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REVIEW ARTICLE

APICAL PREPARATION SIZE IN ENDODONTICS: A REVIEW

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ABSTRACT

Bacteria and their products are the major etiologic factors in endodontic treatment. Therefore, reduction of bacterial contamination is the main aim of endodontic treatment. The goal will be reached with an appropriate chemo-mechanical preparation along with preservation of as much of tooth structure as possible. The apical limit of root canal instrumentation and obturation is one of the major controversial issues in root canal therapy. So this article provides an overview of importance of anatomy of apex and current concepts regarding the apical preparation size for individual tooth.

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INTRODUCTION

The aim of endodontic treatment is to eliminate microorganism from the root canal system and prevention of reinfection. To achieve this objective, root canals were cleaned before filling using mechanical instrumentation, supplemented with irrigants and intracanal medication (Srikanth *et al*., 2015). Enlargement of the apical area has been advocated to ensure an adequate depth of penetration of the irrigants for better cleansing. However, the extent of apical enlargement required is a matter of debate. Preparation to larger apical size has been suggested by its protagonists to be the most efficacious way of cleaning and disinfecting the canals. Larger apical preparations allow better removal of infected dentin, enhance the flushing action of irrigants in the apical region, and significantly reduce the bacterial load in the canal system (Khademi *et al*., 2006).

Anatomy of root apex: The classic concept of apical root anatomy is based on three anatomic and histologic landmarks in the apical region of a root: the Apical Constriction (AC), the Cementodentinal junction (CDJ), and the Apical Foramen (AF). Kuttler's description of the anatomy of the root apex has the root canal tapering from the canal orifice to the AC, which generally is 0.5 to 1.5 mm inside the AF (Akashi Chaudhari *et al*., 2014) (Figure 1).

Apical constriction: The AC generally is considered the part of the root canal with the smallest diameter; it is also the reference point clinicians use most often as the apical termination for shaping, cleaning, and obturation. The distance between the AC and the AF ranged between 0.4-1.2 mm, while its reported location in relation to the root apex ranged between 0.5-1.01 mm (Akashi Chaudhari *et al*., 2014).

Significance: Repeated instrumentation extending beyond the constriction is unwarranted. It causes peri-radicular inflammation and often destroys the biologic constriction of the root apex. Although same, perforations of the floor of the nose, maxillary sinus or mandibular canal as a result of excessive over extension of instruments can lead to severe post treatment pain, delayed healing and ultimate failure.

Cementodentinal junction: The CDJ is defined as the point in the canal where cementum meets dentin; it is the point where pulp tissue ends and periodontal tissues begin. The location of the CDJ in the root canal varies considerably. The location of CDJ generally not in the same area as the AC, and estimates place it approximately 1 mm from the AF (Akashi Chaudhari *et al*., 2014).

Significance: The significance of the Cementodentinal Junction lies in its implication by a number of investigators as the precise region to which the root canal should be filled. Kuttler (1955) claimed that the distance between the CDJ and the apical foramen averaged 0.507mm in young people and 0.784mm in older people, thereby enabling the clinician to measure more precisely the distance to which the root filling should extend (Dean Baugh and James Wallace, 2005).

Apical foramen: It is defined as an aperture at or near the apex of root through which the blood vessels and nerves of the pulp enter or leave the pulp cavity (Akashi Chaudhari *et al*., 1994). The average distance between the AF and the root apex was found to be less than 1 mm.AF deviation has been associated with aging and deposition of cementum (Table 1) (Morfis *et al*., 1994).

Apical patency: According to American Association of Endodontics glossary, Patency is defined as "a canal preparation technique where the apical portion of the canal is maintained free of debris by recapitulation with a small file through the apical foramen". Buchanan defines a patency file as a small flexible K-file, which is passively moved through the apical constriction 0.5–1mm beyond the minor diameter, without widening it (Khatavkar Roheet and Hegde Vivek, 2010).

Importance of apical patency: Apical patency as mentioned merely refers to the passage of a small instrument beyond the confines of the root in an effort to prevent blockage of the foramen as a result of the dentin debris formation during root canal therapy. This procedure ensures a biologic cleansing of the apical most regions by allowing the flow of irrigants and finally the obturation material (sealer) (Khatavkar Roheet and Hegde Vivek, 2010).

Use of patency filing has a number of advantages. They are as follows: Establishment and Maintenance of Glide path, Provides the clinician with knowledge of the anatomy of the apical root curvature, Facilitates Length Determination, To improve the efficiency of irrigation at the apical 3rd level, Minimizes apical blockage and loss of length, Reduced chances of Accidental errors, Decreased Post-operative sensitivity, Mechanical disruption of Biofilms, Relieves apical pressure, Allows for obturation to apical foramen.

Apical clearance: The use of smaller diameter files results in virtually no contact of the instrument with the canal walls. Hence the concept of 'Apical Clearing' or 'Clearing of the apical foramen' was introduced. This procedure involved determination of the 'Working Width' i.e. estimation of the file that binds at working length.

Working Width: Apical width or working width is the term said for the size of the preparation to which the apical portion of the canal should be enlarged (Tapish Garg and Meenu Garg, 2013).

Working length estimation: Different working lengths have been proposed, but the most widely accepted approach seems to be choosing a working length of 1 mm coronal to the root apex. According to these concepts, the cemental canal should not be instrumented. The major concern during root canal therapy of teeth with vital pulp has been to preserve the vitality of the pulp stump.

For this reason, several authors have recommended that the working length should be determined 1-2 mm short of the radiographic root apex. Kuttler stated that all root canal procedures should terminate 0.5 mm short of the AF, as this point is considered to be the nearest to the AC. To remain close to the AC, a range of 0.5–1.5 mm short of the radiographic apex was recommended as an appropriate working length depending on the specific root being treated (Akashi Chaudhari *et al*., 2014).

Weine Modification: If radiographically there is no resorption of root end or bone, shorten the length by the standard 1mm. If periradicular bone resorption is apparent, shorten by 1.5mm, and if both root and bone resorption apparent, shorten by 2mm (Akashi Chaudhari *et al*., 2014) (Figure 2).

Terminologies

Apical Scouting: Process of determining the anatomy and cross-section diameter of apical 1/3 rd of root canal. Fine instrument sizes such as # 8, # 10, and # 15 can be used for apical scouting (Tapish Garg and Meenu Garg, 2013).

Apical Gauging: Process of determining the most apical cross-sectional diameter of the canal where a hand or rotary endodontic instrument fits snugly at the terminus and resists any further apical travel (Tapish Garg and Meenu Garg, 2013).

Apical Tunning: Apical tunning is the process to confirm that the diameter of the master apical file (MAF) represents the true size of the foramen (Tapish Garg and Meenu Garg, 2013).

Optimal apical preparation: Despite the findings of many studies that recommend canal preparation with files larger than #30/35 for better penetration of irrigants and elimination of bacteria during cleaning and shaping, Weiger *et al* found that apical instrumentation to a #30 size file with 0.06 coronal taper is effective for the removal of debris and smear layer from the apical portion of root canals (Roland Weiger *et al*., 2006).

Master apical file size: -smaller or larger: Wu *et al*. (2002) reported that the first file to bind in the apical root canal system did not necessarily reflect the true canal diameter at the proposed working length because the apical anatomy is often irregularly shaped and not a round configuration. Despite much interest and research in this area, master apical file sizes remains a controversial topic. Systematic review may be divided into three schools of thought: (1) the investigators who suggested apical enlargement significantly reduced microbial flora (Ørstavik *et al*. 1991, Dalton*et al*. 1998, Shuping *et al*. 2000, McGurkin-Smith*et al*. 2005); the investigators who suggested apical enlargement had no significant effect in microbial reduction (Yared and Bou Dagher 1994, Nair *et al*., 2005). Strindberg (1956) Kerekes and Tronstad (1979) advocated a higher healing rate where the master apical file size was kept as small as possible. Wu *et al*. (2000) reported that enlargement of the apical root canal system did not ensure removal of the inner layer of dentine from all apical root canal walls or all infected necrotic pulp tissue also Bier *et al*. (2009) reported potential fracturing of teeth instrumented to sizes above 40 (Aminoshariae and Kulild, 2015).

Current concept: Ideally, the minimum size to which a root canal should be enlarged cannot be standardized and varies from case to case.

Table 1. Size of main apical foramina (5)

Teeth	Mean values (U)
Maxillary incisors	289.4
Mandibular incisors	262.5
Maxillary premolars	210
Mandibular premolars	268.25
Maxillary Molars	
Palatal	298
Mesiobuccal	235.05
Distal	232.2
Mandibular Molars	
Mesial	257.5
Distal	392

Table 2. The recommended master apical file sizes are given as follows: (11)

Tooth type	Maxillary	Mandibular
Central incisors	50-70	25-40
lateral incisors	45-60	25-40
Canines	45-60	30-50
Premolars	25-40	30-50
Molars		
•Mesiobuccal	25-40	25-40
•Distobuccal/Mesiolingual	25-40	25-40
•Palatal / distal	30-50	25-40

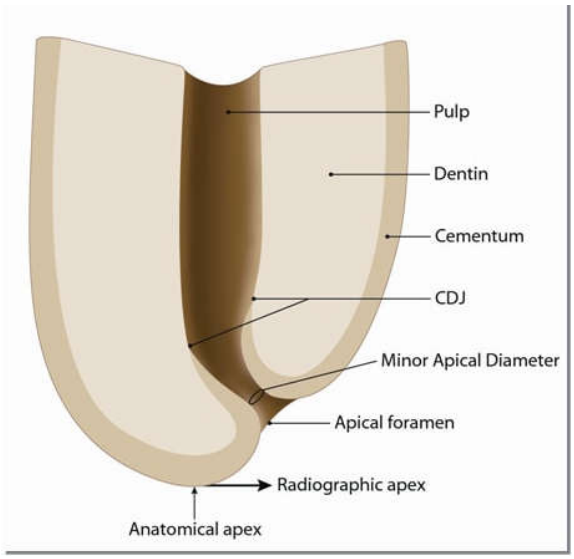

Figure 1. Schematic diagram showing anatomic features of root apex

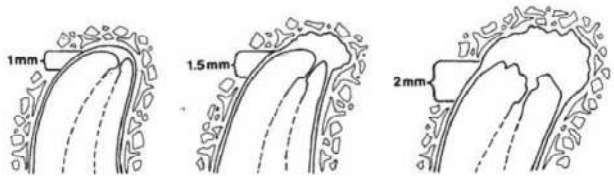

Figure 2. Weins modifications

The factors that should be taken into consideration before deciding the optimum size of enlargement at working length are as follows

- Initial canal width has to be assessed both clinically and radiographically. The canal of narrow tooth, such as a mandibular incisor, cannot be enlarged as much as the canal of a mandibular canine.
- Whether root canal is vital, calcified or infected.
- Presence or absence of periradicular pathology/ resorption.
- Radius of canal curvature which make the shaping procedure more difficult.
- Canal configuration with more attention to be given to complex anatomies like a C-shaped canal and isthmus region (Louis, 2014).
- Most commonly employed recommendations for Nickel-Titanium greater tapered files in shaping canals of posterior teeth: (Table 2)
- Master Apical File size 25 with 8% tapered instruments
- Master Apical File size 30 with 6% tapered instruments
- Master Apical File size 40 with 4% tapered instruments (Dean Baugh and James Wallace, 2005).

Role of apical instrumentation: Guidelines or standards for apical preparation were introduced by Weine. He advocated enlarging the apical part of the root canal to three sizes larger than where the first file bound. Buchanan he proposed that enlarging the canal size would cause apical transportation or zips. The literature has shown that root canal systems need to be enlarged sufficiently to remove debris and to allow proper irrigation to the apical third of the canal. Berg advocated grossly tapered preparations to prevent extrusion of guttapercha. Ram concluded that canals need to be enlarged to a #40 file size so that maximum irrigation is in contact with the apical debris (Dean Baugh and James Wallace, 2005).

Reduction of intracanal bacteria: An appropriate apical sizing method can help the operator avoid unnecessary enlargement of the apex whereas predictably reducing intracanal debris (Coldero and McHugh, 2002). Hsiehel *et al*. (2007) and Boutsioukis *et al*. (2010) reported that Enlargement to size 30 allows effective replacement 2mm apical to an open-ended needle when combined with at least a 0.06 taper while size 35 combined with a 0.05 to 0.06 taper leads to significant irrigants refreshment almost 3mm apical to the needle tip and effective removal smear layer from apical region (Coldero and McHugh, 2002).

Minimum size for penetration of an irrigant

- Penetration of an irrigant into the instrumented root canal system is a function of the irrigant needle diameter in relation to the preparation size.
- Studies have shown that the canal size along with the diameter of the irrigating needle and the depths of its penetration significantly affect the removal of debris from the root canal system.
- The apical penetration of the irrigants is only 1 mm beyond the needle tip.
- It is pertinent to note here that when used a 27-G needle for irrigation whose external diameter corresponds to an ISO 40 file and hence can penetrate to 1 to 2 mm short of the apex only in canals enlarged with the step-back technique to a minimum apical size of 30.
- Thus, a minimum enlargement to size 30 must have been necessary for adequate penetration of the needle into the canal to ensure optimal cleaning of the apical region (Coldero and McHugh, 2002).

Apical preparation size in relation with new irrigating devices

Photon Initiated Photo acoustic Streaming: Lloyd *et al*. (2013) showed that laser-activated irrigation using PIPS tips

eliminated organic debris from canal isthmus at a significantly greater level compared with standard needle irrigation. The PIPS tip does not need to reach the canal terminus, and it is placed into the coronal reservoir only of the root canal. Therefore, this technique allows for minimally invasive preparation of the root canal (Haken Arslan et al., 2014).

Ultrasonic Irrigation: An ultrasonic device converts electrical energy into ultrasonic waves of a certain frequency by magnetostriction or by piezoelectricity; frequency of the oscillating instrument is fixed at 24 kHz and 30 kHz (Haken Arslan et al., 2014; Van Der Sluis, 2007). Lee *et al*. (2004a) and van der Sluis *et al*. concluded that within certain limits (size 20, taper 0.04 to size 20, taper 0.10) the greater the taper the more dentine debris can be removed (Van Der Sluis, 2007).

Ozone Irrigation: Ozone acts as a super-oxygenator, bringing oxygen to tissues and assisting the body in its natural healing process. Different instruments for delivering of ozone are Product photo (Prozone), the ozotop, OzoTop safety**.** This instruments use combination of ultrasonically-agitated and heated sodium hypochlorite, alternated with EDTA (Smear Clear), and Sterilox to chemically clean the canals (Shiva Gupta and Deepa, 2016; Subiksha, 2016).

Ozone Nano bubble water: As the half-life of ozonated water is about 20 min only because of which it degrades back into oxygen, hence its potency must be assured by using it within first 5–10 min after production. To overcome such a problem CHIBA and TAKAHASHI developed ozone Nano bubble water in 2008 (Alan Holland, 2010).

Apical preparation size for curved canals: It has been demonstrated that cleaning of the root canal is not always easily accomplished, especially during the preparation of narrow and curved canals. Enlargement with stainless steel hand instruments larger than size 30 in mesial canals of mandibular molars will most likely lead to a high frequency of procedural errors, such as ledging, canal straightening, zipping, apical transportation and strip perforations. This is because most mesial roots of mandibular molars demonstrate curvature in both mesio-distal and buccolingual directions (Cunningham and Senia1992), and the dentine thickness is narrowest in the apical third region (Gani and Visvisian1999). Large instruments are less flexible and, therefore, does not stay centered in the canal, especially in curve ones. This results in the unnecessary removal of dentin on one side of the canal, leaving untouched dentin on the other side (Abbasali Khademi and Mohammad Yazdizadeh, 2006).

Conclusion

Our ultimate goal should be to preserve as much tooth structure as possible without compromising disinfection and eradication of bacteria from the root canal system. This means enlarging the canal to the smallest size and taper possible that will still allow for sufficient volume of irrigant. According to many studies we concluded that the apical instrumentation up to #30 file with 0.06 taper is effective for the removal of smear layer from the apical portion of root canal. It appears unnecessary to remove dentine in the apical part of the root canal when a suitable coronal taper is achieved. But in case of curved canals, increased apical enlargement did not result in a complete apical preparation, whereas it leads to the unnecessary removal of dentin.

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