lasers in dentistry

Recent literature

Dr Igor Cernavin, Australia

When considering whether to work with lasers and in which field they could be applied, recent studies provide many application options and issues for practitioners to consider. The following presents some of the newest research on possible areas of application and further investigation.

Petrov et al. used a femtosecond laser with a high repetition rate, which is probably the future of lasers for hard-tissue removal to achieve fast and more precise ablation in dentine and enamel. They concluded that the ultra-fast femtosecond laser used in their work holds the promise of a significant drilling ability without collateral thermomechanical effects. It achieved high processing efficiency, overcame disadvantages of other laser systems reported, and can be used to develop an instrument for cavity preparation based on fast and precise ablation. Their further aim is to exceed the speed of conventional drilling instruments and thus to reduce the treatment time, which in turn will bring comfort to the patient.

Levine published an article on how to choose the right laser for one’s practice, which readers may find of interest. Levine

Hashimoto et al. investigated fluoridated hydroxyapatite for application as an implant coating for titanium bone substitute materials for dental implants. They concluded that fluoridated hydroxyapatite coatings are suitable for real-world implantation applications.
Giannelli et al. carried out a double-blind, randomised, single-centre, split-mouth clinical trial investigating the efficacy of and patient-reported outcomes after one year of treatment of severe periodontitis with a laser and light-emitting diode (LED) procedure adjunctive to scaling and root planing.\(^4\) Their study confirmed the efficacy of combined phototherapy and scaling and root planning, which had emerged from previous clinical trials, extending its field of application to severe periodontitis.\(^4\)

Belcheva et al. carried out a study whose aim was to evaluate the positive effects of the carbon dioxide laser (10,600 nm) with acidulated phosphate fluoride gel on enamel acid resistance.\(^5\) Their conclusion was that this combination was more effective in protecting the enamel surface and resisting demineralisation than was carbon dioxide laser irradiation or fluoride alone.\(^5\)

Campos et al. published a double-blind study on immediate laser-induced haemostasis in anticoagulated rats subjected to oral soft-tissue surgery.\(^6\) There has been much controversy about the management of patients on oral anticoagulants requiring oral surgical procedures. The haemostatic properties of high-power lasers were perceived to be potentially helpful during oral soft-tissue surgeries in anticoagulated patients. The authors concluded that laser-induced haemostasis is an alternative for intra- and postoperative bleeding control in patients on anticoagulation therapy.\(^6\)

As oncological treatment can result in changes in the oral cavity, Carvalho et al. drafted a guide, based on a systematic review, directed at the team of health professionals involved in the oral care of oncological patients.\(^7\) The review concentrated on randomised clinical trials involving paediatric and adult oncological patients, focusing on the prevention and treatment of oral complications.\(^7\) The studies included in the review emphasise the provision of Low Level Laser Therapy, among other interventions, to minimise the severity of oral problems in such patients.\(^7\)

Tani et al. carried out an in vitro study that compared photo-biomodulation potentiality using red (635 ± 5 nm) or near-infrared (808 ± 10 nm) diode lasers and violet-blue (405 ± 5 nm) LED operating in a continuous wave with a 0.4 J/cm energy density, on human osteoblast and mesenchymal stromal cell viability, proliferation, adhesion and osteogenic differentiation.\(^8\) They concluded that the 635 nm laser had a potential effective option for promoting/improving bone regeneration.\(^8\)

Ghouth et al. carried out a systematic review of the evidence on the use of laser Doppler flowmetry in the assessment of the pulpal status of permanent teeth compared with other sensibility and/or vitality tests. They concluded that, despite the higher reported sensitivity and specificity of laser Doppler flowmetry in assessing pulp blood flow, this data is based on studies with a high level of bias and serious shortfalls in study design.\(^9\) More research is needed to study the effect of different laser Doppler flowmetry’s parameters on its diagnostic accuracy and the true cut-off ratios by which a tooth could be diagnosed as having a normal pulp.\(^9\)

Kaur et al. compared soft-tissue wound healing using diode lasers (810 nm) versus the conventional scalpel approach as an uncovering technique during second-stage surgery for implants.\(^10\) They found that it can minimise surgical trauma, reduce the amount of anaesthetic required, improve visibility during surgery owing to the absence of bleeding and eliminate postoperative discomfort.\(^10\)

Efficiency in debonding porcelain laminate veneers was studied by Al-Balkhi et al. using several laser parameters and two different application modes of the Er:YAG laser (contact and non-contact mode).\(^11\) Their finding was that the Er:YAG laser is an effective tool in debonding porcelain laminate veneers. The non-contact application mode was more efficient in reducing debonding time than the contact application mode, but resulted in a higher change in pulp temperature.\(^11\)

Kellesarian et al. carried out a comprehensive review to assess the effectiveness of erbium lasers in the removal of all-ceramic fixed dental prostheses and found that the benefits of lasers over mechanical instrumentation for crown removal encompassed efficient restoration retrievability without restoration or tooth surface damage and a relatively easier and more time-effective procedure with no prerequisite for anaesthetic agents.\(^12\) It is, however, imperative for clinicians to be well trained and exhibit adequate knowledge regarding recommended power settings and laser-safety parameters with reference to interactions between light and different tissues and ceramics.\(^12\)

The effect of Er:YAG (Smart 2940D Plus, DEKA) and Er,Cr:YSGG (Waterlase iPlus, BIOLASE) lasers on the shear bond strength between orthodontic brackets and dental porcelain in comparison
with conventional acid etching with 9% hydrofluoric acid (Ultradent Products) was investigated by Mirhashemi et al. They concluded that with the laser groups the failures were mostly adhesive, while they were mostly cohesive with the controls. In the case of the Er:Cr:YSGG laser, although the conditioning outcome met the bond strength requirement for orthodontic brackets (6–8 MPa) they concluded that the bond strength must be further improved by fine-tuning the irradiation parameters.

Yassaei et al. assessed the efficacy of an Er:YAG laser and pastes containing casein phosphopeptide-amorphous calcium phosphate (CPP-ACP) with and without fluoride and their combination for prevention of white spot lesions in the enamel. They found that the Er:YAG laser was able to decrease demineralisation. It further proved to be a potential alternative to preventative dentistry and was more effective when combined with CPP-ACP products. This would be useful especially for orthodontics.

Sarmadi et al. evaluated patients’ experiences of two excavation methods, the Er:YAG laser and rotary bur, and the time required with these methods, as well as objective assessments of quality and durability of restorations over a two-year period. Their conclusions were that the Er:YAG laser technique was more time-consuming than the rotary bur, but despite this, the laser technique caused less discomfort and was preferred as an excavation method by patients.

Li et al. carried out a meta-analysis to systematically evaluate the applications of Er:YAG lasers for the removal of caries and cavity preparation in children. They concluded that the time required for Er:YAG laser treatment was longer than that for the conventional mechanical method, but there was less pain associated with the Er:YAG laser treatment. There were no significant differences in the complete retention rate, marginal discoloration and marginal adaptation when compared with the conventional method.

Pinheiro et al. assessed the utility of dental acid etchants containing 37% phosphoric acid and methylene blue dye as a sensitising agent for photodynamic therapy to reduce Streptococcus mutans in dentinal caries. They concluded that this treatment can be used as a photosensitising agent for photodynamic therapy to reduce the S. mutans burden in dentinal caries.

Laser dentistry offers many application options and numerous research approaches that might be interesting to investigate or to stay up-to-date with for practitioners. This consideration of recent literature has shown that there is still much potential for the increased use and application of lasers in the different fields of dentistry.

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Treatment of oral leukoplakia with a 980 nm diode laser

Dr Maziar Mir, Prof. Norbert Gutknecht, Dr Masoud Mojahedi, Germany; Dr Jan Tunér, Sweden & Dr Masoud Shabani, Iran

Leukoplakia is a common precancerous lesion of the oral cavity. It is defined as “a predominantly white lesion of the oral mucosa that cannot be characterised as any other definable lesion”. Clinically, leukoplasias are divided into homogenous (a thin, flat and uniform white plaque with at least one area that is well demarcated, with or without fissuring) and non-homogeneous lesions that are characterised by the presence of speckled or erythroplakic and nodular or verrucous areas. Various non-surgical treatments (including the use of carotenoids [beta-carotene, lycopene]; vitamins A, C and K; fenretinide; bleomycin; photodynamic therapy) and surgical treatments (including cryosurgery, electrocautery, laser ablation) have been reported. This article presents successful results of oral leukoplakia treatment with a 980nm diode laser.

Case report

A 55-year-old female patient with a white discoloration of her buccal mucosa that had been diagnosed as oral leukoplakia was referred for treatment with laser. The patient’s medical history showed no systemic medical problems, no allergies, no prescribed medications or drugs that the patient was taking and no history of past surgical procedures, which was why the patient did not need to be referred for medical consultation. The oral and maxillofacial examination of the patient revealed no temporomandibular joint dysfunction, myofascial disturbances or parafunctional habits. The patient maintained good oral hygiene. Based on these observations, oral homogenous leukoplakia was diagnosed (Fig. 1). Laser-assisted surgery with a 980nm diode laser was recommended to the patient as a treatment approach.

Procedure

After completion of the consent form, the operation area was anaesthetised through infiltration with 2% lidocaine with 1:80,000 adrenaline (1.8 ml; Darou Pakhsh Pharmaceutical). The patient’s information, such as the examination sheet and the completed consent form, was reviewed. The controlled area was defined and laser signs were properly displayed to secure the operating room. The eye protection (safety glasses) of the patient, her guardian and the assistant was checked. The patient’s mouth was then rinsed with 0.2% chlorhexidine oral rinse (Shahre Daru Pharmaceutical) for a duration of one minute. Then the oral leukoplakia was removed by means of a high-power diode laser (GIGAALASER). The laser was set to contact mode and the following parameters: wavelength of 980nm, power of 1.5W, 400µ fibre, initiated fibre and continuous wave.
After the procedure

The patient was advised to keep the area around the surgical site as clean as possible. She was also told to avoid foods and liquids that may have irritated the sensitive tissue and made it painful to eat. If necessary, over-the-counter analgesics were to be taken. The laser settings were documented in the patient’s medical file.

Immediately after surgery, excellent oral leukoplakia removal was observed, with no bleeding, no carbonisation and no char (Fig. 2). The patient did not experience any discomfort and was satisfied. The first post-operative follow-up was scheduled one day after the procedure. As expected, healing was progressing well and there were no signs of swelling or pain (Fig. 3). At the follow-up after one month, a successful outcome was clinically observed (Fig. 4).

Discussion

Diode lasers are used extensively in many dental practices. Laser–tissue interaction with a high-power diode laser is based on photothermal effects. According to Nammour et al., the removal of a minimum of 1 mm in lesion depth and 3 mm of surrounding healthy tissue can lead to the highest treatment success rate. Natekar et al. argue that diode laser or carbon dioxide laser surgery seems to be more effective than cryotherapy. Monteiro et al. report favourable experiences regarding oral leukoplakia surgery with an Er:YAG laser. The 980 nm wavelength has low tissue penetration, which can be advantageous for removing superficial structures and protecting surrounding healthy tissue. Laser surgery of oral leukoplakia may be helpful in reducing malignant transformation of lesions. However, each patient should be aware of the recurrent nature of the lesion, which is why periodic monitoring is mandatory. Removing oral leukoplakia through laser surgery is usually a quick procedure that typically does not result in bleeding, pain (in most cases) or oedema. Moreover, there is usually no need for analgesics, since lasers have analgesic effects on tissue. Since oral leukoplakia lesions tend to transform into malignant lesions, this procedure is traditionally classified as an advanced laser procedure.

Conclusion

The use of a 980 nm diode laser following the treatment protocol which is described in this article has proven to be a successful alternative for treating patients with homogenous leukoplakia. Given the recurrent nature of the lesion, however, long-term follow-up appointments should be considered mandatory for the patient and should be taken seriously by the treating clinician.

about

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Facial swelling caused by infected teeth
Dual wavelengths for immediate healing

Dr Imneet Madan, UAE

Primary teeth retain their position in children’s mouths until they reach the age of 10 to 12, when molars exfoliate. Until then, it is vital for primary teeth to stay cavity-free and in a healthy condition. A mindset that we encounter quite commonly is that primary teeth do not necessarily need to be treated, as they are to fall out anyway. Yet, the contrary is true: it can be argued that primary teeth play a vital role in paving the way towards healthy permanent dentition.

They have an important purpose and are of great significance for children. They contribute to a harmonic cosmetic smile, building children’s self-confidence as a consequence—and, of course, they are vital for creating beautiful childhood photographs. Furthermore, primary teeth serve as natural placeholders for permanent teeth to erupt in the right position. Besides that, they are vital for digestion, since properly chewed food is digested better. Primary teeth are also important for the jaws to develop properly. Additionally, they help children to express themselves verbally, and they keep children from developing parafunctional habits, such as tongue thrusting or mouth breathing. Given these vital functions of primary teeth, it is by all means necessary to retain them and to refrain from premature extractions.

When dental health is compromised and the resulting conditions remain untreated, there is a strong possibility that permanent teeth will erupt into an unhealthy dental environment, thus, compromising overall health. Good oral hygiene and well-maintained primary teeth, however, allow permanent teeth to erupt in a healthy fashion. Chronic untreated caries is the primary cause of long-standing infections. It goes without saying that the best mode of management is to prevent the onset of the condition in the first place. However, if dental decay and the associated condition are already present in a patient and have reached the stage of chronic infection in the periapical area, which in turn results in facial swelling, it is mandatory to consider treatment options.

Chronic irreversible pulpitis is one of the primary causes of facial swelling, gingival infections, and abscesses. Untreated primary molars with gross decay allow for bacteria to enter and accumulate inside the pulp, leading to the death of the pulp as a consequence. This is referred to as necrosed or non-vital pulp. Bacteria feed on pulp contents and produce exudate that seeps into the facial spaces, often leading to face swelling.

Case reports

This article will depict two cases in which facial swelling was caused by grossly decayed molars in children. In both cases, laser-assisted root canal therapy was suggested as an alternative to extraction in order to retain the teeth. Both children were under periodic follow-up at the time of writing.
Case 1
An 8-year-old girl presented with the left half of her face swollen (Fig. 1). She complained about pain when chewing and continuous discomfort. The child showed mild symptoms of fever. Upon intraoral examination, it was found that tooth #74 had Grade II mobility and periapical swelling was present (Figs. 2 & 3). Intraoral periapical radiographs showed a widening of the periodontal ligament in the periapical area (Figs. 4 & 5). The tooth was tender to percussion and the child was in discomfort owing to infection and swelling extending up to the lower jaw. In this case, the submandibular swelling was primarily caused by long-standing carious decay that extended into the pulp, resulting in a periapical infection.

Case 2
A 4-year-old boy came to our surgery with his face swollen in the area around a maxillary right posterior tooth (Fig. 6). The swelling extended from the upper right cheek to his ears and lower eyelids. The boy had a fever and he had not slept well the night before the appointment. Upon intraoral examination, it was noted that tooth #54 had Grade I mobility and that it had an old filling. Intraoral periapical radiographs (Figs. 7 & 8) and the medical history of the patient revealed that a deep filling with indirect pulp capping had been done approximately five months before, in August 2018. At the time the filling was done, dental decay had been in close proximity to the nerve, but the procedure was carried out nonetheless.

Before the treatment

Treatment options
Two options were proposed for treating the compromised primary tooth. The first approach would involve tooth extraction followed by the insertion of a space maintainer. The second option was laser-assisted root canal therapy. Yet, a successful treatment outcome could not be guaranteed with this option. In the case of a reinfection, the first option would have to be seriously considered. Scientific research has shown that bacteria remains in the root canals to a depth of up to 1,000 µm. Conventional root canal therapy is able to clean canals up to this depth. With laser-assisted treatment, however, canals can be cleaned to a depth of 600–800 µm. The two treatment options, as well as the associated costs, were explained to the parents. In both cases, the parents opted for the laser-assisted root canal therapy.

Informed consent
Owing to the nature of the pathology, only an uncertain prognosis could be made. The parents understood that, in the case of failure, the teeth would need to be extracted. The treatment costs for both approaches were thoroughly explained to them. Consent forms for the approach that was agreed on were completed and signed.
steps to children that are about to be treated. Surgical terms should be euphemised and communicated in a child-friendly manner. For instance, a nasal mask can be referred to as “happy air”, a laser as “popping light”, cavities as “sugar bugs”, a dental cavity as “hole”, a cotton role as “tooth pillow”, irrigating the canals as “washing the sugar bugs”, obturation as “putting cream in the tooth” and applying tooth filling material as “closing the hole”.

Neurolinguistic programming
In the cases described here, neurolinguistic programming was used as a way to obtain the children’s attention and cooperation and to have them follow deep-breathing instructions. In combination with conscious sedation through nitrous oxide, neurolinguistic programming works well for calming down children ahead of treatment. In both cases, treatment started already at the first appointment owing to severe swelling. The procedure began five minutes after administering sedation in Case 2. The amount of administered nitrous oxide was slowly increased to 55%. During treatment, a movie was shown overhead for the purpose of distracting the children. Since both children were able to listen attentively after the treatment, the steps for the next visit were communicated to them. Before leaving the practice, they were given a small reward for behaving well and listening attentively during the appointment, which hopefully had a positively reinforcing effect.

Nitrous oxide
Nitrous oxide, commonly known as “laughing gas”, was administered in order to relax the receptors. It has an analgesic or anxiolytic effect, which causes temporary depression of the central nervous system. It is absorbed rapidly and remains relatively insoluble in any tissues in the body. At the end of the procedure, 100% oxygen is used to flush out the nitrous oxide. There is minimal impairment of bodily reflexes.

Surgical procedure
The Er,Cr:YSGG laser, with the MX7 tip, was directed to the occlusal surface and set to the following parameters: 2,780 nm, 3.75 W, 25 Hz, water 80 and air 60. Rotary instruments were used to enlarge the canals up to ISO #35. Intermittent irrigation with saline and chlorhexidine was done. For sterilising the canals initially, the Er,Cr:YSGG laser, with the RFT2, was set to 2,780 nm, 1.25 W, 50 Hz, water 24 and air 34. Paper points were then used to dry the canals. A diode laser in continuous wave mode was then used, set at 940 nm, 1.5 W, 2 mm/second, four to five turns in circular motion. At that point, an open dressing was put on to the site.

At the second appointment, two days later, the open dressing was removed. The canals were re-irrigated with saline and chlorhexidine. Both erbium and diode lasers were used to sterilise the radicular and periapical areas.
In Case 1, the canals showed no bleeding and were completely dry. Zinc oxide eugenol obturation was carried out, followed by a base filling with dental cement (GC Fuji IX GP, GC) and composite filling on top. In Case 2, since the swelling had not regressed completely, it was decided to place a temporary filling first (Fig. 10).

In Case 1, the procedure was completed after two appointments, whereas in Case 2, it was complete after three (Fig. 11). There was no need to prescribe antibiotics postoperatively. Periodic follow-up appointments were scheduled for both patients, with the first starting three months after the treatment. Stainless-steel crowns were prospectively planned in the case of no further re-infections.

Discussion

Microbiology of periapical infections
The microbiology of fistulas is complex. The deep areas around the periapical region are low in oxygen, allowing only anaerobic bacteria to dwell there. They cause pain, swelling, tenderness and exudation of pus. A high prevalence of Enterococcus species and Porphyromonas gingivalis is found in the necrotic pulp of 2- to 5-year-old children. P. gingivalis has been found to affect about 27% of primary teeth. Prevotella nigrescens, Prevotella intermedia and Porphyromonas endodontalis also contribute to the infectious processes inside the pulp. Fusobacterium nucleatum too is a bacterium that contributes to an increase of the earlier-mentioned symptoms. Enterococcus faecalis, P. gingivalis and F. nucleatum are found in extensive numbers, especially in fistulas related to primary teeth. It is because of the complex nature of the primary root canal microbiology that conventional treatment supported only with antimicrobials often is not completely successful.

Reasons for complicated infections in primary teeth
Primary teeth diagnosed with chronic gross decay have a high chance of recurring infections. There are certain factors that compromise the health of primary tooth root canals. For a start, there is the anatomical root configuration. Variations in the root canal anatomy of primary teeth can complicate dental treatment. Primary teeth have flat ribbon-shaped canals with multiple lateral canals that often cannot be properly sealed after treatment. Also, these lateral canals accommodate bacteria in their deep ends. Roots in primary teeth are in a constant state of resorption due to eruptive forces from the underlying permanent teeth. This leads to a steady ingress of bacteria. Moreover, canal openings in the apical delta contribute to bacteria spreading even further. Another factor compromising the health of root canals of primary teeth is the complex resident bacterial flora. As stated earlier, scientific research suggests that bacteria are found at a depth of up to 1,000 µm in the root canals.

Benefits of laser-assisted treatment
Conventional irrigants used in pulpectomy penetrate canals to a depth of about 100 µm. Penetrating a depth between 500 µm and 1,000 µm, lasers of different wavelengths can be considered a valuable treatment alternative. They permanently destroy the microbial cell membrane, thus, stopping any further growth. As laser allows for such a deep reach, there is a higher possibility of bacterial lysis. After laser-assisted treatment, clinical symptoms should have ceased to exist and radiographs should show no signs of treatment failure.

Conclusion

Laser-assisted endodontic treatment in compromised primary teeth has come a long way. When this treatment is suggested as an alternative approach to dental extraction, most parents tend to opt for this treatment, since they understand that early loss of primary tooth can lead to numerous complications later in life. In addition, dental extraction is most certainly more psychologically challenging for a child.

Editorial note: References can be provided by the author upon request.

about

Dr Imneet Madan is a UAE-based dentist specialising in paediatric dentistry and laser dentistry. She obtained an MSc in Lasers in Dentistry from the Aachen Dental Laser Center at RWTH Aachen University in Germany. In addition, she is a coach in neurolinguistic programming, a psycho-communicative approach, and has Six Sigma Green Belt certification.

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Irrigation in endodontics—
New standards in the dental office

By DTI

A main goal of endodontic treatment is to effectively irrigate the canal and thus prevent reinfection of the peri-apical tissue. Recently, a range of new products have appeared, many of them claiming to provide effective and safe irrigation. We spoke to German endodontist Dr Uwe Radmacher about his experience with the new IrriFlex irrigation needle launched by PD (Produits Dentaires) in March this year.

The success of endodontic treatment depends on the eradication of microbes from the root canal system and prevention of reinfection. How important is irrigation in this process?

Irrigation is like a 3D file. I liken it to drilling pipelines in a generally complicated root canal system with many variations and flooding these with an effective irrigant, which is still sodium hypochlorite, able to reach anastomoses and lateral canals. The infected tissue can be removed and sufficient cleaning and disinfection can occur. The 3D cavity is prepared.

Mechanical devices have been developed to improve the penetration of irrigants and effectiveness of irrigation in the most apical part of the main root canal in order to overcome the limitations of conventional metal needles. Could you tell us what these limitations are, and how these have impacted on your day-to-day treatment workflow and irrigation protocol?

First of all, chemical and mechanical disinfection have the same impact on successful outcomes in endodontics. Currently, there is none without the other.

The main claim of mechanical shaping is the creation of a tapered, funnel-like preparation to support an effective eradication of microbes and to support proper sealing. At the same time, the apical foramen should not be unnecessarily enlarged and should be kept as small as is practical. Discussion about the preparation sizes to be reached is as old as endodontics itself.

Previously, irrigation needles were mostly not able to reach the most apical part and prevent blocking due to remaining debris. Furthermore, there is a present risk of blocking the needle and over-extruding fluid, especially with a front-vented design. Personally, I did not like the common single-side-vented needles for my irrigation protocol because I did not feel comfortable with the penetration of the fluid at the most apical point. Owing to the existing needle diameters and a small apex size, it is frequently not possible to reach working length and rinse the debris out. This back-draft can’t be compensated for by activating the fluid with sonic and ultrasonic devices just when a particular block of remaining debris has already appeared is frequently not as easy to detect as it is in an endodontic training glass block. Thus, the prevention of residual debris by irrigating the critical parts of the root canal system copiously and continually is essential for successful treatment outcome.

You have recently begun using IrriFlex, a new revolutionary 30-gauge irrigation needle. What is the main benefit of this new product, and how has it affected your irrigation procedure?

I did some trials before the official launch with the new TruNatomy shaping files (Dentsply Sirona). Previously, it was almost impossible to create proper delivery and exchange of the fluid in the apical third of the root canal. This changed totally when the new IrriFlex became part of the game. The needle is totally flexible and comes in size...
30/.04 and perfectly fits even the tiny TruNatomy Prime shaping file with a size of 26/.04 v.

The efficient delivery up to working length and the minimised risk of over-extrusion of the double-side-vented design is the final building block of sustainable disinfection.

IrriFlex features two back-to-back side vents and thus delivers a greater volume of irrigant compared with conventional side-vented needles. How can this feature improve the endodontic irrigation procedure?

Irrigation is now much more powerful in the critical most apical part with a tremendously decreased risk of accidentally pushing sodium hypochlorite through the apical foramen into sensitive areas like the sinus and mental nerve. This is definitely a huge improvement.

The new-generation root canal instrumentation systems respect the canal anatomy as far as possible. Can you tell us whether IrriFlex furthers this aim?

IrriFlex is fundamental for preserving the dentine using TruNatomy shaping files, for example. The orifice of the root canal, the entrance of the funnel, is about 40 per cent smaller, and the taper in the upper two-thirds is regressive. Even by using devices to agitate the irrigation fluid, there is no possibility of removing the debris without a tiny and highly flexible irrigation needle that reaches the apical end.

IrriFlex is undoubtedly a game changer in endodontic irrigation. Do you consider it your new irrigation standard?

Absolutely, IrriFlex has become a fundamental part of my irrigation protocol.
Hi! I am Dr Anna Maria Yiannikos and I am excited to welcome you to the 8th part of this loved series filled with communication protocols. This series includes the most popular and challenging scenarios that might occur in your dental practice and presents successful ways of how to deal with them—so your patients will always leave your practice feeling satisfied and thinking: “My dentist is THE BEST!”

Each article of this series will teach you a new, easy to use specialised protocol, which can easily be customised and adapted to your own dental clinic’s requirements and needs right from day one.

I am here to provide answers to the communication problems you might come across with your patients in
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Your daily practice. These problems can put you in a difficult position, make you lose sleep or, even worse, make you lose faith in yourself and your abilities, which is very common in our field of expertise. Today’s challenging topic is… how to transform an anxious patient into a loyal one.

5 revolutionary tips

I am going to share five revolutionary tips with you that guarantee the transformation from an apprehensive patient into a long-term friend of your dental practice. You should always keep the following points in mind when dealing with fearful patients!

1. Prepare yourself

Before your patients arrive at the practice, make sure to inform yourself and develop an in-depth knowledge of each patient’s individual fears. Also check with your assistants whether they are aware of the patient’s anxieties. In case you are already sitting down with your patients during an appointment, pay particular attention to their facial expressions, their body language, and their reactions in general—if they, for instance, start sweating for no apparent reason.

2. Do not make your patients wait

Let’s state the obvious: No one likes to be kept waiting. In addition, being kept waiting in the waiting room for longer than necessary only results in anxious patients getting even more anxious. Every minute they spend alone with their fearful thoughts is a harmful minute.

3. Talk to your patients

By speaking to your patients and engaging them in conversation, you can make them feel more at ease. Use encouraging phrases like ‘bravo, the step that you took today is so essential for your health!’ or comforting ones such as ‘don’t worry, I will explain everything you want to know as detailed as possible’ or ‘I will inform you ahead of time in case you are about to feel any sensation or discomfort’. However, do avoid criticism regarding your individual fears by any means possible. For instance, refrain from derogatory or patronising phrases like ‘come on, behave like an adult’. Moreover, discuss the treatment plans with your patients in detail before you start with the therapy. Encourage them to ask questions by saying ‘is there anything more you would like to know? I am willing to give you anything you need in order to make you feel as comfortable as possible’. Take your time to win their trust.

4. Give demonstrations

Take away the patient’s fears by demonstrating the tools that you are about to use in the upcoming treatment. For instance, if you would like to use a drill, a laser, an ultrasound or an airflow—demonstrate the sounds of these tools beforehand. Furthermore, remember to minimise the time your patients spend in the dentist chair. If your patients are already anxious, they most likely want to spend as little time in there as possible.

5. Motivate your patients

After the treatment is finished, advise your patients to immediately book a follow-up appointment and motivate them to take part in a pleasant activity that same day. This will help them to associate their dentist visit with a positive experience. Thus, they are more likely to attend another appointment shortly thereafter, fostering a loyal dentist–patient relationship in the long run.

Isn’t that easy?

Implement the above-mentioned steps into your daily practice and you will notice a significant increase in the number of your patients. If fearful patients had a positive experience at your dental clinic, they will share the story everywhere and with everyone, from friends and relatives to colleagues. If you want to attract more patients, there is no way that is more effective than the sheer power of the spoken word!

This is a very useful insight, wouldn’t you agree? I am sure that you are looking forward to the next issue of roots magazine, where I will present the ninth part of this unique series of communication concepts and touch on even more beautiful and interesting topics. Are you curious about what’s next? We will take an honest look at how to deal with your own delays and, in addition, how to transform someone who is constantly complaining into a loyal patient. This is a common and challenging situation that we as dentists face in our clinics on a constant basis. In this regard, I will provide 5 essential tips that will help to cope with these situations more effectively.

Until then, remember that you are not only the dentist of your clinic, but also its manager and leader. For further questions and requests for more information and guidance, keep in touch by sending me an e-mail to dba@yiannikosdental.com or via our website www.dbamastership.com. I am looking forward to our next trip of business growth and educational development!

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This big international update in endodontics by Dr. Arnaldo Castellucci will be held in one of the most beautiful venues of Firenze city – the old historical building “Convitto della Calza”. This is a wonderful place located at the entrance to Florence close to Boboli gardens, Palazzo Pitti and Pante Vecchio.

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Questions?

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