The objective of endodontic treatment has continue to be a constant since root canal treatment was first performed; the prevention or treatment of apical periodontitis such that there is complete healing and an absence of infection while the overall long-term goal is the placement of a definitive, clinically successful restoration and preservation of the tooth.

From about 1895 to 1995 there was more change in clinical endodontics than in perhaps the previous 100 years combined. In these 10 years, clinical endodontics changed forever with the emergence and development of four very dynamic in our armamentarium.48,50

Where We Were

The Dental Operating Microscope

Superior vision became attainable with the integration of the dental operating microscope (DOM). Diagnostically, the operating microscope is an invaluable aid in locating cracks and tracking vertically fractured teeth.45 It allows a more detailed view of root canal patencies, enabling the operator to more efficiently examine, clean and shape complex anatomy.45 It provides superior resolution, thereby aiding the removal or bypassing of separated canals.45 A microscope provides an improved surgical technique allowing for smaller curettes, shallower bevels and the location of isthmi and other canal irregularities thereby allowing an unprecedented success rates of up to 96.8 per cent.8 A DOM has significantly shown to improve the probability of locating a second mesial buccal canal in maxillary molars. Ballassari et al. showed that the M2-Jawal was located in 90 per cent of maxillary molars with the operating microscope but only 5 per cent with unaided vision.8

Nickel Titanium Instruments

Canal preparation procedures became more predictably successful with the emergence of nickel titanium files (NiTi files). This superelastic alloy has shape memory, allowing for better maintenance of the original canal anatomy. These files produce less extrusion of debris, allow greater cutting efficiency and reduce the time for canal shaping compared to stainless-steel files. They are biocompatible, antiseptic and do not weaken following sterilization.2,4,5 Full rotary has been the mainstay for nickel titanium systems for years, reciprocating motions have taken the market by storm by allowing less debris extrusion and quicker negotiation to the apices and less file fatigue.

Mineral Trioxide Aggregate

This decade of extraordinary change concluded with the introduction of mineral trioxide aggregate (MTA). This remarkable and biocompatible restorative material has become the standard for pulp capping and has salvaged countless teeth that previously had been considered hopeless. In vital pulp therapy, when MTA is used as a direct pulp cap to maintain pulp vitality, studies have shown that these areas were free of inflammation and all of them had calcium formation after five months.49 MTA has proved to be the ideal pulpotomy agent in terms of dentin bridge formation and preserving normal pulpalarchitecture.50 MTA produces favourable results when it is used as a root-end filling material in terms of lack of inflammation, presence of cementum and hardtissue formation.50 It is used to repair both furcal and lateral perforations with a relatively high degree of success and to seal both internal and external resorptive defects from an orthograde and retrograde approach.50

The treatment of teeth with open apices and necrotic pulps has always been a challenge for the dental practitioner. MTA can effectively be used as an apical barrier in teeth with necrotic pulps and open apices.50

Where We Are

Irrigants and Irrigation Techniques

Perhaps the greatest international attention in recent years has focused on methods to improve endodontic disinfection in the root canal system. The desired attributes of a root canal irrigant include the ability to dissolve necrotic and pulpal tissue, bacterial decontamination with a broad antimicrobial spectrum, the ability to enter deeply into the dentinal tubules, biocompatibility and lack of toxicity, the ability to dissolve inorganic material and remove the smear layer, ease of use and moderate cost. The combination of sodium hypochlorite and EDTA has been used worldwide for antisepsis of root canal systems. Sodium hypochlorite has the unique ability to dissolve necrotic tissue and the organic components of the smear layer.50 It also kills sessile endodontic pathogens organised in a biofilm.50,51 There is no other root canal irrigant that can meet all these requirements, even with the use of methods such as increasing the temperature22–25 or adding surfactants to increase the wetting efficacy of the irrigant.50,51

Irrigation techniques such as EDTA have therefore been recommended as adjuvants in root canal therapy in combination with sodium hypochlorite as they dissolve organic dentin particles and aid in the removal of the smear layer during instrumentation.51 It is very important to note that while sodium hypochlorite has unique properties that satisfy most requirements for a root canal irrigant, it also exhibits tissue toxicity that can result in damage to the adjacent tissues, including nerve damage should sodium hypochlorite incidents occur during canal irrigation.15 It is therefore very important that irrigant delivery devices are used that not only allow accurate placement of the irrigant but also delivery them in a safe and effective manner without apical extrusion.

Root canal irrigation systems can be divided into two categories: manual agitation techniques and machine-assisted agitation techniques.46 Manual irrigation includes positive pressure irrigation, which is commonly performed with a syringe, and the side-vented needle. Machine-assisted irrigation techniques include sonic and ultrasonic devices, as well as newer systems such as the EndoVac (SybronEndo, USA), which delivers apical negative pressure (ANP) irrigation.

The operating microscope has become an indispensable aid in the field.

SONICS

Diagnostic, the operating microscope has become an indispensable aid in the field. In surgical endodontics, specially designed extra tips are used ultrasonically for superior root-end cavity preparation. This allows minimal removal of root structure while allowing the operator to retain the original canal anatomy. These files reduce the number of exposed dentinal tubules and minimizes apical leakage.49,50

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The operating microscope has become an indispensable aid in the field.
Endo research in the Asia Pacific region is significant

An interview with Prof. Luke Sung Kyo Kim, President of the Asia Pacific Endodontic Confederation

Up to 1,000 representatives from endodontic societies all over the Asia Pacific region, the US and the Middle East are expected to attend the upcoming biannual congress of the Asian Pacific Endodontic Confederation (APEC) in Seoul, South Korea, in March. Dental Tribune Asia Pacific had the opportunity to speak with APEC’s president Prof. Luke Sung Kyo Kim, who is also Chairman of the Department of Conservative Dentistry at the Kyungpook National University’s School of Dentistry in Daegu in South Korea, about the congress and the state of endodontics in the region.

Dental Tribune Asia Pacific: Prof. Kim, how many members does the APEC currently have, and how often does it meet?

Prof. Luke Sung Kyo Kim: It may come as a surprise to you that our organisation is almost 50 years old. Since the APEC was founded in 1985, 15 national endodontic societies have joined the confederation. Our membership includes representatives from professional bodies in Australia, Japan, Korea, Hong Kong, Singapore, Taiwan, Malaysia, Indonesia, India and the Philippines. Iran, Jordan and the US are members from outside the region.

Our general congress takes place every two years, with smaller meetings or events held at larger international endodontic congresses in the intervening period.

The upcoming congress in Seoul will bring members of APEC together once more. What are the most important issues that will be discussed?

From a clinical point of view, the use of the operating microscope and newly developed NiTi rotary instruments will be key issues. We decided on “New horizons in endodontics” as the congress theme, as we expect much of the current research in our region to be presented at the event.

What research is currently being conducted in the region, and what are the most prominent institutions when it comes to endodontics?

Much significant research in our region is concerned with coronal leakage, behaviour of NiTi rotary instruments, and the biochemical aspects of the dental pulp or periapex. While MTA (mineral trioxide aggregate) was primarily developed in the US, much of the research on this material has been conducted by scientists here.

Many universities all over the region regularly produce excellent results. If you look at the major journals in endodontics, such as the Journal of Endodontics and the International Endodontic Journal, there are quite a number of current articles written by authors from universities in South Korea, Japan, Australia, Hong Kong and Taiwan, to name a few.

Besides MTA, endodontics has evolved significantly owing to the use of lasers, CRCT and new instrumentation that only requires one file to prepare root canals. Have these developments already found their way into endodontic practices in the Asia Pacific region, and what are the current trends there?

Most of these techniques are already available and used in clinical practice throughout the Asia Pacific region. Endodontists practising in the most developed markets have all the state-of-the-art equipment, including MTA-like materials, NiTi rotary instruments, operating microscopes, heat-controlled gutta-percha filling devices and electronic apex locators, at their disposal.

What was behind the decision to host the congress in Korea, and what is the state of endodontics there?

The APEC congress has been held in Korea three times and the Korean Academy of Endodontics has been a long-time member of APEC, with clinical specialists from Korea like me having worked as councillors and officers for the organisation. Therefore, Korean members have also been greatly involved in the organisation of this congress.

In combination with the high level of endodontics, which is comparable to most developed countries in the world, this expertise makes the country a perfect host for this kind of event. Specialists in Korea are very much up to date with the latest developments in the field and therefore scholars and students from all over the world come to Korea to learn about or share information and research on endodontics.

What are your expectations of the meeting?

I expect that the latest techniques, concepts, instruments and materials in our field will be presented at the congress. With these concepts and products on display, endodontic specialists will be able to update their knowledge. Visitors can look forward to getting hands on with the most advanced treatment concepts in our field.

Thank you very much for the interview.
endodontic therapy should be the restorative and periodontal aspect, then an implant may be considered. Both root canal therapy and orthograde retreatment as a first and second line of intervention are more cost-effective and compare to implant therapy. Current cost structures indicate that implants are limited to a third line of intervention.

There are numerous studies that support the excellent clinical results of endodontic treatment. Kim and Iqbal conducted a review of the relative success rates of endodontic treatment and implants. The literature review found equal survival rates of single-tooth implants and endodontically restored teeth. Both therapies had overall survival rates of 94 per cent, thus providing predictable outcomes.

However, implants have a longer mean and median time to function, and have a higher frequency of postoperative complications requiring additional treatment intervention.

Where We Are Going
Science and research will elevate the specialty of endodontics to its rightful pinnacle. The cornerstone of our specialty’s integrity and relevance must be built on a strong foundation of randomized clinical trials and evidence-based endodontics. The future of endodontics is bright as we continue to develop new techniques and technologies that will allow us to perform endodontic treatment painlessly and predictably, and continue to satisfy one of the main objectives in dentistry, that being to retain the natural dentition.

Digital Radiography
Cone-Beam Computed Tomography (CBCT)
What digital radiography has provided us for imaging in the present, CBCT (cone-beam computed tomography) will carry us into the future. CBCT technology has been around since the 1980s; however, only recently has it become a viable option for the endodontic office. Cone-beam technology uses a cone-shaped beam of radiation to acquire a volume in a single 360-degree rotation, similar to panoramic radiography. It has advantages over conventional medical CT, including increased accuracy, higher resolution, scan-time reduction and dose reduction. Endodontic uses include but are not limited to diagnosis of odontogenic and non-odontogenic cysts, cysts vs. granulomas, location of untreated canals and the diagnosis of certain root fractures. The extent of internal, external and cervical resorption can be accurately mapped and the presurgical evaluation of anatomical landmarks can be precisely surveyed.

Regenerative Endodontics
Regenerative endodontics has become an exciting possibility, allowing stem cells found in the dental pulp to regenerate and replace diseased tissue with healthy tissue and revitalize a tooth. The vascularization of necrotic teeth with immature replacement. The technique is the need for extraction and implantation of the natural tooth, obviating which will ultimately allow revascularization and its coronal sealing. Revascularization techniques have allowed quick transfer and communication. Therefore, they are precisely guided and only recently has it become a viable option for the endodontic office. Cone-beam technology uses a cone-shaped beam of radiation to acquire a volume in a single 360-degree rotation, similar to panoramic radiography. It has advantages over conventional medical CT, including increased accuracy, higher resolution, scan-time reduction and dose reduction. Endodontic uses include but are not limited to diagnosis of odontogenic and non-odontogenic cysts, cysts vs. granulomas, location of untreated canals and the diagnosis of certain root fractures. The extent of internal, external and cervical resorption can be accurately mapped and the presurgical evaluation of anatomical landmarks can be precisely surveyed.

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For more information about the RECIPROC® system on www.RECIPROC.com
Prof. Hideaki Suda & Dr Toshihiko Yoshioka
Japan

In addition to intra-oral and panoramic radiographs, various visual techniques are available for endodontic treatment today. Above all, information obtained through the dental microscope has become essential.

"See better, do better" is a slogan in modern endodontics. The dental microscope is a wonderful tool for problem-solving in endodontics, for instance for the removal of broken instruments and root-filling materials, finding missed canals, perforation repair, diagnosis of tooth fractures, evaluation of marginal integrity of restorations, precise manipulation in periradicular surgery and deep dental caries, and confirmation of root-canal cleanliness. Yoshioka et al. (2002), for example, reported that the rate of detection of root-canal orifices under a microscope was significantly higher than the number detected with the naked eye. It was also found that surgical loupes were relatively ineffective compared with the microscope.

In addition, computed tomography (CT) is becoming increasingly popular among endodontists, particularly in the assessment of difficult cases and for problem-solving in endodontic treatment. Higher use (34.2 per cent) of CBCT was demonstrated by a recent web-based survey of active members of the American Association of Endodontists in the US and Canada (Dailey et al. 2010). Owing to its high radiation dosage, however, careful consideration is needed before taking CT images. Consequently, a project team from the Japanese Association for Dental Science presented a report in 2010 on the use of CT in dentistry, and a joint position statement by the American Association of Endodontists and American Academy of Oral and Maxillofacial Radiology was issued in February 2011. The combined use of the dental microscope and CT for apicectomy was approved as an advanced dental technology by the Ministry of Health, Labor and Welfare in Japan in 2007, and seven Japanese dental hospitals have been using the technology since February 2015.

Optical coherence tomography (OCT) is a high-resolution imaging technique that allows micrometre-scale imaging of biological tissues over small distances. It was introduced in 1991 and uses infra-red light waves that are reflected from the internal microstructure within the biological tissues (Shemesh et al. 2008). There have been reports on its use for intra-canal imaging, diagnosis of vertical root fracture (Yoshioka et al. 2013) and perforations. Since OCT is non-invasive and free of radiation, this technology may be very useful for endodontic diagnosis and treatment (Figs. 1a–2).

Prof. Hideaki Suda is a professor of Pulp Biology and Endodontics at the Tokyo Medical & Dental University’s Graduate School. During the APEC congress in Seoul, he will be presenting a paper titled "Visual information and imaging technology in endodontics."
VDW launches obturators entirely made of gutta-percha

MUNICH, Germany: VDW’s latest innovation makes use of the advantages commonly associated with gutta-percha, as the new GUTTAFUSION carriers for the thermoplastic obturation of root canals are now made entirely of this material. According to the German specialist company, these obturators now feature a core made of cross-linked gutta-percha that remains stable even when heated and therefore simplifies post space preparation procedures.

In addition, they are coated with gutta-percha, which flows evenly when heated in the GUTTAFUSION oven, for example, filling the whole root canal system, including ramifications, isthmuses and the apex.

Root canal fillings done with GUTTAFUSION can be removed easily for retreatment, the company said. Especially designed for use with tweezers and fingers, the obturator handle allows for easy application of the obturators in molars. According to VDW, no other instruments are required for separation.

GUTTAFUSION has a high radiopacity and is compatible with most rotary NiTi systems.

The three obturator sizes correspond to the R25, R40 and R50 instruments. The correct obturator size can also be determined with a NiTi size verifier, which is available in sizes 20 to 55.

GUTTAFUSION obturators for RECIPROC are particularly convenient.

OptraSculpt Pad now features non-stick surface

SCHAAN, Liechtenstein: The OptraSculpt Pad is a new modeling instrument from Ivoclar Vivadent. It boasts foam pad attachments to allow clinicians efficient, non-stick application of composite filling materials, without leaving any marks.

Natural-looking results are easy to accomplish in anterior and cervical restorations with this material, the Liechtenstein company said.

The highly flexible synthetic foam adapts to the shape of the tooth and therefore allows smooth contouring of the filling. Reference scales on the instrument’s handle are intended to assist in the creation of aesthetic and anatomically correct anterior restorations. In addition, the markings allow comparison of the clinical situation with the ideal average tooth width proportion and angular alignments in the upper anterior dentition.

According to Ivoclar Vivadent, OptraSculpt Pad is particularly suited to the placement of Class III, IV and V restorations and direct veneers.
Endodontic management of a hypertaurodontic maxillary first molar
A case report with a two-year follow-up

Drs Jojo Kottoor, Denuil Valerian Albuquerque, Anuj Bhardwaj, Sonal Dham & Natanasabapathy Velmurugan India

Taurodontism is a morphological variation in which the body of the tooth is enlarged and the roots are reduced in size. Taurodontic teeth have large pulp chambers and apically positioned foramina.1 This variation was first described by Gorjanović-Kramberger; however, the term “taurodontism” was first introduced by Sir Arthur Keith to describe molar teeth resembling those of ungulates, particularly bulls.2

The term “taurodontism” comes from the Latin term “tauro,” which means “bull” and “dont,” which means “tooth” or “bull tooth.”3 Such morphological variations are an endodontic challenge and even more difficult to treat when additional roots and/or canals are present. The endodontic management of one such taurodontic molar is reported in this case report.

Case report
A 44-year-old male patient was referred to our clinic for treatment of the right maxillary first molar (tooth #16). The preoperative periradical radiograph (Fig. 1a) suggested the following possibilities:

- a mesio-occlusal caries lesion with endodontic involvement;
- a highly calcified and elongated pulp chamber extending up to the trifurcation;
- three short roots with the trifurcation in the apical third; or
- a periapical radiolucency in relation to the mesiobuccal and palatal root apex.

Clinically, vitality tests were negative and a diagnosis of hypertaurodontism, according to Arthur Keith3 to describe molar teeth resembling those of ungulates such as bulls.4 The canals were instrumented up to F4 and endodontic treatment was planned.

Local anaesthesia of 2 % lidocaine with 1:100,000 epi- nephrine was administered to the patient. The mesial surface of the tooth was restored with composite resin (Z100, 3M ESPE) after caries excava- tion to enable optimal isolation. Under rubber dam isolation, the access cavity was established with an Endo Access bur and an Endo Z bur (DENTSPLY Tulsa).

A dental operating microscope (DOM; Seiler Revelation) was used throughout the procedure to facilitate visualisation. The calcified mass occluding the pulp chamber was removed using ETD 18D ultrasonic tips (Satelec/Acteon). Three root canal orifices were located: two narrow orifices, the mesiobuccal and distobuccal, and a wide palatal orifice. Root canal orifices were named according to the nomenclature proposed by Kottoor et al.5

An electronic apex locator (Root ZX, Morita) was used to determine the initial working length, which was confirmed radiographically (Fig. 1b).

The root canals were cleaned and shaped with ProTaper (DENTSPLY Maillefer) rotary instruments. The buccal canals were instrumented up to F2 and palatal canal to F4. The canals were irrigated with 2.5 % sodium hypochlorite using ultrasonics, 17 % aqueous solution of EDTA, and 0.2 % w/v chlorhexidine gluconate.

The canals were dried using sterile paper points and obtu- rated with gutta-percha cones and AH Plus sealer (DENTSPLY DeTrey) using an electronic apex locator. Cold lateral compaction of the gutta-percha and AH Plus sealer (Fig. 1e).

Follow-up clinical examination after a week revealed that the tooth was asymptomatic and was not sensitive to percussion or palpation. Subsequent- ly, endodontic management of tooth #15 was completed. The 24-month follow-up radiograph showed complete resolution of the periapical rad- iolucency in relation to the mesiobuccal and palatal root apices (Fig. 1f).

Discussion
Taurodontism is frequently associated with other anoma- lies and syndromes. These include Klinefelter syndrome,6 ectodermal alterations,7 Down syndrome,8 Mohr syndrome,9 Wolf-Hirschhorn syndrome,10 Lowe syndrome,11 Tschirch-dento-ossseous syndrome,12 Williams syndrome,13 and Seckel syndrome,14 but it is not a con- stant feature of these syndromes.15

However, identification of patients with multiple tau- rodontic teeth could lead to early recognition of a systemic disorder and improve quality of life. It has also been found to be associated with dental anom- alies such as oligodontia, supernumerary teeth, and ame- logenesis imperfecta.16 In this case, the patient was a healthy male with a negative medical history.
its aetiology is still unknown, but it has been suggested that this may be caused by a failure of the diaphragm of Herwig’s epithelial root sheath to involute at the correct time and horizontal level or changes in the mitotic activity of cells of the developing teeth that can affect root formation or influence by external factors on the development of the teeth. Differences in opinion exist regarding the amount of displacement and/or morphological change required to constitute taurodontism. Based on the relative amount of apical displacement of the pulp chamber floor, Shays22 classified taurodontism as hypotaurodontism, mesotaurodontism, and hyper-taurodontism. Feichtinger and Bossiwal23 state that the distance from the bifurcation or trifurcation of the root to the cemento-enamel junction should be greater than the occluso-cervical distance for a taurodontic tooth. Keene24 proposed the Taurodont Index, relating the height of the pulp chamber to the length of the longest root.

Although there are many classification systems to determine the severity of taurodontism,22 the classification proposed by Shifman and Chanannoi25 in 1978 is the most widely used system. According to this index, taurodontism is present if the distance from the lowest point at the occlusal end of the pulp chamber to the highest point at the apical end of the chamber, divided by the distance from the occlusal end of the pulp chamber to the apex and multiplied by 100 is 20 or above (hypotaurodontism: TI 20–30; mesotaurodontism: TI 30–40; hyper-taurodontism: TI 40–75).

Except for a higher prevalence of taurodontism among females in a Chinese sample,26 no study has found a gender difference for this abnormality. Although permanent mandibular molars are most commonly affected, taurodontism is occasionally observed in mandibular premolars and even in maxillary premolars, mandibular canines, and incisors.27,28 Its prevalence has been reported as ranging from 5.67 to 60 % of subjects.29 In a recent study, it accounted for 18 % of all anomalies."30

Endodontic treatment in taurodontic teeth has been described as complex and challenging because the apical position of the pulp chamber floor makes it difficult to identify and locate root canal orifices. In the present case, an apical third trifurcation with four root canals was observed. The mesiobuccal and distobuccal canal orifices were very narrow and close to each other, which made identification and negotiation of these orifices very difficult. Additionally, the proximity of the orifices and deeply situated opening of the canals made it difficult to identify the P-MB during the initial visit.

However, during the second visit, the use of D.O.M. enhanced the visualisation of the pulp chamber floor by better illumination of the depths of the cavity. Hence, success was largely dependent on the use of magnification, which allowed for the identification of the P-MB canal with ease. During instrumentation, the shortened length of these canals allowed for instrumentation with the apical third of the file, also making it time consuming. Thus, endodontic treatment of taurodontic teeth may be complex, particularly regarding the cleaning and shaping of the root canals and root- and canal obliteration, especially in hypertaurodontic teeth.

Conclusion

The case report has described the successful endodontic treatment of a hypertaurodontic maxillary first molar that would have seemed impossible to perform with conventional techniques. Success was mostly attributed to the use of magnification, which allowed better visualisation of the four canals orifices. This case report has served to illustrate to clinicians that sound knowledge and modern equipment facilitate enhanced management of endodontically challenging taurodontic teeth.

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