

An *in vitro* study of the effect of spreader penetration depth on apical microleakage

Shahriar Shahi¹⁾, Vahid Zand¹⁾, Siavash S. Oskoee²⁾, Majid Abdolrahimi³⁾
and Amir H. Rahnema⁴⁾

¹⁾Department of Endodontics, Tabriz university of Medical Sciences, Tabriz, Iran

²⁾Department of Operative Dentistry, Tabriz university of Medical Sciences, Tabriz, Iran

³⁾Dental School, Tabriz university of Medical Sciences, Tabriz, Iran

⁴⁾Private practice, Tabriz, Iran

(Received 2 July and accepted 23 October 2007)

Abstract: The purpose of this study was to evaluate the effect of spreader penetration depth on apical microleakage using the lateral compaction method. A total of 96 extracted maxillary central incisors were instrumented using the step-back method, and randomly divided into the following four experimental groups: A) with tug-back and spreader penetration 1 mm short of the working length; B) without tug-back and spreader penetration 1 mm short of the working length; C) without tug-back and spreader penetration to the working length; D) with tug-back and spreader penetration to the working length. Microleakage evaluation was conducted using the dye penetration method, and ANOVA test was used for statistical analysis. The results showed that there was a significant difference in the amount of microleakage between the groups with spreader penetration to the working length and the groups with spreader penetration 1mm short of the working length. There was no significant difference between the groups with and without tug-back. (J. Oral Sci. 49, 283-286, 2007)

Keywords: lateral compaction; spreader; tug-back; microleakage; dye penetration.

Introduction

The obturation phase of root canal treatment has always received a great deal of attention. Historically, obturation has usually been considered the most critical step and the most frequent cause of treatment failure (1). According to the Washington study, nearly 60% of root canal treatment failures were caused by incomplete root canal obturation (2). The majority of failures related to deficiencies in obturation are long-term. Failure tends not to manifest itself over a short period of time, because of the usually low volume of irritant(s) or the slow release of irritant(s) into the periapical tissues. Therefore the persistence or development of periapical pathosis may not be evident for months or even years following treatment (1). There is no question that tissue debris and bacteria are usually not totally removed from the pulp space during cleaning and shaping. These constitute a potential source of failure. Delivanis showed that bacteria sealed in the canal lost their viability (3), but even necrotic bacteria could be antigenic and cause inflammation, and an adequate seal can prevent the activation of such irritants.

With lateral compaction, master cone adaptation is considered an important factor in the development of a fluid-tight seal at the apical extent of the root canal preparation and in the total obturation of the root canal space (4).

Weine and Wenckus (5), and also Johnson and Guttman (6), have advocated placing the master cone to the full length of the prepared canal, or just short of it, and that it need not have resistance to removal, referred to as "tug-back". Tug-back is rarely obtainable in properly flared smaller-diameter canals because there is just a small area of close

Correspondence to Dr. Shahriar Shahi, Department of Endodontics, School of Dentistry, Tabriz university of Medical Sciences, Golgasht Street, 5166614713 Tabriz, Iran
Tel: +98-914-314-2971
Fax: +98-411-336-6977
E-mail: shahriar_shahi@hotmail.com

approximation between the cone and the canal walls. Moreno has suggested that the master cone should be adapted to within 0.5 mm of the apical foramen before lateral condensation (7). However, Ingle has maintained that the master cone should extend to 1 mm short of the working length (2). Grossman (8) and Morse (9) stated that after adapting the master cone to the full prepared length, it should be trimmed 1 mm to 1.5 mm short of this length. Allison et al. showed that the most important factor affecting the quality of the apical seal was the shape of the canal; those canals that allowed deep spreader penetration had little apical microleakage (10). These authors found that "there was little or no microleakage if the spreader had penetrated within 1 mm of the prepared length" (4). Although master cone tug-back may affect the quality of the apical seal, there is disagreement and a lack of consensus about what constitutes adequate tug-back. In addition, there are no published experimental data pertaining to the effect of spreader depth penetration within the prepared length. Therefore the purposes of this study were, firstly, to examine the relationship between master cone tug-back and the apical seal, and secondly to examine the relationship between spreader penetration to the full prepared length and the adequacy of the apical seal.

Materials and Methods

Ninety-six maxillary central incisors with vital pulps and mature apices and minimum curvature (less than 5 degrees) were selected. The degree of canal curvature was determined using the method suggested by Schneider (11). The size of the apical foramen was gauged with a #15 file (K-file, Maillefer, Ballaigues, Switzerland). Straight line access was obtained and the working length was established within 0.5 mm of the apical foramina. The length of the canal was measured by inserting a #10 file (K-file, Maillefer) into the canals. When the tip of the file was visible at the apex, 0.5 mm short of the file penetration length was considered to be the working length. The canals were cleaned and shaped using the step-back method, and a #35 file (K-flexofile, Maillefer) was chosen as the master apical file (MAF). The canals were then flared with a #60 file (K-flexofile, Maillefer). The taper of the canals was evaluated by placing a #B nickel-titanium (Ni-Ti) finger spreader (Maillefer, Dentsply, Ballaigues, Switzerland) into each canal to the working length, without the spreader touching the canal walls and without it experiencing any resistance. Then the teeth were randomly divided into four experimental groups as follows:

Group A; with tug-back and spreader penetration 1 mm short of the prepared length,

Group B; without tug-back and spreader penetration 1

mm short of the prepared length,

Group C; without tug-back and spreader penetration to the prepared length, and

Group D; with tug-back and spreader penetration to the prepared length.

Root canals were obturated by the lateral condensation method using a #35 Diadent (Diadent, Burnaby, Canada) master cone and Aria Dent (Aria Dent, Tehran, Iran) accessory cones with AH26 (Dentsply, Konstanz, Germany) sealer. Master cone tug-back was confirmed by the resistance of the cone to removal from the canal, and a radiograph confirmed the working length. In some specimens in the groups without tug-back (groups B and C), the canal was further instrumented with master apical file (MAF) to eliminate tug-back. In the groups with tug-back (groups A and D), if tug-back was not present, the gutta-percha cone was cut 1 mm shorter at the tip to achieve tug-back (6).

The master cones were coated with sealer and placed in the canals. A #25 finger spreader was then inserted into the canal(s) for 5 sec on each penetration, and the gutta-percha was condensed against the canal wall using the lateral condensation technique. After removal of the spreader from the canal, accessory gutta-percha cones were coated with sealer and inserted in the space left by the spreader on removal. On average, 5-7 accessory cones were placed into each canal. The length of spreader penetration into the canal(s) was controlled using rubber stoppers measured to the working length in groups C and D and 1 mm short of the working length in groups A and B. Radiographs from a proximal view were obtained for each specimen after obturation to allow evaluation of the obturation quality. In each experimental group, 2 teeth were considered as positive controls and 2 others as negative controls. In the positive controls the canals were instrumented but not filled, and in the negative controls the canals were instrumented and filled in the same way as the teeth in the experimental groups, but the entire surfaces of the specimens were covered with fingernail varnish and sticky wax. The crowns of all specimens were resected at the cemento-enamel junction (CEJ). The specimens were stored at 100% humidity at 37°C for 7 days. Then the root surfaces of all the specimens were coated with fingernail varnish and sticky wax, leaving the apical foramen open, except in the negative controls. The apical foramina of the eight teeth in the positive controls were allowed to remain patent to determine if leakage would occur throughout the length of the canal. The apical foramina of the eight teeth in the negative control group were sealed with zinc-oxide eugenol and coated with fingernail polish and sticky wax. All specimens were

submerged in a 2.5% solution of methylene blue for 72 h. Vertical grooves were cut on the buccal and palatal aspects of all the specimens and the teeth were split longitudinally. Gutta-percha was removed and a stereomicroscope used to assess the microleakage.

The degree of microleakage was determined by linear measurement of the dye penetration. The extent of dye penetration into the specimens was measured separately by two individuals at two different times, and the mean value of the recorded measurements was chosen as the extent of dye penetration into each specimen. The four experimental groups were compared for master cone tug-back (tug-back versus non tug-back) and spreader penetration (within the working length versus 1mm short of the working length) using ANOVA followed by a post-hoc Tukey test.

Results

No dye penetration was observed in the negative control group, and dye penetration into the entire canal length was observed in the positive control group.

The results of the study indicated that the mean value of dye penetration was 1.9 mm in group D, 3.2 mm in group A, 3.9 mm in group B, and 1.7 mm in group C (Fig. 1).

ANOVA test showed that the differences observed were statistically significant ($P < 0.001$) with the greatest dye penetration in group B and the least dye penetration in group C (Table 1). As illustrated in Table (1) and according to the post-hoc Tukey test, the differences in dye penetration between groups D and A ($P = 0.002$) and groups D and B ($P < 0.001$) were significant, but the difference observed between groups D and C ($P = 0.630$), and groups A and B ($P = 0.131$) was not significant. However, the differences observed between groups A and C ($P < 0.001$) and groups B and C ($P < 0.001$) were significant.

Discussion

Lateral compaction is a commonly used obturation technique in endodontic treatment. The major advantage of this technique is control of the obturation length. Secondly it is a technique that is applicable to most root canal systems. It is a relatively easy technique, requiring only the use of a spreader to achieve lateral condensation.

In the present study, methylene blue dye was used to assess apical microleakage. Methylene blue consists of very fine sub-microbe-size particles that contribute to the accuracy of the experiment. If these particles cannot penetrate into the space between the canal walls and the gutta-percha cones, it is obvious that larger particles such as bacteria and their endotoxins will not penetrate either (12).

Ni-Ti #25 finger spreaders were used in this study. According to Sobhi and Khan, nickel-titanium spreaders may give better results for lateral compaction because of their deeper penetration (13). On the other hand, stress patterns induced by nickel-titanium spreaders radiate along the surface of the canals, thus reducing the concentration of stress and the potential for vertical root fracture (14).

The results of this study indicated that there were statistically significant differences in dye penetration between the groups with spreader penetration to the working length and the groups with spreader penetration 1 mm short of the working length, leading to the conclusion

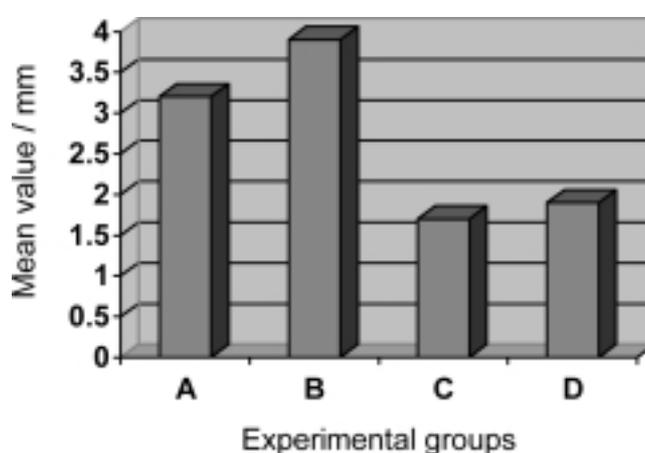


Fig. 1 The mean values of microleakage in four experimental groups.

- A: with tug-back, spreader penetration 1mm short of the prepared length
- B: without tug-back, spreader penetration 1mm short of the prepared length
- C: without tug-back, spreader penetration to the prepared length
- D: with tug-back, spreader penetration to the prepared length

Table 1 Comparison of microleakage between experimental groups using ANOVA

Groups	Number	Mean \pm SD (mm)	F	P value
A	20	3.23 \pm 1.37		
B	20	3.86 \pm 0.91		
C	20	1.70 \pm 1.05	12.82	0 < 001
D	20	1.90 \pm 1.14		
Total	80	2.67 \pm 1.43		

- A: with tug-back, spreader penetration 1mm short of the prepared length
- B: without tug-back, spreader penetration 1mm short of the prepared length
- C: without tug-back, spreader penetration to the prepared length
- D: with tug-back, spreader penetration to the prepared length

that, regardless of the role of tug-back, a better seal can be obtained by deeper penetration of the spreader into the canal. As stated by Allison, deeper penetration of the spreader produces a better apical seal (4). In the present study, in the group in which no tug-back was present but the spreader reached the canal working length, the extent of dye penetration was less than in the other groups, and was even less than in the group where tug-back was present and the spreader reached the canal within the working length.

The results of this study do not explain why in the groups without tug-back and with deeper spreader penetration, microleakage was less than in the groups with tug-back. However, it is probable that when there is no tug-back and the spreader reaches the canal working length, there is enough space for the insertion of accessory gutta-percha cones. Therefore, due to the compactibility of gutta-percha, the entire canal space in the apical third is filled with compacted gutta-percha, which assumes the anatomic shape of the canal. However, when tug-back is present, there may not be complete adaptation to the canal walls, and empty spaces may remain between the canal walls and the master cone. Because the canal space is not always prepared as a uniform cone with a rounded form, and due to contact of a segment of the gutta-percha cone with the canal wall, the spreader cannot reach the canal working length in that area, leading to a breach in the seal.

Finally, considering the results of the present study and the controversy regarding the role of tug-back in creating a better seal, it is suggested that further leakage tests be conducted to verify our results. In addition, long-term clinical and animal studies on the role of tug-back and spreader penetration to the working length in creating a better seal, and thus the success of endodontic treatment, need to be performed.

The results of this study revealed that there was a significant difference in the amount of apical microleakage between the groups with spreader penetration to the working length and the groups with spreader penetration 1 mm short of the working length, and that there was no significant difference between the groups with and without tug-back. Thus it appears that spreader penetration depth may have a role in determining the amount of apical microleakage. However, before recommending spreader penetration to the working length in clinical situations, further *in vitro* and *in vivo* studies should be carried out.

References

1. Walton RE, Torabinejad M (2002) Principles and practice of endodontics. 3rd ed, Saunders, Philadelphia, 240-242
2. Ingle JI, Beveridge E, Glick D, Welchman J (2002) The Washington study. In Endodontics, 5th ed, Ingle JI, Bakland LK eds, Williams and Wilkins, Baltimore, 747-757
3. Delivanis PD, Mattison GD, Mendel RW (1983) The survivability of F43 strain of *Streptococcus sanguis* in root canals filled with gutta-percha and Procosol cement. J Endod 9, 407-410
4. Allison DA, Michelich RJ, Walton RE (1981) The influence of master cone adaptation on the quality of the apical seal. J Endod 7, 61-65
5. Weine FS, Wenkus CS (2004) Canal filling with semisolid materials. In Endodontic therapy, 6th ed, Weine FS ed, Mosby, St Louis, 276
6. Johnson WT, Guttman JL (2006) Obturation of the cleaned and shaped root canal system. In Pathways of the pulp, 9th ed, Cohen S, Hargreaves KM eds, Mosby, St Louis, 375-376
7. Moreno A (1977) Thermomechanically softened gutta-percha root canal filling. J Endod 3, 186-188
8. Grossman LI, Oliet S, Del Rio CE (1988) Endodontic practice. 11th ed, Lea & Febiger, Philadelphia, 244-245
9. Morse DR (1974) Clinical endodontology: a comprehensive guide to diagnosis, treatment and prevention. Charles C Thomas, Springfield, 457-461
10. Allison DA, Weber CR, Walton RE (1979) The influence of the method of canal preparation on the quality of apical and coronal obturation. J Endod 5, 298-304
11. Schneider SW (1971) A comparison of canal preparations in straight and curved root canals. Oral Surg Oral Med Oral Pathol 32, 271-275
12. Orstavik D, Eriksen HM, Beyer-Olsen EM (1983) Adhesive properties and leakage of root canal sealers *in vitro*. Int Endod J 16, 59-63
13. Sobhi MB, Khan I (2003) Penetration depth of nickel titanium and stainless steel finger spreaders in curved root canals. J Coll Physicians Surg Pak 13, 70-72
14. Joyce AP, Loushine RJ, West LA, Runyan DA, Cameron SM (1998) Photoelastic comparison of stress induced by using stainless-steel versus nickel-titanium spreaders *in vitro*. J Endod 24, 714-715