Comparison of Spreader Penetration and Obturation Density during Lateral Compaction of .04 and .02 Tapered Master Cones

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Objective: *To compare the initial penetration depth of nickel-titanium (NiTi) and stainless steel (SS) spreader during lateral compaction of .04 and .02 tapered master gutta-percha cones and the quality of the canal seal.*
Methods: *Forty extracted mandibular premolars with a single curved canal were prepared using standardised rotary instrumentation technique. NiTi and SS spreaders were used to obturate the canals containing a .04 or .02 master cone while the penetration depths were measured. Horizontal sections were cut 2 and 4 mm from the apex and photographed under a stereomicroscope. The area of the canal and gutta-percha in cross-section was measured using an image analysis program.*
Results: *NiTi spreaders penetrated to a significantly greater depth than SS spreaders ($p < 0.01$). At the 2-mm level, there was significantly more gutta-percha using the .02 tapered gutta-percha cone in the NiTi spreader group than in the SS spreader group ($p < 0.05$), but no significant difference occurred using .04 tapered gutta-percha ($p > 0.05$). At the 4-mm level, there was no significant difference in obturation density either between the NiTi spreader and the SS spreader or between the .02 and .04 tapered gutta-percha ($p > 0.05$).*
Conclusion: *NiTi spreaders penetrated to a significantly greater depth than SS spreaders and the area occupied by gutta-percha was significant greater when filling curved canals with .02 tapered gutta-percha.*
Key words: *lateral condensation, master cone, nickel-titanium, spreader*

The greater penetration of nickel-titanium (NiTi) finger spreaders that has been reported in curved canals is presumably due to their greater flexibility, which allows them to follow the curvature of the canal[1]. The introduction of NiTi files with larger tapers has enabled the formation of well centred, more circular preparations with a predefined standardised taper in the apical portion of the root canal system. To optimise the obturation of canals prepared by files with larger tapers, gutta-percha of larger tapers has been developed that corresponds to the apical canal shapes created by these files. Although larger taper gutta-percha is intended for use with a warm vertical-compaction technique, its use also has been advocated with a cold lateral-compaction technique[2]. Filling canals prepared with NiTi instruments with a correspondingly tapered gutta-percha master cone and lateral condensation may be advantageous in that a larger and more uniform mass of gutta-percha is introduced that potentially has less sealer entrapped in the filling mass[3]. Because of the close approximation of the gutta-percha cone to the prepared canal walls, a potential disadvantage results from the inability of a spreader tip to predictably penetrate to within 1 to 2 mm of the working length. This could result in inadequate compaction of the master cone in the apical portion of the canal, which might cause a potential deficiency in the seal of the canal[4]. The purpose of the present study was to compare the initial penetration depth of NiTi and stainless steel (SS) spreaders dur-

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ing lateral compaction of .02 or .04 tapered master gutta-percha cones and to evaluate the quality of obturation.

Materials and Methods

Specimen selection and canal preparation

Forty extracted human mandibular premolars with single canals and fully formed apices were used in this study. All teeth were stored in buffered 10% formaldehyde after extraction. Canal curvature was determined by Schneider's method using digital radiographs. The canal curvature was greater than 20 degrees. Each tooth was prepared in the following way. The coronal part of each crown was removed with a carbide bur to create a reproducible reference point. Working length was determined by inserting a #10 K-file into the canal until it became visible at the apical terminus, and 1 mm was subtracted from that length. All canals were prepared using rotary instruments in an ATR motor with a 16:1 reduction at 300 rpm. Each canal was then instrumented using GG bur and ProFile .04 taper NiTi rotary instruments and 2.5% sodium hypochlorite was used as the canal rinsing solution. The preparation was completed when the tip of a taper 40/.04 rotary file reached the working length without any force. Canal patency was re-verified with a #10 file after instrumentation and then the canals were dried with paper points.

Spreader penetration measurement

The apparatus, with the tooth secured, was placed on an Instron (Instron, USA) to measure the force used during spreader placement. The apical 4 mm of each gutta-percha cone was coated with canal sealer before they were placed into the canals. All finger spreaders used within each canal were inserted into the canal at a consistent entry point on the side corresponding to the outer aspect of the canal curvature. An apical force of 15 N, with no rotational force, was applied to place the spreader.

In this study, size #25 NiTi (Smart Tech, Beijing) and size #25 SS finger spreaders were used with size 40/.04 taper and 40/.02 taper gutta-percha cones. Four groups of measurements were obtained within each canal. The groups consisted of: (a) NiTi spreader with size 40/.02 taper master cone; (b) NiTi spreader with size 40/.04 taper master cone; (c) SS spreader with size 40/.02 taper master cone; (d) SS spreader with size 40/.04 taper master cone. For each group of measurements, the depth of spreader penetration was recorded three times using a new master cone for each measurement and averaged for analysis.

File working length and spreader penetration were determined by using silicone stops on the instrument. Measurements were recorded as distance, by subtracting the depth of spreader penetration from the predetermined working length. One operator performed all data collection.

Canal filling

The canals were filled using lateral condensation of gutta-percha by the same operator. The canal was dried with paper point and a thin coat sealer was applied to the walls using size #40 K-file. The master cone with apical 4 mm coated with sealer was placed slowly into the canal to full working length. Lateral condensation of gutta-percha was carried out using size #20 accessory cones and a spreader starting at 1 mm from the working length. Excess gutta-percha was then removed from the canal entrance using a System B instrument and the gutta-percha mass was then condensed vertically using a plugger.

After obturation the teeth were stored at 37 ºC and 100% humidity for 7 days to ensure complete setting of sealer. By using a low-speed saw (Leica SP1600, Wetzlar, Germany) with constant fresh-water coolant directed toward the interface between the saw disk and the tooth, each root was horizontally sectioned at 2 mm and 4 mm from the apex without causing any smearing of gutta-percha. The sections were viewed under a stereomicroscope at 40 x magnification (Zeiss, Germany) equipped with a digital camera; the photographs were scanned as TIFF (Tagged Image File Format) images. Digital images were analysed using Image J to calculate the percentage ratios of gutta-percha (PGP) to the total root canal area. A single investigator who was blinded to the specimens measured all the cross sections.

Data management

Statistical analyses were carried out using statistics package. Significant differences between the techniques were assessed for spreader penetration using paired Student's *t*-test, and the other preparation using the Mann-Whitney U test.

Results

NiTi spreaders penetrated to a significantly greater depth than SS spreaders both for .02 and .04 tapered gutta-percha ($p < 0.01$, Table 1). At a level of 2 mm, there was significantly more gutta-percha using a .02 tapered gutta-percha cone in the NiTi spreader group than in the SS spreader group ($p < 0.05$, Table 2; Figs 1 and 2); no difference occurred using .04 tapered gutta-percha cone ($p > 0.05$). At the 4-mm level, there was no difference be-

TABLE 1 Spreader penetration measured as distance from working length (n = 20, mean ± SD, mm)

Group	.02 master cone	.04 master cone
SS	1.43 ± 0.46	2.79 ± 0.41
NiTi	0.48 ± 0.27	1.95 ± 0.36
p	< 0.01	< 0.01

TABLE 2 PGP at different section levels from the apex for groups (n = 10, mean ± SD, %)

Group	2 mm level		4 mm level	
	.02 master cone	.04 master cone	.02 master cone	.04 master cone
SS	89.40 ± 4.11	95.93 ± 1.55	94.24 ± 6.84	95.50 ± 5.57
NiTi	93.54 ± 4.03	94.46 ±1.07	92.66 ± 2.70	93.23 ± 3.02
p	< 0.05	> 0.05	> 0.05	> 0.05

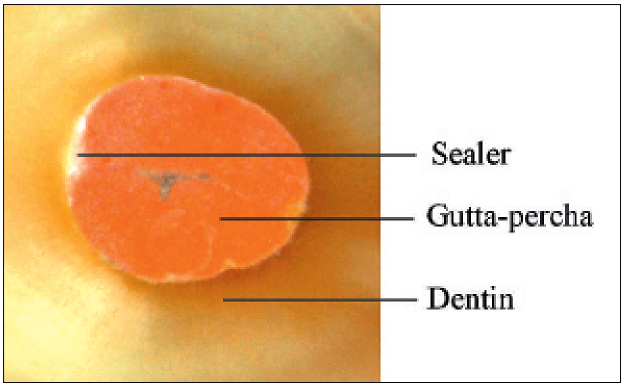

Fig 1 Representative image of a filled canal at the 2 mm level (NiTi spreader and 40/.02 master cone).

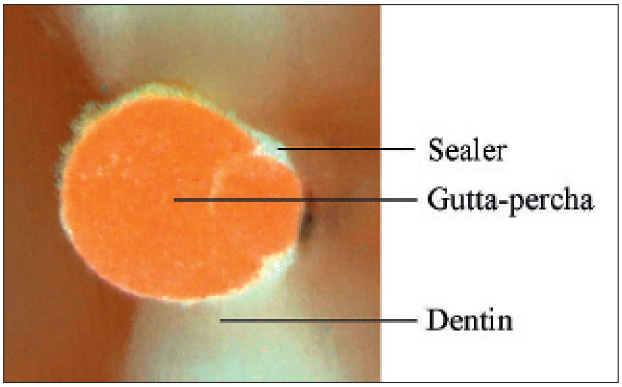

Fig 2 Representative image of a filled canal at the 2 mm level (SS spreader and 40/.02 master cone).

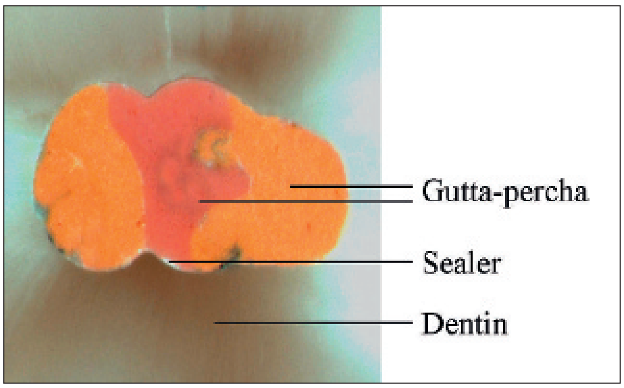

Fig 3 Representative image of a filled a canal at the 4 mm level (NiTi spreader and 40/.04 master cone).

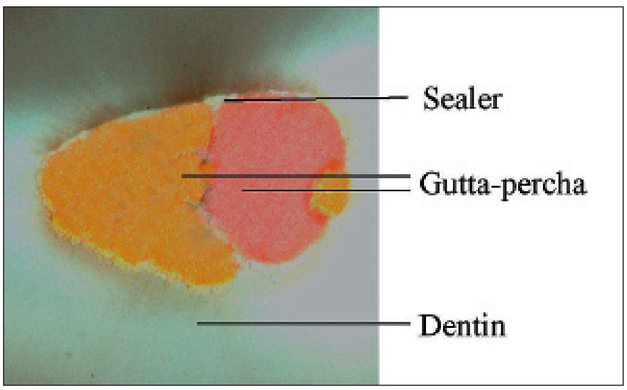

Fig 4 Representative image of a filled canal at the 4 mm level (SS spreader and 40/.04 master cone).

tween the two groups either in different spreaders or in different tapered master cones ($p > 0.05$, Table 2; Figs 3 and 4).

Discussion

One of the most commonly used methods for root canal obturation is lateral condensation of gutta-percha[5]. This conventional technique for obturation of evenly tapered spaces uses a master .02 taper standard gutta-percha cone followed by the addition of further accessory gutta-percha after lateral condensation with spreaders. It has been shown that the apical seal is best when the spreader can be placed close to the working length[6]. The data from the present study showed that NiTi spreaders penetrated farther apically than SS spreaders, consistent with the report of Wilson and Baumagartner[2].

The present study confirms that spreader penetration is much greater in curved canals using .02 tapered master cones than .04 tapered master cones. This result suggests that .04 tapered master cones may provide linear resistance in the apical portion of the canal that prevents spreader penetration beyond the working length. The larger taper of the master cone may also decrease the space available for spreader penetration.

The quality of canal seal obtained with lateral compaction and the relationship between depths of spreader penetration has not been thoroughly investigated. Gordon et al[7] reported no difference of the area filled with gutta-percha between the lateral condensation .02 and .06 taper cone. Bal et al[4] found no difference in the coronal leakage of laterally compacted .02 and .06 taper gutta-percha master cones in canals prepared with a .06 tapered file using a bacterial leakage model, although the spreader penetration was significantly less for the .06 master cone group. The data from the present study reveal that there were significant differences in PGP between SS and NiTi spreader when using a .02 master cone, at the level of 2 mm to the apex. The pooling of sealer could be seen in the SS group due to the SS spreader not being able to penetrate to within 1 mm of the apex because of the high angle of canal curvature when the master point was in place. As a result, small accessory cones may not have negotiated the curve to reach the working length, so there was less gutta-percha at this level. Although there is no evidence that root fillings containing more gutta-percha and less sealer have a higher clinical success rate, there is a general preference for the technique whereby more gutta-percha is compacted into the root canal so that it adapts more closely to the canal wall[8].

Clearly, the quality of the canal seal is influenced by a number of factors, including the irregularity of the canal. For example, teeth with wide bucco-lingual canals may allow deeper spreader penetration than round canals, as the coronal part of the .04 master cone is much wider than that of the standard master cone.

Conclusions

NiTi spreaders may achieve deeper penetration with the master cone in place, obtaining the most favourable apical seal during lateral condensation. It is possible that obturation using a NiTi spreader in a curved canal would result in a better apical seal.

References

1. Ingle JI, Bakland LK. Endodontics. 5th Edition. Philadelphia: Wilkins, 2002.
2. Wilson BL, Baumagartner JC. Comparison of spreader penetration during lateral compaction of .04 and .02 tapered gutta-percha. J Endod 2003;29:828-831.
3. Hembrough MW, Steiman HR, Belanger KK. Lateral condensation in canals prepared with nickel titanium rotary instruments: an evaluation of the use of three different master cones. J Endod 2002;28:516-519.
4. Bal AS, Hicks ML, Barnett F. Comparison of laterally condensed .06 and .02 tapered gutta-percha and sealer in vitro. J Endod 2001; 27:786-788.
5. Nielsen BA, Baumgartner JC. Spreader penetration during lateral compaction of resilon and gutta-percha. J Endod 2006;32:52-54.
6. Wu M-K, Kast'akova A, Wesselink PR. Quality of cold and warm gutta-percha fillings in oval canals in mandibular premolars. Int Endod J 2001;34:485-491.
7. Gordon MP, Love RM, Chandler NP. An evaluation of .06 tapered gutta-percha cones for filling of .06 tapered prepared curved root canals. Int Endod J 2005;38:87-96.
8. Wu MK, de Groot SD, van der Sluis LW, Wesselink PR. The effect of using an inverted master cone in a lateral compaction technique on the density of the gutta-percha fill. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2003;96:345-350.