Original Article

Relation between Apical Seal and Apical Preparation Diameter: An In Vitro Study

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Background: The current recommendations for the apical preparation diameter, one of the most important mechanical imperatives in the apical third preparation, are to preserve the apical foramen in its original position along with its narrowest diameter to avoid any complication such as tearing, zipping, or transport of the foramen. The aim of our study was to see the correlation between apical seal and apical preparation diameter. Materials and Methods: In total, 90 extracted maxillary incisors were randomly allocated into three groups of 30 teeth each according to the apical preparation size: Group 1: finishing file F1 corresponding to size 20 reached the working length, Group 2: prepared up to size 30 corresponding to finishing file F3, and Group 3: prepared up to size 50 corresponding to finishing file F5. After the filling of the root canals, the teeth were isolated and immersed in a dye solution, then cut longitudinally, photographed, and the dye penetration were calculated using a computer software. Results: Comparison of the three different apical preparation sizes showed no statistically significant differences regarding the apical microleakage. Conclusion: The most important value of the dye penetration was observed in the group with the largest apical diameter. Keywords: Apical foramen, apical preparation diameter, apical seal

INTRODUCTION

The scientific and biological pillar of endodontics is well rooted and highlights the dominant role of microorganisms in the initiation, development, and persistence of periapical disease and apical periodontitis.¹⁻⁵ Therefore, the main principles for successful root canal treatment (RCT) are the prevention of oral flora and toxins from entering through the root canal system into the periapical tissues. This is obtained by obturating the root canal system completely, including the coronal and apical seal.⁶⁻⁸ Inadequate obturation techniques of the root canal system have been found to be the most frequent reason of failure post RCT.⁹ The apical constriction (AC) is an anatomical and morphologic landmark that helps to improve the apical seal when the canal is obturated.¹⁰⁻¹² When the apical foramen is located through apex locator, the correct position of the AC can be estimated. The preparation and obturation are always within the confines of the root.

The three-dimensional and hermetical apical seal increases the tooth life. Studies have shown that there exists a relationship between the apical preparation diameter and the apical sealing. Thus, it is important to understand that is to check which apical limit and which apical diameter size should we choose.¹³⁻¹⁸ Distance between minor and major diameter of the root has been found to be a mean of 0.5 mm in the age group of 25 years and a mean of 0.65 mm in the age group of 55 years.

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Anatomical studies of the apical third of the root canal have shown that the apical foramen matches with root vertex in only 17%–46% of patients. The current recommendations for the apical preparation diameter [Figure 1], one of the most important mechanical imperatives in the apical third preparation, are to preserve the apical foramen in its original position along with its narrowest diameter to avoid any complication such as tearing, zipping, or transport of the foramen. Thus, the aim of our study was to see the correlation between apical seal and apical preparation diameter.

**Materials and Methods**

Freshly extracted 90 central incisors were selected and they were randomly allocated into three experimental groups of 30 teeth each.

Group 1: Canals were prepared up to size 20 corresponding by Coltene HyFlex rotary system (South Carolina, USA) coinciding F1.

Group 2: Canals were prepared up to size 30 by Coltene HyFlex rotary system coinciding F3.

Group 3: Canals were prepared up to size 50 by Coltene HyFlex rotary system coinciding F5.

The endodontic access cavities were prepared by high-speed diamond burs and all root canals were instrumented by the same endodontist. Patency of each canal was established by gently passing an 8 k-file, and the working length was determined using a 10 k-file (Mani Files) into the canal until it became visible through the apical foramen, and then 1 mm was subtracted. The canals were instrumented using the Crown–Down technique with Coltene HyFlex rotary system files up to the apical size of the F1 finishing file, and F3 or F5 to increase the apical diameter. Then the canals were irrigated with 5.25% sodium hypochlorite (NaOCl). The master-cone adjustment was carried out by the tug-back test. Thereafter, the root canal filling was performed using the cold lateral condensation technique. To ensure that all specimens were of the same length, they were cut 17 mm from the apex using a diamond bur. Two layers of acrylic paint were applied to the root surface, except for the apical 2 mm that remained exposed. Specimens were then immersed for 2 days in 1% methylene blue. After removal, the roots were cut longitudinally following the principal axis of the tooth root. The roots were then photographed using a smartphone. Student’s *t* test was used to assess the results statistically.

**Results**

In the positive control group, specimens showed maximum microleakage:

- Group 1: Revealed a dye leakage variable between 0 and 2.7 mm with an average of 1.0450 (±0.9267)
- Group 2: Revealed a dye leakage variable between 0 and 5 mm with an average of 1.4237 (±1.1348)
- Group 3: Revealed a dye leakage variable between 0.6 and 9.4 mm with an average of 2.6787 (±2.2783)

*P* > 0.05 means that there are no significant differences in the apical leakage between the three different apical preparation sizes (20, 30, and 50 also coinciding F1, F3, and F5). Calculation of dye penetration depths in the three experimental groups showed same in all groups in Figure 2. The average, variance, and standard deviation for all three experimental groups are shown in Table 1. Comparison of the three different apical preparation sizes showed no statistically significant differences regarding the apical microleakage. Comparison of the three different apical preparation sizes showed no statistically significant differences regarding the apical microleakage.

**Discussion**

Research has shown that if the apical root canal has a round shape, then the chances are that the first file that binds reflects the diameter of the apical canal;
Table 1: Average, variance, and standard deviation for all three experimental groups

| Group | Average (mm) | Standard deviation |
|-------|--------------|--------------------|
| F1    | 1.0450       | ±0.9267            |
| F3    | 1.4237       | ±1.1348            |
| F5    | 2.6787       | ±2.2783            |

However, many apical root canals are oval and indeed, where the first file does not bind and does not reflect the apical diameter.[18-22] A review of the literature disclosed several articles that the dimension varies tremendously within the canal. Kuttler’s[19] classic study showed apical diameter dimensions for teeth from patients 20 years and younger and 60 years and older. Green’s[23] study reported the AC sizes for maxillary first bicuspids, maxillary molars, and mandibular molars. Authors[24-33] made morphometric measurements of diameters in the AC on anterior, premolar, and molar teeth and showed a wide range, but instead instrumented teeth at various distances (e.g., 0.5 mm) from the foramen. Ponce and Fernandez[34] studied the cementodentinal junction in 18 anterior teeth and presented the diameters of the ACs at the cementodentinal canal junction. They found AC diameters ranging from 29 to 35 mm. Unfortunately, Ponce’s sample size was limited. The literature has shown a number of studies concerning the AC dimensions. There have been several comprehensive studies[19-26] that have investigated the diameters of the AC. Other studies are confined to a limited age group or sample size. Because the anatomy in this region is so complex and variable, most studies do not reflect the true horizontal dimensions of this region of the canal. More thorough studies about the shape and size of the AC are needed. Apical enlargement is based on the presumption that the canal debridement would be improved by increasing the apical diameter.[21] It is justified by the fact that microorganisms colonize the dentinal tubules in a depth of 200–300 μm where they remain inaccessible.[22] Indeed, Falk and Sedgley[23] have shown that larger apical diameter preparation ensures a higher efficiency of the irrigation solution and reduces the bacterial growth at the apical level. Brunson et al.[24] maintain that larger apical preparation increases the volume of the irrigation solution at the apical level and it eliminates the tissue debris.

**Conclusion**

The most important value of the dye penetration was observed in the group with the largest apical diameter. There is still no real consensus to the exact size of the apical preparation. Moreover, it is necessary to construct a sufficient tapering along the root canal allowing the efficiency of the chemo-mechanical cleaning of the apical third and to guarantee a deep penetration of the irrigation while preserving as much as possible the integrity of the noble anatomical structures of this apical area. Clinicians desire easier and faster endodontic therapy. Also dental material manufacturers are suggesting that this is attainable with rotary instruments. However, in their desire to make instrumentation “easy,” some are suggesting apical enlargement to only a size no. 20, no. 25, or no. 30, giving the erroneous impression that apical canal diameters are more or less the same small size. As endodontists, we should be careful to adopt the best available evidence for supporting clinical treatment plans. Moreover, because the apical dimensions of root canals range from very large to very small, we should seek instruments and techniques that can help the dentist determine when instrumentation to the correct apical size and apical diameter has been achieved. Although much has been discussed in this area, additional research is clearly warranted.

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**Conflicts of interest**

There are no conflicts of interest.

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