# The oval shaped root canal: a clinical review

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## ABSTRACT

One of the main objectives of endodontic treatment is the thorough preparation of the root canal system and proper obturation for obtaining a three-dimensional seal. To achieve this goal, clinicians must have a comprehensive knowledge of the normal anatomy of the relevant root canal system and its common variations. Cross-sectional root canal configurations have been classified as round, oval, long oval, flattened, or irregular. The oval shaped canals should have a different approach regarding management compared with normal root canal configurations. The recognition of oval configurations determines that a different approach be applied in cleaning, shaping and obturation. Because of the importance of executing a suitable treatment option for oval shaped canals, a comprehensive review of published information is vital. The aim of this study was to address the definition, prevalence, and treatment protocols for oval shaped canals.

**Key words:** Oval shaped canal, anatomy, endodontics.

## INTRODUCTION

One of the main objectives of root canal treatment is the thorough chemical/mechanical debridement of the root canal system and its complete obturation with a suitable material. A proper coronal restoration is vital to prevent coronal ingress of microorganisms and their byproducts.[1] To achieve this goal, clinicians must have adequate knowledge regarding normal root canal anatomy of the relevant tooth and its common variations.[2,3]

Adequate mechanical instrumentation is required in addition to effective irrigation to achieve sufficient disinfection during endodontic treatment.[4,5] It has been shown that mechanical instrumentation techniques alone leave large amounts of the canal wall un-instrumented.[6] Bartha *et al.* (2006)[7] as well as Weiger *et al.* (2006)[8] concluded that, in order to overcome this limitation, the size of the apical preparation should be increased. Although this approach will remove more contaminated dentine and allow better penetration of irrigants into the apical region, it will also predispose the root canal to a risk of stripping, transportation and the tooth itself to weakening.[9]

The intrinsic anatomy of the root canal system creates further challenges, emphasizing the necessity of proper disinfection measures. Isthmuses, inter-canal communications, curvatures and oval shaped canals can make disinfection a considerable challenge.[10] Oval shaped canals pose may questions to the operator during the instrumentation and obturation phase of root canal treatment. The purpose of this literature review was to emphasize the different aspects of the anatomy, instrumentation and obturation of oval shaped canals.

## ACRONYMS

**AET:** Anatomic Endodontic Technology
**SAF:** Self Adjusting File

### Definition of oval shaped root canal

Cross-sectional root canal configurations have been classified as round, oval, long oval, flattened or irregular.[11] Metrically, Jou *et al.* (2004)[11] defined ''oval'' as having a maximum diameter of up to two times greater than the minimum diameter and ''long oval'' as having a maximum diameter of two to four times greater than the minimum diameter. A cross-section of a mandibular canine with an oval shaped canal is shown in Figure 1.

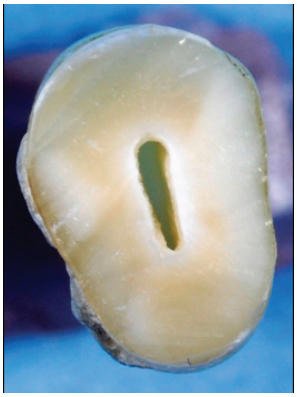

**Figure 1:** Cross-section of a mandibular canine with an oval shaped canal

### Prevalence

A high prevalence of oval and long oval root canals (even in the apical area) has been reported (Table 1).[12-15] According to Wu *et al.* (2000),[12] long oval canals occur in the apical portion in about 25% of cases. In some groups of teeth such as mandibular incisors and maxillary second premolars, however, the prevalence

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**Table 1:** Prevalence of oval shaped canals

| Author(s)/ Year | Tooth type | Population | Prevalence | Method of study |
|---|---|---|---|---|
| Mauger *et al*. (1998)[14] | 100 mandibular incisors | Not applicable | 42% | Apex resection at 20-degree facial bevel |
| Gani and Visvisian (1999)[15] | 40 first maxillary molars | Argentina | 32.5% in mesiobuccal and palatal canals<br>10% in mesiopalatal canal<br>20% in distobuccal canal | Cross sectioning |
| Wu *et al*. (2000)[12] | 180 extracted human teeth, 20 for each tooth group | Not applicable | 25% | Horizontal sectioning |
| Marroquin *et al*. (2004)[13] | 523 maxillary and 574 mandibular molars | Egypt | Varied | Computer-aided stereomicroscope |

is greater than 50%. In the distal roots of mandibular molars, the prevalence is 25-30%. This complex anatomy may be regarded as one of the major challenges in the endeavour to achieve proper debridement through root canal instrumentation.

Marroquin *et al*. (2004)[13] investigated the apical anatomy of 523 maxillary and 574 mandibular molars from an Egyptian population, using computer-aided stereomicroscopy. The findings showed that the most common physiological foramen shape was oval (70%). The mean of the narrow and wide physiological foramen diameters in mandibular molars was 0.20–0.26 mm respectively, 0.18–0.25 mm in the mesiobuccal and distobuccal canals of maxillary molars and 0.22–0.29 mm in maxillary palatal canals. Findings also revealed a high percentage of two physiological foramina in the mesial roots of the mandibular and in the mesiobuccal roots of the maxillary first molars. In another study, the apical diameters of the roots of the maxillary first molar were observed and were recorded as mostly oval in shape.[14]

Mauger *et al*. (1998)[15] showed that after resecting the apices of mandibular incisors at a 20-degree facial bevel, the average facio-lingual diameter of canals was 0.75 mm at a distance of 3 mm from the apex. They found that oval canals contributed 42% and long oval canals 40% towards the findings of the study. It can be speculated that most canals of mandibular incisors are not round in shape.

## Instrumentation techniques

Proper instrumentation of root canals and complete debridement is one of the primary objectives in endodontics.[16] However, it is rarely fully achieved due to anatomic variations in the root canal system, such oval shaped canals.[17] Long oval canals can create even more challenges during cleaning/shaping and obturation.

Different instrumentation techniques have been described to prepare oval canals. These include the use of sonic and ultrasonic instruments[18], manual instrumentation[19] or the use of rotary nickel-titanium (Ni-Ti) instrumentation techniques[20,21] and finally reciprocating instrumentation techniques.[22,23] None, however, has been shown to completely clean and shape the root canal and to maintain the oval shape outline form. In these canals, most rotary Ni-Ti instrumentation techniques as well as manual instrumentation operated in modified reaming actions (e.g., balanced force and quarter-turn techniques), will lead to deviation from the original oval shape showing key-hole, dumbbell-shaped, or central bulge effects.[24] It has been claimed that files used circumferentially in a reciprocating hand-piece improved the preparation of the oval coronal-middle part of the root canal.[25]

## Instrument design

The cutting efficiency and cleaning ability of root canal instruments are dependent on the particular instrument design as well as the dynamics used during instrumentation. In this respect, there are some differences amongst the configurations of the instruments.[28] Instruments having a non-square cross-section are generally more efficient during cleaning and shaping than those having a square cross-sectional design.[26,28,29]

## New rotary instrumentation methods

### Anatomic Endodontic Technology (AET)

AET (Ultra Dent Products Inc., South Jordan, UT, USA) has been designed in an effort to maintain the original shape of the canal during instrumentation. It has been claimed that the intention is to minimize the number of instruments required for preparation of the canals. The system consists of a new generation of flexible stainless-steel instruments, disposable syringes and 30-gauge needle tips.[26-28] The AET files have a square cross-sectional design similar to hand files.

The Shaping files have been designed to prepare the bulk of the canal to within 3–4 mm of total working length. They are operated using a 4:1 speed reduction hand-piece with a 30 degrees clockwise/anti-clockwise milling-type cutting action, like the M4 reciprocating hand-piece. The Apical files remove debris only at the tip and must be used manually to prepare the apical portion of the canal.[25,26]

These instruments are more rigid compared with Ni-Ti rotary instruments. The use of stainless-steel (SS) instruments in this type of motion is more efficient in maintaining the contour of the oval shaped canal. This technique also results in a larger preparation shape allowing an increased exposure of the canal walls to irrigants. In contrast, Ni-Ti instruments operate only in rotary motion and without applied buccal/lingual pressure, and the result is partial removal of tooth structure with un-instrumented areas on the opposing root canal walls.[25,26]

Zmener *et al*. (2005)[27] showed that canals shaped with AET had lower debris and smear layer scores compared with canals prepared using the ProFile system (Dentsply, PA, USA) or with manual preparation techniques. The results of this particular study concluded that better instrumentation scores may be obtained in canals prepared with AET; however, complete cleanliness could not be achieved with any of the investigated techniques.

Another important fact to consider is that efficient debridement of the root canal system depends on more than just the type of instrument or the instrumentation technique. In order to remove debris and smear layer more effectively, chemical irrigation is recommended in conjunction with mechanical preparation.[29-31]

**Self adjusting files**

The Self Adjusting File (SAF) (ReDent-Nova, Raanana, Israel) has been introduced in an effort to eliminate some of the limitations of Ni-Ti instruments. It is a unique, hollow, flexible instrument designed as a compressible thin-walled pointed cylinder. It is claimed that the flexibility and the compressibility allow the instrument to conform to the canal shape (both longitudinally and cross-sectionally) providing a three-dimensional adaptation.[32,33] The instrument is operated using a reciprocating, vibrating handpiece. The hollow design allows for a continuous delivery of irrigant solutions. A recent study showed that the percentage of root canal area affected by the SAF system is greater compared with other popular rotary systems.[34] Another study showed that the SAF system resulted in canal walls free of debris and with no visible smear layer.[35] Conclusively, the SAF system shows great potential and may be advantageous in promoting disinfection of oval shaped canals.

Siqueira *et al*. (2010)[10] conducted an *in vitro* study and compared the efficacy of the SAF system with that of rotary instruments in the effort to eliminate Enterococcus faecalis from long oval canals. The SAF proved to be significantly more effective in the disinfection of long oval canals compared with rotary instruments and traditional syringe/needle irrigation. Another *in vitro* study of long oval canals proved that the SAF system promoted a significant reduction in bacterial populations regardless of the NaOCl concentration. The most conclusive results were obtained after six minutes of operation with the SAF system.[36] According to De-Deus *et al*. (2012)[37], preparation of flat oval canals with the SAF system led to a significantly higher percentage of gutta-percha-filled areas compared with canals prepared with the ProTaper system (Dentsply, OK, USA) (syringe/needle irrigation). Another study by Ruckman *et al*. (2013)[38] compared the ability of SAF in the debridement of long oval shaped canals of SAF with that of ProFile and hand instrumentation techniques. The authors concluded that all three techniques removed similar amounts of contrast medium from the apical part of these canals. Further studies by de Melo Ribeiro *et al*. (2013)[39] showed that the SAF instrument achieved significantly more contact with the dentine walls compared with traditional rotary systems (K3; SybronEndo, West Collins, CA, USA). The results showed that more debris was removed by SAF in the apical third of mandibular incisors with oval shaped canals in contrast with the traditional rotary systems.

**F2 ProTaper instrument**

Yared (2008)[40] proposed a new preparation technique using only the F2 ProTaper instrument in a reciprocating movement. The use of a single Ni-Ti instrument could be beneficial and might be more cost-effective than conventional rotary systems. Although the first clinical experiment of this technique appeared promising, other important parameters still need to be properly assessed with further research. When the system was tested in oval shaped canals, De-Deus *et al*. (2010)[41] observed that the single file F2 ProTaper technique displayed the poorest debridement quality.

**Single file systems**

WaveOne (Dentsply Maillefer, Ballaigues, Switzerland) and Reciproc (VDW, Munich, Germany) may be appropriate for preparation of the oval shaped canals; however, Versiani *et al*. (2013)[42] concluded that neither of these technique was capable of completely preparing the oval shaped canals, whilst Topcu *et al*. (2014)[43] showed that these systems are not efficient in debridement of the oval shaped canals.

## Obturation

Obturation of irregularly-shaped canals is more challenging compared with canals with a round cross section. In endodontics, lateral condensation does not result in a reliable outcome for complete obturation of un-instrumented areas.[44] Thermoplastic techniques may be equivalent to or better than the lateral condensation technique and less dependent on the canal shape than lateral condensation.[45,46] Root canals prepared using rotary systems may be obturated with a single cone of the same size and matched taper as the final instrument used for debridement. Although this technique offers little possibility for filling irregularities within the canal, the outcome in simulated canals and extracted teeth has been comparable with results obtained with the lateral condensation technique.[47]

De-Deus *et al*. (2008)[48] found that the gutta-percha filled areas in oval shaped canals after obturation was significantly higher for thermo-plasticized techniques compared with lateral condensation techniques. Ozawa *et al*. (2009)[49] compared different obturation techniques (single cone, lateral condensation technique, and Thermafil) in oval shaped canals. They found that in the middle and coronal thirds of the canal, Thermafil had the lowest percentage of sealer with the highest volume of filling material.In the apical third, the filling material was well adapted to the canal walls for all tested techniques. Another study by Moeller *et al*. (2013)[50] showed that there was no significant difference in the percentage occurrence of voids between the lateral condensation technique and the hybrid technique (a combination of a gutta-percha master point and thermoplastic gutta-percha).

## Post space preparation

Post space preparation in an endodontically treated tooth with oval shaped canal(s) presents possible complications. In these canals, the risk of leaving un-instrumented areas is high due to the fact that the circular section of an endodontic instrument does not allow for adequate shaping of the root canal walls.[51] To prepare a suitable post space, various drills have commonly been used for removing filling material, and as result of their actions, a smear layer is created within the post space.[52,53] The circular section of these drills hampers a direct cutting action on all the root canal walls in oval shaped canals, thus leaving large portions un-instrumented and still covered by filling materials and/or debris. This leads to lower dentine surface accessibility for adhesive bonding and cementation of fibre posts, resulting in increased risk of post dislodgment and further fractures.[54]

Oval fibre posts also have been introduced, resulting in a reduction of the thickness of resin cements and increased post retention strength as they adapt to the oval form of

the canals.[55,56] Other potential advantages of these posts are: better open dentine tubule scores and increased adhesion.[55] Instead of using rotary instruments for post space preparation, a minimally invasive diamond coated ultrasonic tip may be used for preparation of the space for the oval fibre post.[56]

However, Coniglio *et al*. (2011)[55] showed that the use of circular and oval posts achieved similar retentive strengths in oval shaped canals, while Muñoz *et al*. (2011)[57] revealed that they showed no differences in adaptation to the canals. The latter study also showed that the cement thickness around oval posts is significantly lower than around circular posts. Scotti *et al*. (2014)[58] in an *ex vivo* study evaluated the bond strength and adaptation of fibre posts (with oval and circular cross sections) luted in prepared post spaces in oval canals. They concluded that fibre posts, both round and oval in shape, are better adapted to the apical portion of the prepared post space region. In oval shaped canals, the bond strength was significantly higher in coronal portions when a dedicated drill was used to prepare the post space and an oval post was cemented. According to Krastl *et al*. (2014)[59] oval posts did not increase fracture resistance of oval shaped canals compared with circular posts. Er *et al*. (2013)[60] revealed that circular fibre posts created more stress on oval shaped canals compared with oval fibre posts.

### Retreatment of oval shaped canals

Retreatment of root filled teeth requires complete removal of the existing filling material as well as a repeat mechanical preparation, cleaning and filling of the affected canals.[61] Zmener *et al*. (2006)[62] used an *ex vivo* study to compare the efficacy of the ProFile system, AET and manually manipulated Hedstrom files in the removal of gutta-percha and sealer from oval shaped canals. The study concluded that all techniques are suitable for the removal of filling materials in these canals, but completely clean canal walls could not be achieved with any of the tested techniques. The mean percentage of remaining gutta-percha and sealer was significantly higher for the ProFile system in the coronal and middle thirds. However, in the apical third, there was no significant difference between the three methods. In another study, Keles *et al*. (2014)[63] showed that the additional use of the SAF system after a retreatment procedure with rotary systems improved the removal of filling materials.

## CONCLUSIONS AND RECOMMENDATIONS

A high prevalence of oval root canals has been reported. These canals create great challenges during the instrumentation and obturation phases of root canal treatment. Files used circumferentially in a reciprocating hand-piece improve the preparation of the oval coronal-middle part of the root canal. Non-square cross-sectional designed instruments are generally more efficient during cleaning and shaping than a square cross-sectional design. For obturation of these canals, thermoplastic techniques may be equivalent to or better than the lateral condensation technique and less dependent on the canal shape than lateral condensation. The ProFile system, AET and manual removal of gutta-percha and sealer with Hedstrom files are suitable for the removal of filling materials in retreatment of these canals.

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