Review Article

The Role of Root Canal Preparation on Apical Geometry: A Review of the Literature

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Abstract

The amounts of apical enlargement have been a controversial issue for a long time. The enlargement of the apical part of the canal may severely impact the endodontic prognosis. Enlargement of the apical portion to a larger size may negatively affect the ability to control the filling material during root canal obturation. In addition, an open-apex increases the risk for overfilling which has been shown to be related with decreased success rate. The retreatment of a tooth with apically enlarged canal may be even impossible. Further preparation of an apically enlarged canal may increase the risk of iatrogenic errors and also excessive apical root weakness. The present article aimed to address *in vitro* and clinical studies on apical enlargement, effect of coronal pre-flaring on the size of the master apical file, and clinical applications of apical enlargement.

Keywords: Apical enlargement, coronal enlargement, penetration of bacteria

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Introduction

Traditionally, it has been stated that root canals should be prepared by controlled removal of dentin to produce a taper with the minimum diameter at the apical constriction and the maximum diameter at the orifice, preserving the original shape of root canal to preserve the strength of the root canal. Therefore, the original shape of the canal dictates the final shape of the prepared canal. The width or taper to which the canal should be enlarged has been shown to be a subject of debates. However, the choice is usually based on individual preferences and experiences rather than scientific rules (1).

Radicular access was first proposed by Schilder, it is employed in all cleaning and shaping techniques these days (1). It is a very important step in the cleaning and shaping strategy and creates space in the more coronal regions of the canal. This space enhances placing and manipulating subsequent files as it increases the depth and effectiveness of the irrigation (2).

Circumferential filing is a method of filing whereby the instrument is moved first toward the buccal/labial side of the canal, then reinserted and removed slightly mesially. This movement continues around the preparation to the lingual aspect and then to the distal surface until all the dentin walls receives rasping. In order to prevent strip perforation in mesial canals of

maxillary and mandibular molars, the circumferential filling is modified by anti-curvature filing. Circumferential filing may be accomplished with hand K-files, Hedstrom files, and sonically/ultrasonically activated files. The gates glidden (GG) drills can be used in a descending (firstly 3 and finally 1) or ascending (firstly 1 and finally 3) order. Before introducing GG drills into the canal, usually the canal length is determined and space is increased to size 25 to 30 file (1).

The present study aimed to address the role of preparation on apical geometry in root canal debridement.

Apical enlargement and bacterial reduction

Once microorganisms access the system of the canal, they may invade dentinal tubules and so be responsible for the persistence of canal infection (1). In a study, Shovelton (3) histologically evaluated extracted, non-vital teeth and its findings showed that most teeth were penetrated by bacteria of the radicular dentinal tubules. However, the number of tubules containing bacteria, as well as the depth of bacterial penetration, was highly varied between different teeth and also among the sections of each tooth. It was found that tubule invasion cannot occur immediately after the bacteria appeared in root canal (3).

The microflora within dentinal tubules of the infected root canal may resemble that of deep layers of carious coronal dentin. *Streptococci*, *Lactobacilli*, and *Propioni bacterium* spp. are predominant bacteria; however, *gram-positive anaerobic cocci*, and *Veillonella* spp. less in count. *Obligate anaerobic gram-negative* bacteria were recovered in very low numbers or not at all. The inability to detect fastidious anaerobes within the invaded dentin may be due to some difficulties in cultivating them (3, 4).

Ozaki et al. (4) demonstrated that in carious dentin, P. *endodontalis* was present in low numbers. In a study performed by Peters et al., (5) it was found that in teeth with apical periodontitis, the flora recovered was similar to that reported in other studies, while *gram-negative* bacteria, including *F. nucleatum*, and *P. intermedia* were routinely recovered. In addition, Akpata and Blechman (6) concluded that *gram-negative obligate anaerobic* bacteria may be more found in infected canals than in carious or non-carious infected dentin. In a study on bovine teeth, Haapasalo and Ørstavik (7) revealed that *Enterococcus faecalis* may heavily invade dentinal tubules up to 400 µm.

ElAyouti et al. (8) found that in curved root canals, increased enlargement of the apical portion cannot result in a complete apical preparation, whereas it may lead to an unnecessary dentin removal. The results of another study carried out by Coldero et al. (9) reported no difference in the intra-canal bacterial reduction when rotary preparation with sodium hypochlorite and EDTA irrigation was used with or without apical enlargement technique. They stated that when an acceptable coronal taper is achieved to allow suitable irrigation of the canal with antibacterial agents, it may not be necessary to remove the dentin of the apical portion.

The results of a study conducted by Paque et al. (10) showed that the apical canal geometry was affected by 6 different preparation techniques. Khademi et al. (11) demonstrated that the minimum preparation size required for the penetration of root canal irrigants to the apical area was #30. Boutsioukis et al. (12) showed that canal enlargement larger than #25 may improve the irrigation by syringe.

According to Sousa et al. (13) that apical patency may be not a necessary part of the root canal treatment of teeth with vital pulps. They showed that size #30 may be the favored master apical file. Arvaniti and Khabbaz (14) indicated that apical preparation to size #30 and tapers 0.04-0.08 cannot affect canal debridement and so recommended>30 for preparation of the apical third of the canal.

According to Albrecht et al. (15), debris can be better removed using 0.04-0.08 ProFile GT when the size of apical preparation was #40 compared to #20. However, when a taper of 0.10 could be produced at the apical area, there was no difference in debris removal between these two sizes.

De Gregorio et al. (16) demonstrated that #40.06 apical preparations may significantly increase the volume of root canal irrigants at the working length regardless of the curvature degree.

Brunson et al. (17) revealed that an increase in apical preparation size/taper may result in an increase in the irrigant volume. Also, apical enlargement to #40/.04 allowed for maximum volume of irrigation in apical third when using the apical negative pressure irrigation systems.

According to Usman et al. (18), no difference was found between each level within each apex size. However, the GT size #20 showed more debris in the apical area, compared to #40. Furthermore, Marinho et al. (19) recommended size #40 as the favored master apical file and showed that endotoxin levels of canals are predictable by increasing the apical enlargement. In line with the results of the aforementioned study, Hecker et al. (20) suggested size #40-50 as the favored apical size and showed that the apical preparation size in two-canalled maxillary and mandibular premolars should be at least six sizes larger than the first apical file.

Rollison et al. (21) showed that apical preparation to #50 was more effective in debriding infected canals than preparation to #35. Additionally, Card et al. (22) recommended the apical size of #80 for cuspids/bicuspids and apical size of #60 for molars.

Saini et al. (23) showed that canal enlargement to three sizes larger than the first apical file seems to be adequate and so further enlargement cannot provide any additional benefit. Moreover, Weiger et al. (24) recommended that canals should be prepared to size larger than that routinely recommended.

In a study by Tan and Messer (25), it was revealed that apical enlargement in greater sizes was beneficial for debridement of the apical third area. Fornari et al. (26) showed that no apical size allowed the canal walls completely prepared. According to Wu et al. (27) neither the first K-file nor the first Lightspeed that bound at the working length reflected the accurate diameter of the apical area in curved canals.

The results of a study carried out by Aydin et al. (28) on a comparative evaluation of the ProTaper #30.09-0.055 and Hero Shaper #30.04, showed no difference in terms of the working length and numbers of bacteria. Silva et al. (29) demonstrated that enlargement of the foramen may result in more apical deviation; however, no difference was observed among the experimental groups in terms of microleakage.

According to Srikanth et al. (30), minimal apical enlargement for irrigant's penetration to apical area was #30.Borlina et al. (31) showed that enlargement of the apical foramen to #25 was favorable to the healing of chronic apical periodontitis.

Nair et al. (32) found apical microorganisms play significant critical role in failures of endodontic therapies. It is mandatory to remove this infected dentin during the canal preparation. Silva et al. (33) compared the effectiveness of large apical preparations and complementary canal preparation with the self-adjusting file in removing endotoxins from canals related to apical periodontitis. They showed that the protocol of apical enlargement were effective in a significant reduction of endotoxins. However, complementary preparation with the self-adjusting file failed to eliminate residual endotoxins beyond those obtained with the R40.

In a systematic review, Aminoshariae and Kulild (34) concluded that contemporary chemo-mechanical techniques (with canal enlargement) cannot eliminate bacteria during endodontic treatment at any size. In another systematic review (35), they showed that in necrotic pulps cases with periapical lesions; apical enlargement would increase the overall outcome.

Effect of coronal pre-flaring on the size of the master apical file

Some researchers suggest that the apical enlargement of a canal should be based on estimation of the initial diameter of the apical foramen by3 file sizes larger than the first file fits at the apical area (36-38). Detection of the apical constriction is based on the clinician's tactile sense.

Philippas and Applebaum (39) showed that progressive formation of dentine in the pulp space narrows the canal diameter. In addition, Wu et al. (27) reported that determination of the apical diameter based solely on the clinician’s experience is not an accurate way. As a result, canal enlargement at working length with 3 instruments with increasing file diameters cannot guarantee complete removal of the infected dentine. Furthermore, Tan and Messer (25) showed that using of traditional methods for determination of apical diameter may underestimate the real diameter. They also reported that the enlargement of the coronal and middle thirds of the canal may result in more accurate evaluation of the apical diameter.

Clinical implications of the apical enlargement

Even though the use of nickel-titanium (Ni-Ti) rotary preparation techniques allows curved canals to be enlarged to sizes 45-80, the effect of such preparation on tooth structure should be studied. Nowadays, the increased flexibility of Ni-Ti files reduces the deviation of the canal curvature from the original shape (40). It also seems that apart from the skill of the clinicians, there are many procedural risks related with enlargement of the apical part of the canal (38, 40).

Generally, the weak evidences for apical enlargement as a means of microbial removal, and the significantly increased risk of iatrogenic errors, the disadvantages of apical enlargement far outweigh the benefits (41-45).

References

1. Schilder H. Cleaning and shaping the root canal. Dent Clin North Am. 1974;18(2):269-296.
2. Howe CA, McKendry DJ. Effect of endodontic access preparation on resistance to crown-root fracture. J Am Dent Assoc. 1990;121(6):712-715.
3. Shovelton DH. The presence and distribution of microorganisms within non-vital teeth. Br Dent J. 1964;117(35):101-107.
4. Ozaki K, Matsua T, Nakae H, Noiri Y, Yoshiyama M, Ebisu S. A quantitative comparison of selected bacteria in human carious dentine by microscopic counts. Caries Res. 1994;28(3):137-145.

5. Peters LB, Wesselink PR, Buijs JF, van Winkelhoff AJ. Viable bacteria in root dentinal tubules of teeth with apical periodontitis. J Endod. 2001;27(2):76-81
6. Akpata ES, Blechman H. Bacterial invasion of pulpal dentin wall *in vitro*. J Dent Res. 1982;61(2):435-8.
7. Haapasalo M, Ørstavik D. *In vitro* infection and disinfection of dentinal tubules. J Dent Res. 1987;66(8):1375-1379.
8. 8.Elayouti A, Dima E, Judenhofer MS, Löst C, Pichler BJ. Increased apical enlargement contributes to excessive dentin removal in curved root canals: a stepwise micro-computed tomography study. J Endod. 2011;37(11):1580-1584.
9. Coldero LG, McHugh S, MacKenzie D, Saunders WP. Reduction in intracanal bacteria during root canal preparation with and without apical enlargement. Int Endod J. 2002;35(5):437-446.
10. Paque F, Ganahl D, Peters OA. Effect of root canal preparation on apical geometry assessed by micro-computed tomography. J Endod. 2009;35(7):1056-1059.
11. Khademi A, Yazdizadeh M, Feizianfard M. Determination of the minimum instrumentation size for penetration of irrigants to the apical third of root canal systems. J Endod. 2006;32(5):417–420.
12. Boutsioukis C, Gogos C, Verhaagen B, Versluis M, Kastrinakis E, Van der Sluis LW. The effect of apical preparation size on irrigant flow in root canals evaluated using an unsteady Computational Fluid Dynamics model. Int Endod J. 2010;43(10):874-881.
13. Sousa RA. The importance of apical patency and cleaning the apical foramen on root canal preparation. Braz Dent J. 2006;17(1):6-9.
14. Arvaniti IS, Khabbaz MG. Influence of root canal taper on its cleanliness: a scanning electron microscopic study. J Endod. 2011;37(6):871-874.
15. Albrecht LJ, Baumgartner JC, Marshall JG. Evaluation of apical debris removal using various sizes and tapers of ProFile GT files. J Endod. 2004;30(6):425–428.
16. de Gregorio C, Arias A, Navarrete N, Del Rio V, Oltra E, Cohenca N. Effect of apical size and taper on volume of irrigant delivered at working length with apical negative pressure at different root curvatures. J Endod. 2013;39(1):119-124.
17. Brunson M, Heilborn C, Johnson DJ, Cohenca N. Effect of apical preparation size and preparation taper on irrigant volume delivered by using negative pressure irrigation system. J Endod. 2010;36(4):721-724.
18. Usman N, Baumgartner JC, Marshall JG. Influence of instrument size on root canal debridement. J Endod. 2004;30(2):110-112.
19. Marinho AC, Martinho FC, Zaia AA, Ferraz CC, Gomes BP. Influence of the apical enlargement size on the endotoxin level reduction of dental root canals. J Appl Oral Sci. 2012;20(6):661-666.
20. Hecker H, Bartha T, Lost C, Weiger R. Determining the apical preparation size in premolars: part III. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2010;110(1):118–124.
21. Rollison S, Barnett F, Stevens RH. Efficacy of bacterial removal from instrumented root canals *in vitro* related to instrumentation technique and size. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2002;94(3):366–371.
22. Card SJ, Sigurdsson A, Ørstavik D, Trope M. The effectiveness of increased apical enlargement in reducing intracanal bacteria. J Endod. 2002;28(11):779-783.
23. Saini HR, Tewari S, Sangwan P, Duhan J, Gupta A. Effect of different apical preparation sizes on outcome of primary endodontic treatment: a randomized controlled trial. J Endod. 2012;38(10):1309-1315.
24. Weiger R, Bartha T, Kalwitzki M, Lost C. A clinical method to determine the optimal apical preparation size. Part I. Oral Surg Oral Med Oral Radiol Endod. 2006;102(5):686–691.
25. Tan BT, Messer H. The effect of instrument type and pre-flaring on apical file size determination. Int Endod J. 2002;35(9):752–758.
26. Fornari VJ, Silva-Sousa YTC, Vanni JR, Pecora JD, Versiani MA, Sousa-Neto MD. Histological evaluation of the effectiveness of increased apical enlargement for cleaning the apical third of curved canals. Int Endod J. 2010;43(11):988–994.
27. Wu MK, Barkis D, Roris A, Wesselink PR. Does the first file to bind correspond to the diameter of the canal in the apical region? Int Endod J. 2002;35(3):264-267.
28. Aydin C, Tunca YM, Senses Z, Baysallar M, Kayaoglu G, Ørstavik D. Bacterial reduction by extensive versus conservative root canal instrumentation *in vitro*. Acta Odontol Scand. 2007;65(3):167-170.
29. Silva JM, Brandão GA, Silva EJ, Zaia AA. Influence of working length and foraminal enlargement on foramen morphology and sealing ability. Indian J Dent Res. 2016;27(1):66-72.
30. Srikanth P, Krishna AG, Srinivas S, Reddy ES, Battu S, Aravelli S. Minimal apical enlargement for penetration of irrigants to the apical third of root canal system: a scanning electron microscope study. J Int Oral Health. 2015;7(6):92-96.

31. Borlina SC, de Souza V, Holland R, Murata SS, Gomes-Filho JE, Dezan Junior E, Marion JJ, NetoDdos A. Influence of apical foramen widening and sealer on the healing of chronic periapical lesions induced in dogs' teeth. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2010;109(6):932-940.
32. Nair PN, Henry S, Cano V, Vera J. Microbial status of apical root canal system of human mandibular first molars with primary apical periodontitis after "one-visit" endodontic treatment. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2005;99(2):231-252.
33. Silva EJ, Ferreira VM, Silva CC, Herrera DR, De-Deus G, Gomes BP. Influence of apical enlargement and complementary canal preparation with the Self-Adjusting File on endotoxin reduction in retreatment cases. Int Endod J. 2017;50(7): 646 – 651.
34. Aminoshariae A, Kulild JC. Master apical file size - smaller or larger: a systematic review of healing outcomes. Int Endod J. 2015;48(7):639-647.
35. Aminoshariae A, Kulild J. Master apical file size - smaller or larger: a systematic review of microbial reduction. Int Endod J. 2015;48(11):1007-1022.
36. Christie WH, Thompson GK. The importance of endodontic access in locating maxillary and mandibular molar canals. J Can Dent Assoc. 1994;60(6):527-532.
37. Ingle JI, Bakland LK, Baumgartner JC. Ingle's Endodontics. 4th ed. Hamilton: B.C. Decker Inc., 2008.
38. Weine FS. Endodontic Therapy. 5th ed. St Louis, MO: Mosby, 1996.
39. Philippas GG, Applebaum E. Age factor in secondary dentin formation. J Dent Res. 1966;45(3):778-789.
40. Figdor D, Sundqvist G. A big role for the very small--understanding the endodontic microbial flora. Aust Dent J. 2007;52(1 Suppl):S38-51.
41. Walton RE, Rivera EM. Cleaning and shaping. In: Walton RE, Torabinejad M, eds. Principles and Practice of Endodontics. 2nd ed. Philadelphia: W.B. Saunders, 1996.
42. Kerekes K, Tronstad L. Long-term results of endodontic treatment performed with a standardized technique. J Endod. 1979;5(3):83-90.
43. Strindberg LZ. The dependence of the results of pulp therapy on certain factors. An analytical study based on radiographic and clinical follow-up examinations. Thesis. 1956;14:1-175.
44. Grahnén H, Hansson L. The prognosis of pulp and root canal therapy. A clinical and radiographic follow-up examination. Odont Revy. 1961;12(3):146-165.
45. Sjögren U, Hägglund B, Sundqvist G, Wing K. Factors affecting the long-term results of endodontic treatment. J Endod. 1990;16(10):498-504.

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