Excellence in endodontics

Daniel Flynn discusses endodontic microsurgery

‘Endodontic surgery has evolved to become a technically accurate, highly predictable procedure with remarkable success rates’

1 Root canal retreatment through the crown
2 Endodontic microsurgery
3 Extraction +/- prosthetic replacement

One are the days of the clumsy apicectomy and amalgam retrograde fillings. Endodontic surgery has evolved to become a technically accurate, highly predictable procedure with remarkable success rates.

Implant technology has meant many teeth of questionable prognosis are extracted in the name of future predictability. While implants have been a wonderful adjunct in the dental armature, our primary role as dentists is to try and conserve the existing dentition that have good long-term prognosis.

Classically an apicectomy was a treatment of last resort, using large bulky instruments, rough approximations and excess amounts of amalgam. The biological ramifications of additional canals, cracks, apical deltas and poor initial root canal treatments may have been overlooked resulting in poor success rates. This has understandably resulted in a negative perception of apical surgery amongst the dental profession who erroneously believe success rates to be around 60 per cent when the actual figure for endodontic microsurgery is over 91 per cent after five to seven years (1).

Modern techniques and equipment have transformed the procedure. Using CBCT scans from the outset we can plan surgery exactly; three-dimensional picture of bone loss is clear as is the position of anatomically sensitive structures; lengths can be accurately measured and existing treatment such as posts and MB2s assessed.

The following case is an example of the techniques which we now use. The patient presented following multiple episodes of pain and swelling from the UL5. There was an initial root canal treatment and subsequent retreatment provided by a competent GDP using rubber dam and sodium hypochlorite irrigation. There was a well-fitting new crown placed and no associated periapical bone loss is clear as is the position of anatomically sensitive structures; lengths can be accurately measured and existing treatment such as posts and MB2s assessed.

Radiographic examination (Fig 1) revealed a large radiolucency associated with the UL5. There was an initial root canal treatment and subsequent retreatment provided by a competent GDP using rubber dam and sodium hypochlorite irrigation. There was a well-fitting new crown placed and no associated periapical bone loss.

A provisional diagnosis of acute exacerbation of chronic apical periodontitis was made and the treated canal appeared centered in the root there was a question whether there was a second canal present in the tooth. Also there appeared to be an apical bulosity present which could mean multiple paths of exit.

A mucoperiosteal flap was raised with micro-blades that produce neat, precise incisions as they cut in multiple directions. Once the flap was raised, the perforation in the buccal plate was identified and root tip located. The granulation tissue was curettaged and haemostasis achieved.

Following resection of 3mm of the root tip perpendicular to the long axis of the tooth a retroreparation was completed with ultrasonic irrigation. The tissues were compressed and the flap closed with 5/0 monofilament sutures that were removed painlessly after 72 hours as reattachment had taken place.

At the four-month review the buccal swelling had completely resolved and radiographically there was significant healing present. The patient was delighted with the outcome.
There are significant differences between the above microsurgical techniques and traditional surgery approaches.

1. Osteotomy size
The use of smaller instruments, magnification and illumination allows access to the root tip, often without removing any additional buccal bone should the plate be already perforated. Staining

Fig 4 Soft tissue removed

the PDL, makes it easier to differentiate between bone and root tip. The smaller the size of the osteotomy, the quicker the healing (2)

2. Bevel Angle
Traditionally the root was resected at 45 degrees for access, visualisation and sealing purposes. But, this method results in the exposure of a greater amount of dentinal tubules and may not remove enough of the apical anatomy lingually. Modern techniques using a cut perpendicular to the long axis of the tooth result in exposure of far fewer tubules, enables a smaller osteotomy, retention of more buccal bone and no periodontal communication. There is less chance of a lingual perforation in the retro-preparation and it is easier to identify the apices of

Fig 5 Haemostasis achieved, parallel resection of root tip and retropreparation sealed with MTA

Fig 6 Soft tissue sent for histological investigation

‘The use of smaller instruments, magnification and illumination allows access to the root tip, often without removing any additional buccal bone should the plate be already perforated’
the roots.

3. Root end resection
It is recommended to remove 3mm of the root tip. At this level 89 per cent of apical ramification and 95 per cent of lateral canals are removed (5). Following resection it is critical that the root end is inspected under high power visualisation, stained and viewed with micro-mirrors. Identification of isthmuses, cracks and lateral canals may be treated at this stage.

4. Retropreparation
Micro-hand pieces and burs are no longer the ideal treatment for retro-preparation. Instead, diamond coated ultra-sonic tips are excellent for allowing the operator to clean along the original canal, the isthmus and minimise microcrack formation.

The use of MTA as a root end filling material is another improvement. Superior to amalgam in terms of sealability and biocompatibility, it is more difficult to place and doesn't give an aesthetically pleasing result when viewed on a radiograph post-operatively. Critically MTA results in regeneration of periodontal ligament and cementum cells and appears to have inductive effects on bone and tissue cells. Super-ERA has also shown favourable results using microsurgical techniques.

Endodontic microsurgery is a great option to keep in mind when planning treatment and has an added bonus for patients being the least expensive intervention when compared to endodontic retreatment and crown, extraction and fixed partial denture, or extraction.

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Fig. 7 Examining a resected root tip with a micro-mirror and implant (4)

Fig. 8 Post-operative radiograph

Fig. 9 Four-month review (almost complete healing and asymptomatic)

Fig. 10 Examining a resected root tip with a micro-mirror and implant (5)

About the author
Dr Daniel Flynn received his MFSRCSI from the Dublin Dental Hospital, Trinity College, Dublin in 2002. Daniel has recently joined the EndoCare team headed by Dr Michael Sultan. Daniel lectures and provides hands-on courses for general practitioners. He also teaches Endodontics at the Eastman Dental Institute for Oral Healthcare Sciences.


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Do we treat patients based on radiolucency?

Dr Sander Loos provides a case report

Just after Christmas, on 26 December 2010, a 76-year-old male patient, who was in great pain, consulted the emergency dentist. The patient indicated that he felt a throbbing pain in his lower left jaw. The pain was unbearable and had kept him awake all night. The dentist took radiographs of teeth #36 and 57 and an orthopantomogram (OPG; Figs 1 & 2).

Although the radiograph did not show the full anatomy of tooth #57 and its surrounding structures, the dentist diagnosed apical periodontitis (AP) and advised an endodontic retreatment or extraction and an implant. To make the patient comfortable for the time being, he prescribed 500 mg Amoxicillin and Ibuprofen.

After another sleepless night, the patient consulted a different emergency dentist on 27 December. The analgesics did not give him pain relief and he was starting to become desperate. The second dentist confirmed the original diagnosis and referred the patient to an oral surgeon because an endodontist was not available at short notice. He requested apical surgery on tooth #57.

The following day, the oral surgeon took another OPG and concluded that surgery was not the best treatment option in this case because the apex was located too close to the nerve alveolaris inferior and access to the apices of tooth #57 was difficult.

He also confirmed the diagnosis of an AP and suggested extraction or endodontic retreatment.

On 5 January 2011, the patient visited my office for the first time. The pain had diminished but not disappeared. Intra-oral examination showed a well-restored dentition with a cantilever bridge on teeth #35 to 37, with #36 and 37 functioning as cantilever supports. (Fig 3)

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As previously taken radiographs were not available and the OPT was considered unsuitable for proper diagnosis, a peri-apical radiograph (Fig. 3) was taken. The radiograph showed that tooth #37 had previously been treated endodontically. The mesial canals were filled with silver cones rather too short of the apex. There also appeared to be some gutta-percha and a large metal post in the distal canal. Additionally, radiolucency was noticeable around the apex of the mesial root. According to the patient, he had received endodontic treatment about 15 years ago owing to pain following bridge cementation. The tooth had been without symptoms since then.

Considering the history and my clinical and radiographic findings, my differential diagnosis was:

1. Painful AP owing to reinfection or leakage
2. Painful marginal periapontitis distal of tooth #37 owing to poor oral hygiene
3. Vertical root fracture (VRF) of the distal root of tooth #37

As diagnosis 1 and 3 would have required rather invasive therapies (re-treatment or extraction), we opted to rule out the local marginal periodontitis first. Under local anaesthesia, the distal pocket was thoroughly cleaned and the patient was instructed to use dental floss distal of tooth #37 on a daily basis.

On 31 January, three weeks after initial treatment, the patient returned for evaluation and appeared free of complaints. There was no bleeding on probing and pain could not be provoked.

It should be noted that by selecting this strategy, neither an AP nor a VRF was definitively excluded as a cause of pain. It should be taken into account that owing to the patient being on antibiotics, the symptoms of the AP may have temporarily disappeared and returned at a later stage. Nevertheless, at that point we treated the patient based on history, a radiograph and patient complaints rather than merely on the basis of the radiolucency evident on the radiograph.

In May 2011, the patient returned to our office once again. He was free of complaints, pockets were within normal limits and there was no bleeding on probing.

“The radiographic picture is only one means of diagnosis... the picture may show a lot of rarefaction, but to use it as the sole means of diagnosis is unwise.” Thomas Philip Hinman, 1921
Root-canal retreatment is a very common procedure that endodontists and general practitioners are faced with on almost a daily basis. The biggest challenge here is to re-establish the initial pathway of the canal and its original exit or apex. During the past decade, several techniques required that gutta-percha be used to fill the root canals. Sometimes and for many reasons, such as leakage or short preparation and/or obturation, the gutta-percha needs to be removed and the canal renegotiated.

Generally, NiTi rotary files were used in such cases in order to facilitate and expedite our task. However, the files used to accomplish this task faced additional challenges, that is, the debris coming from the previous obturation and the density of the obturation material. The first difficulty is piercing the mass of the obturation material. Here, our choice of file should focus on a strong tip that can take the pressure and engage the mass of the gutta-percha, break it down and push it back into the access cavity. The second challenge is to select an instrument that can enter the root-canal structure and engage the obturation material, pushing it out coronally, while offering enough flexibility to go around curves and shape the root-canal surface safely.

Today, thanks to heat treatment that has changed the world of rotary NiTi files, allowing us to modify the crystalline structure of the metal, we have been able to obtain several types of the alloy to give us different files, from the Twisted File to the latest modification of the K5 system, the K3XF (SybronEndo; Fig. 1). The K5 system files are known to be robust yet very safe.

The slight modification in their structure gives these files much-needed flexibility, while preserving their very high safety levels. The clinical applications are very simple. My favourite sequence of the K5 system is the G-pack, which allows me to do crown-down using the taper of the files and keeping the tip stable at ISO 0.25. This sequence allows for a very nice start, removing the obturation material from the coronal third with relatively short files, such as orifice openers, and doing so in a relatively short time. The deeper we go, the more we need to decrease the taper, especially when curves are present inside the canals and smaller taper files are needed.

It is at this particular moment that the flexibility of the heat-treated alloy gives the files the ability to negotiate the curves without any distortion of the canal or macro-damage to the file structure (as has been demonstrated in research and clinically).

Clinical cases
The first clinical case could be described as a very bad day in a dental office. Two files had been trapped and separated in the mesial canals and the patient was referred to the clinic but had to drive for more than two hours to...
get to our clinic. When I first saw the X-rays (Fig. 2), I remembered a very similar case from several years ago with practically the same location of file separation. The separated files in the mesial canals were clearly visible. It was also noticeable that the distal canal had not been treated to full length. Ultrasonic tips and the use of an operating microscope allowed me to retrieve the separated files and it was then time to reshape the canals and retreat the distal canal (Fig. 5). Owing to the combination of requirements for the treatment of this case—shaping and retreatment in one tooth—my instruments of choice were K3XF files. I started with 25.08, followed by 28.06 and concluded crown-down with 25.04.

This gave access to the apical part, which was enlarged to 55.04 in the mesial and distal canals in order to prepare the apical portion of the root-canal system. The speed of the micro-motor for the shaping procedure was 500rpm and a sequence of push-and-pull movements—four to five strokes per canal—with each file was used in order to reach full working length. Figure 4 shows the obturation of the canals, which was performed with RealSeal (SybronEndo) after both separated files had been removed and the root-canal system reshaped.

The second case came as another referral. The patient was suffering from pain in her lower molar and was sent to the office in order to check the case and give the necessary treatment. The preoperative X-ray (Fig. 5) showed an apical lesion with an incomplete root-canal treatment. Because diagnostics found no sign of a root-canal crack, retreatment was my choice. However, we had to overcome two obstacles: the crown placed on the tooth and the fibre post inside the distal canal. I decided to go through the crown without removing it in order not to place any tension on the distal canal. When analysing the anatomy, it appeared that the roots were fused. In such cases, avoiding any tension is recommended in order to avoid any cracks.

Under the microscope and through the crown, I managed to remove the filling surrounding the post. With the use of the ultrasonic WHAT, I managed to remove the fibre post itself together with the previous filling from the access cavity. Using the K3XF after removal of the fibre post was a great help in reshaping the root-canal system, which appeared very convergent.

The files displayed no sign of metal fatigue and the 25.06 was taken deeper into the canal compared with the standard K3 files. The extra flexibility and strength of the K3XF allowed me to perform crown-down and final apical shaping. Obstruction of the root-canal system was performed with the Elements Obturation Unit (SybronEndo) and RealSeal material. The post-operative X-ray (Fig. 6) shows that the merging canals had been cleaned, shaped and filled; and the same had been done for the fibre-post space.

Conclusion
In the two clinical cases presented here—both rather a challenge for root-canal retreatments—the final results were an endodontic success. This lends support to the fact that each challenge needs to be treated separately without fear or tremor from the initial pre-operative X-rays. Our fear shall control neither our judgment nor our choices!

I would like to thank Yulia Vo-robyeva, interpreter and translator, for her help with this article.

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Rubber dam hazards?

Dr Kenneth Serota gives his opinion

The September issue of Oral Health included an article by Dr Ellis Neiburger entitled Rubber dam hazards. The contextual inaccuracy, skewed perspective and postulatory bias of the author was disingenuous at best and horrifying at its worst.

I'm not certain how it managed to secret itself into our beloved periodontal pocket. Before I comment on the text, I'd like to share a scientific article with you published by Smith and Pell in the British Medical Journal in 2005 (entitled Parachute use to prevent death and major trauma related to gravitational challenge.

Design systematic: Review of randomised controlled trials. Data sources: Medline, Web of Science, Embase, and the Cochrane Library databases; appropriate Internet sites and citation lists.

Study selection: Studies showing the effects of using a parachute during free fall.

Main outcome measure: Death or major trauma, defined as an injury severity score ≥ 15.

Results: We were unable to identify any randomised controlled trials. Advo-
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cates of evidence-based medicine have criticised the adoption of interventions evaluated by using only observational data. We think that everyone might benefit if the most radical protagonists of evidence-based medicine organised
Dentistry is perched on a slippery slope. In North America alone, it represents a silo of approximately $60 billion. Evidence-based science has been replaced by self-styled science and the concept of “nondiatria. Horrifying, anyone. For example, the Venn diagram shows the fact that even amongst those whose focus is narrow with a specialty, a segment can be catalysed through market forces to reach something as the holy grail, when another faction sees the same product as having the value of a Gwyneth Paltrow GOOP-substantiated cleanse.

In my own area of interest, a recent article by one of the better-known clinicians questioned the value of the wealth of new endodontic products coming to market, especially the latest NITI iteration that reintroduced reciprocation. The essence of the article was, “if it ain’t broke, don’t fix it”, which then included the take-away message that the product long associated with the reputation of the author had served the discipline well and it too required only a paucity of instruments to achieve 100 per cent predictable clinical success.

To bring this to a purposeful conclusion, I would encourage you to Google Bayes’ theorem. It is in essence an equation and dependent upon whether you are a subjectivist or an objectivist, the theorem suggests that if we assign some a priori probabilities and then compute a posteriori probabilities, the degree of confidence in the hypotheses can be conditioned by the new data that becomes available. For example, the Venn diagram (Fig. 2) relates to a population, the number expected to have a type of cancer, the number that are indeed positive for the cancer and the number that show a false positive by virtue of a test for markers. After the variable, consider the efficacy of lasers by way of example, the degree of penetration into the dental profession, the advocacy of those that use them and the perception of the value inherent based upon their need to see viable applications and substantiated results. It is a technology that will inevitably prove to be an invaluable tool, albeit currently in its infancy.

Read all publications with extreme caution – think HealO-zone. Dentistry is getting very complicated as technology and innovation alter its construct. The one essential aspect that must never be overlooked is the need to sustain biological fundamentalism through assiduously conceived investigations and authorship that follows the Cochrane Collaborative principles. We are about to enter a decade wherein it is manifestly conceivable that teeth can be regenerated or replicat- ed and achieve morphological and functional integration into the gnathostomatic apparatus. While it may not impact on the $4 billion a year whitening arena of oral services, it will impact on many others. The number of rubber dam hazard articles may well breach the levees and floodgates and overwhelm the profession, decimating the landscape and relocating the populace. It is Oral Health’s job to stand on guard:

“Oh Canada, to stand on guard for thee”.

References

About the author

Dr Kenneth S. Serota graduated from the University of Toronto in 1975 and was awarded the George W. Switzer Memorial Key for Excellence in Prosthodontics. He received his Certificate in Endodontics and Master of Medical Sciences degree from the Harvard-Forsyth Dental Center in Boston. A recipient of the American Association of Endodontists Memorial Research Award for his work in nuclear medicine screening procedures related to dental pathology, his passion is education, and most recently e-learning, and rich media. Dr Serota produced the National Endodontic education programme for the Ontarional Dental Association from 1985 to 1997 and was awarded the ODA Award of Merit for his efforts in the provision of continuing education. The author of more than 80 publications, Dr Serota is on the editorial board of Endodontic Practice, Endo Tribune and Implant Tribune. He founded ROOTS, an online educational forum for dentists from around the world who wish to learn cutting-edge endodontic therapy, and recently launched INPLANTS (www.inplants.com) and www.jd-saline.org in order to provide dentists with a clear understanding of the endodontic-implant algorithm as foundational dentistry.

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An in-vitro study

James Prichard discusses the effect of ultrasonic irrigation variables on the dimensions of artificial root canals

**Aim:** To investigate the effects of power setting, type of irrigant and duration of ultrasonic irrigant agitation with IrrisafeTM on the mean percentage change in the cross-sectional area and diameter of artificial root canals in an in-vitro model.

**Methodology:** Twenty-five extracted anterior human teeth were collected and split into two halves, each of which was embedded in epoxy resin. The external root surfaces were polished to produce flat, smooth dentine surfaces. A pilot score was used as a guide to prepare an artificial canal using rotary instruments to a size 30/.06. The root canals were randomly assigned to five groups. Group 1: irrigation with 2.5 per cent NaOCl, ultrasonic agitation at power setting 7 (n=5); Group 2: irrigation with 17 per cent EDTA, ultrasonic agitation at power setting 7 (n=5); Groups 3, 4, and 5 were irrigated with 2.5 per cent NaOCl, 17 per cent EDTA, 2.5 per cent NaOCl, with ultrasonic agitation at power setting 4 (n=5), 7 (n=5) and 10 (n=5) respectively. Irrigant was delivered with a syringe and ultrasonically agitated with a P5 Satelec® and IrrisafeTM tips. Canal area and depth were measured at 17, 16 and 9mm from the canal orifice at baseline and after one, two and five minutes of ultrasonic agitation.

This study came about as a result of a presentation that Chris Stock, Godfrey Cutts and I made to Prof Kish Gulabivala. We showed him a protocol for shaping and then cleaning root canals using Irrisafe. He announced that all steel instruments and tips remove dentine and cut root canals, so I set out to prove him wrong!

I would like to express my thanks to Prof Gulabivala for the idea behind this project and the incredible opportunity he afforded me.

Contemporary endodontics falls into three distinct categories:

1. Preparation (mechanical shaping)
2. Irrigation (syringe flushing and adjunctive cleaning)
3. Obturation (sealing the root canals in three dimensions)

The existence of several morphologically different microorganisms was shown to be associated with necrotic pulps as early as 1984 by W.D. Millar. Bacteria in the root canal system has been shown to cause apical periodontitis in gnotobiotic rats (Kakehashi et al. 1965). Sundqvist demonstrated that 18 out of 19 traumatised but intact teeth associated with periapical radiolucencies gave positive bacterial cultures (Sundqvist 1975).

Schilder (1967) suggested that the root canal be cleaned and then shaped to allow for three-dimensional obturation. However, at least 58 per cent of the root canal surface could remain uninstrumented during root canal treatment (Peters et al. 2001) and 70 per cent more debris remained following instrumentation when compared with instrumentation and irrigation (Baker et al. 1975)

Furthermore the landmark studies of Bystöm and Sundqvist (1981, 1983) demonstrated a 100-1000 fold decrease in bacterial counts when 0.5 per cent Sodium Hypochlorite (NaOCl) was introduced instead of saline. Therefore it has generally been accepted that a chemo-mechanical approach to root canal debridement is required to significantly reduce the bacterial load that may encourage more
predictable healing.

The role of root canal preparation has therefore undergone a shift from one primarily fulfilling a debriding function to one regarded more as establishing radicular access to the complex root canal system, for irrigation and obturation (Gulabivala et al. 2005).

Root canal irrigants should be biologically compatible, chemically able to remove both organic and inorganic substrates, be antibacterial, demonstrate good surface wetting, have no adverse effects on remaining tooth structure and be easy to use and effective within clinical parameters (Gulabivala et. al 2005).

Penetration of irrigants into the root canal is a function of irrigating needle diameter in relation to preparation size (Ram 1977), and placement of the needle closer to the working length increased the efficiency of irrigation (Abou-Rass & Piccinino 1982, Sedgeley et al. 2005).

Improvement of the efficiency of irrigation especially in the apical third of the root canal system has been attempted by agitating the irrigant. The use of hand-files, pumping of well adapted GP cones (manual dynamic), continuous irrigation during rotary instrumentation and sonic and passive ultrasonic devices have all been described (Gu et al. 2009).

Richman first described the use of ultrasonics in endodontics in 1957. Endosonics was a term first described by Martin and Cunningham (1984) and referred to the simultaneous preparation and irrigation of root canals. Passive ultrasonic irrigation (PUI) was first described by Weller et al. (1980) and relates to the non-cutting action of the ultrasonically activated file. The free movement of the file or wire allowed irrigant to penetrate more easily into the apical part of the root canal (Krell et al. 1988)

However significant problems were encountered with k-files as they produce irregular shapes and apical perforations (Stock 1991, Lamley et al. 1989), straightened canals (Chenail & Teplitsky 1985, 1988) and ledged simulated root canals (Al Jadaa et al. 2009).

Irrisafe™ (from Acteon UK) is a stainless steel instrument that is non-cutting, parallel sided and available in two lengths (21 and 25 mm) and two tip sizes (ISO 20 and 25) and designed to be used after root canal shaping is complete to agitate freshly delivered irrigants.

It can be pre-bent in curved canals and introduced to 1mm short of the working length. It should fit loosely within the prepared canal shape so that the movement of the irrigant around the tip is uninhibited and the tip can vibrate freely. Once inserted, the power is activated and the violent movement of the irrigant “scrubs” the walls of the canal thereby implying the effective removal of dentine debris, micro-organisms (biofilm and planktonic bacteria) and organic tissue from the root canal (van der Sluis 2007).

The technique requires that the NaOCl irrigant is delivered in...
The current trend in surgical techniques is to offer minimally - or even non-invasive protocols. By using an operating microscope together with high-tech micro-instruments, it is now possible to treat the entire root canal.

The irrigant effect is amplified not only by the heating effect during non-surgical endodontic treatment and a complete compatibility with sodium hypochlorite, versus nickel-titanium ultrasonic wires. The tip has been designed as a solution for the problems most often encountered during non-surgical endodontic treatments. The new titanium-niobium alloy allows optimum use of ultrasound in the trickiest situations.

The test model is inserted and activated 3ml boli via a syringe fitted with a side vented needle and then IrriSafe® is inserted and activated for 20 seconds. This is repeated three times. In oval canals the tip can be moved towards the walls (avoiding contact dampening) to encourage fluid movement into these areas.

Ideally EDTA liquid is then inserted and agitated for a further 20 seconds before a final flush of NaOCl is performed.

The canal(s) can then be dried and obturation carried out according to preference.

The results of the study
The mean percentage change in cross-sectional area and diameter in descending order were: Group 2 - 52.7 per cent and 26.2 per cent; Group 5 - 42.6 per cent and 25.8 per cent; Group 4 - 25.2 per cent and 9.4 per cent; Group 3 - 14.6 per cent and 5.1 per cent; Group 1 - 6.5 per cent and 3.8 per cent. Linear regression analysis of the data from Groups 1, 2 and 4 revealed that canal dimensions were significantly affected by irrigant regime (p=0.0001), corono-apical level (p=0.009) and duration of irrigant agitation (p=0.0001). Analysis of the data from Groups 5, 4 and 5 revealed that both corono-apical level (p=0.009) and duration of agitation of the irrigant (p=0.0001) significantly affected the increase in canal dimensions.

Conclusions: The test model established that there is a clinically insignificant change in root canal dimensions when manufacturer’s instructions were followed (Group 4). Irrigant choice and combination, duration of agitation and corono-apical level all had a significant effect on the dimensions of the artificial root canal.