

## Original Article

# The effect of tapered master gutta-percha cone on apical seal of straight and curved root canals prepared with nickel–titanium rotary files

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## ABSTRACT

**Background:** Gutta-percha has been the predominant root canal filling material which is developed with different taper. Canal obturation fixed with nickel–titanium (NiTi) instruments and tapered gutta-percha master cone and lateral condensation is advantageous because it is clinically effectual and appears to result in a radiographically acceptable outcome. The aim of this *in vitro* study was to determine the effect of tapered master gutta-percha cone on apical seal of straight and curved root canals using NiTi rotary files.

**Materials and Methods:** In this *in vitro* study total of 130 mandibular molars were selected and divided into six experimental groups ( $n = 20$ ) based on the degree of root canal curvatures ( $0^\circ$ – $20^\circ$  and  $20^\circ$ – $40^\circ$ ) and the taper of master cones (0.02, 0.04, and 0.06). The roots were immersed in the bacterial leakage model and monitored daily for a period of 70 days. Data were analyzed using Kaplan–Meier approach, log-rank test, and Chi-square tests.  $P < 0.05$  was considered statistically significant.

**Results:** The microleakage in the  $0^\circ$ – $20^\circ$  canal curvature using 0.02- and 0.04-tapered master cones was similar and considerably  $< 0.06$ -tapered master cone ( $P < 0.05$ ). However, the microleakage in the  $20^\circ$ – $40^\circ$  canal curvature using 0.02- and 0.04-tapered master cones was more than  $0^\circ$ – $20^\circ$  and for 0.06-tapered master cone was  $< 0^\circ$ – $20^\circ$ , but there was no statistical difference between the use of 0.02-, 0.04-, and 0.06-tapered master cones ( $P > 0.05$ ).

**Conclusion:** The lateral condensation filling technique using 0.02- and 0.04-tapered master cones is more effective in minimizing microbial leakage in straight canals than 0.06-tapered master cone.

**Key Words:** Dental leakage, gutta-percha, root canal obturation

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## INTRODUCTION

The success of an endodontic treatment is based on how effectively all the portals of entry are sealed following cleaning and shaping the canals.<sup>[1]</sup> The aim of canal obturation after preparation is blocking all

the portal of entries into the root canal system through which microorganisms and their irritants can enter the canal and cause reinfection, and also, sealing all the irritants left out in the canal which cannot be removed

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by cleaning and shaping procedures. Therefore, a flawless seal is needed at the apex, lateral and accessory canals, and the coronal orifice.<sup>[2,3]</sup>

The controlled regularly tapered preparation of the curved canals is the ultimate challenge in endodontics. The application of nickel–titanium (NiTi) rotary instruments has become a standard procedure in contemporary endodontics.

In the contemporary obturation techniques and with the development of more predictable shapes with current NiTi, lateral condensation leftovers the most conventional technique for root canal obturation. Discrepancy in file taper can affect the quality of endodontic obturation, which affects the overall achievement of root canal treatment. Lateral condensation technique unlike vertical condensation technique does not create a homogeneous mass of gutta-percha and pools of sealer may be trapped in the filling mass as accessory cones are condensed against each other. Therefore, filling with a master cone with a larger taper may be expedient in that a larger and more uniform mass of gutta-percha is introduced that potentially has less sealer entrapped in the filling mass.<sup>[2,3]</sup>

In addition, obturation with gutta-percha with a larger taper cone requires less time.<sup>[4]</sup> Owing to the close approximation of the gutta-percha cone to the prepared canal walls, a potential disadvantage results from the inability of a spreader or plugger tip to predictably penetrate to within 1–2 mm of the working length.<sup>[2]</sup> This could result in inadequate compaction of the master cone in the apical portion of the canal causing a potential deficiency in the seal of the canal.<sup>[4]</sup>

Many microleakage measurement methods have been tested and performed over the years, such as dye penetration, bacterial leakage, radioisotopes, electrochemical methods, and fluid filtration, which have advantages as well as certain drawbacks.<sup>[2,5]</sup> For example, one of the major problems in which dyes are used for penetration is the small size of the dye molecules and probably false-positive results or the entrapped air in cavities along root canal fillings (negative results).<sup>[2,4]</sup>

In the present study, bacterial leakage method was used to evaluate microleakage since this method is considered to be of greater clinical and biological relevance.<sup>[2,4,6]</sup> The aim of this *in vitro* study was to determine the effect of tapered master gutta-percha

cone on apical seal of straight and curved root canals using NiTi rotary files.

## MATERIALS AND METHODS

In this *in vitro* study total of 130 extracted human mandibular molar teeth were selected.

The inclusion criteria were as follows: teeth that have no defect (devoid of any lines or crack defects) with complete apexes and two distinct canals in their mesial root. The teeth were placed in 1% sodium hypochlorite solution, and the soft tissue, calculus, and bone were removed mechanically from the teeth and thoroughly submerged in 0.9% sterile normal saline for about 20 min.<sup>[7]</sup> Then, the teeth were randomly divided into two groups of 60, based on the degree of root canal curvatures (0°–20° and 20°–40°) by Schilder technique,<sup>[7]</sup> and ten teeth were selected as two control groups ( $n = 5$ ): left nonobtured (positive control) and fully sealed by nail varnish (Colorama, São Paulo, Brazil) (negative control).

For each canal, the working length was determined by passing #8 or #10 K-type file (Dentsply Maillefer, Ballaigues, Switzerland) into the canal until it was just visible at the apical foramen, then subtracting 1 mm.<sup>[4]</sup> Root canals were prepared using #30, 0.06 taper RaCe rotary files (FKG Dentaire, La Chaux-de-Fonds, Switzerland) up to master apical file. Canal orifice was located, and patency was obtained with a K-file no. 10. The canals were irrigated with 2 ml of 2.5% NaOCl between files, and the smear layer was removed by final irrigation with 1 ml of 2.5% NaOCl, followed by 2.5 ml of 17% ethylenediaminetetraacetic acid (Aria Dent, Tehran, Iran), for a period of 5 min.<sup>[4-17]</sup> Then, with new irrigation of 1 ml of 2.5% NaOCl at each change of files, the specimens were washed in sterilized distilled water and autoclaved.<sup>[8]</sup>

Then, each group randomly was divided into six experimental groups ( $n = 20$ ) based on the taper of master cones (0.02, 0.04, and 0.06) as follows:

- Group 1: Root canal curvature <20° and filled with 0.02-tapered gutta-percha master cone
- Group 2: Root canal curvature <20° and filled with 0.04-tapered gutta-percha master cone
- Group 3: Root canal curvature <20° and filled with 0.06-tapered gutta-percha master cone
- Group 4: Root canal curvatures between 20° and 40° and filled with 0.02-tapered gutta-percha master cone

- Group 5: Root canal curvatures between 20° and 40° and filled with 0.04-tapered gutta-percha master cone
- Group 6: Root canal curvatures between 20° and 40° and filled with 0.06-tapered gutta-percha master cone.

The canals were obturated with gutta-percha (VDW, Munich, Germany) and AH Plus sealer (De Trey/Dentsply, Konstanz, Germany). A size 30 master gutta-percha cone was coated with sealer and placed within the canal at the working length. Subsequently, a #25 finger spreader (Dentsply Maillefer) was put in between the canal wall and the gutta-percha point; after removal, a standardized accessory gutta-percha point (0.02 tapered) coated with sealer was inserted into the residual space. The process was repeated until the spreader no longer goes beyond the coronal one-third of the canal. The excess gutta-percha has been removed with a hot plugger (Dentsply Maillefer, Ballaigues, Switzerland), and the coronal filling has been compacted into the root canal orifice. Then, the specimens were kept in an incubator at 100% humidity and 37°C for 14 days before evaluation.

### Polymicrobial leakage

Following the completion of canal obturation, the dental crown was cut by a diamond disk (D and Z Diamant, Berlin, Germany) along with a cooling spray so that all the samples had an equal root length of 10 mm. Two layers of nail varnish (Colorama, São Paulo, Brazil) were applied all over the external surface of teeth but leaving a 2-mm area around the apical foramen and canal orifices. This was done to prevent the bacterial leakage through the lateral canals.<sup>[9]</sup> In the positive control group, the teeth were coated with two layers of nail varnish, except for their apical 2 mm and their coronal access cavities. In the negative control group, the teeth were obturated without sealer and covered completely with two layers of nail varnish including apical portion.

The split chamber microbial leakage model consisted of an upper chamber, and a lower chamber as described by Torabinejad *et al.* was used for microleakage evaluation.<sup>[9]</sup> Initially, to prevent lateral leakage, two layers of nail varnish were used on the external surface of the roots apart from the apical foramen and the orifice areas. To make the two-chamber leakage setup, a hole was made at the end of the 2-ml syringes, and the tooth samples were

placed into the hole so that the orifice area was within the syringe and the apex was out of it. It forms the upper chamber that bacterial suspension was injected. For the lower chamber, the penicillin vial was used which would contain the cell culture medium. The syringes pressed into the vials. The gap between the roots, syringes, and the vials bonnets were sealed with adhesive and nail varnish. Bacterial leakage to brain heart infusion (BHI) broth in the lower chambers was checked per day for 10 weeks. The turbidity of BHI broth in the lower chambers was recorded by the day. Data were analyzed using Kaplan–Meier approach, log-rank test, and Chi-square tests.  $P < 0.05$  was considered statistically significant.

## RESULTS

In the present study, the turbidity of the BHI broth in the vials (leakage) was evaluated daily for a period of 70 days. In all positive control groups, lower chamber BHI medium turned turbid at 24 h after incubation; however, none of negative controls turned turbid.

### The analysis and comparison of leakage in studied groups

The results of leakage in different groups are described in Table 1.

The results depicted in Table 2 demonstrate that there was a significant difference among the microleakage of the 0°–20° canal curvature in the 1, 3 groups and 2, 3 groups ( $P < 0.05$ ); however, no significant difference was noted between the microleakage of Groups 2 and 3 ( $P > 0.05$ ). It suggests that low curvature root canals obturated with the 0.06-tapered gutta-percha are more likely to leak than those obturated with 0.02- and 0.04-tapered gutta-percha. Accordingly, the microleakage of the 20°–40° canal curvature in the 0.04-tapered gutta-percha was more than those obturated with 0.02-tapered gutta-percha, but there was no statistically significant difference between them ( $P > 0.05$ ). As well as, the microleakage of root canal obturated with 0.06-tapered gutta-percha was more than those obturated with 0.02- and 0.04-tapered gutta-percha, but the difference is not itself statistically significant ( $P > 0.05$ ), that is, the efficiency of different taper gutta-percha in providing an apical seal of canals with high curvature is approximately the same [Table 2].

The comparison of canals obturated with 0.02-tapered gutta-percha showed that although the number of leaking specimens per group and the leakage range with curvature of 20°–40° are

**Table 1: The average leak rate per group**

Group	Microleakage score, n (%)
1	10 (50)
2	10 (50)
3	18 (90)
4	12 (60)
5	13 (65)
6	15 (75)

**Table 2: The comparison of leakage between each tested groups**

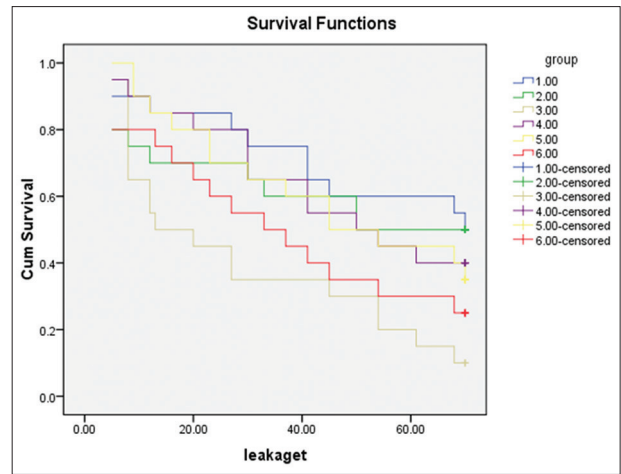
Group	1	2	3	4	5	6
1			0.007	0.376		
2			0.007		0.262	
3	0.007	0.007				0.204
4	0.376				0.500	0.2050
5		0.262		0.500		0.366
6			0.0204	0.25	0.366	

greater than the curvature of 0°–20°, this difference is not statistically significant ( $P > 0.05$ ). Therefore, 0.02-tapered gutta-percha has the same efficiency for filling canals with curvatures of 0°–40° [Table 2]. The comparison of canals obturated with 0.04-tapered gutta-percha showed that although the number of leaking specimens per group and the leakage range with curvature of 20°–40° are greater than the curvature of 0°–20°, this difference is not statistically significant ( $P > 0.05$ ). Therefore, 0.04-tapered gutta-percha has the same efficiency for filling canals with curvatures of 0°–40° [Table 2]. The comparison of canals obturated with 0.06-tapered gutta-percha showed that although the number of leaking specimens per group and the leakage range with curvature of 20°–40° are greater than the curvature of 0°–20°, this difference is not statistically significant ( $P > 0.05$ ). Therefore, 0.06-tapered gutta-percha has the same efficiency for filling canals with curvatures of 0°–40° [Table 2].

**Runtime leakage analysis**

According to the obtained data, the minimum time required for microbial leakage from coronal to the apical region in the molar teeth is 5–8 days. To compare the time of leakage between the studied groups, survival and Kaplan–Meier tests were used. The log-rank test was used to examine whether there is a difference between two groups’ survival times, and statistical differences were found between the studied groups ( $P < 0.05$ ) [Table 3 and Figure 1].

The analysis and comparison of two groups revealed that there was a significant difference



**Figure 1: Kaplan–Meier survival curves for study groups.**

between Groups 1 and 3 as well as 2 and 3, respectively ( $P < 0.05$ ) [Tables 4 and 5].

**DISCUSSION**

The development of NiTi instruments has been developed to make root canal preparation easier and more operative, especially preparation of the curved canals.<sup>[18]</sup>

The present study was conducted on mandibular molar teeth with a curvature of 0°–40°. The canals were prepared using RaCe rotary files with 0.06 taper. These RaCe files are able to preserve the original form of the double-curved (S-shaped) canal with least possible root canal transportation.<sup>[9]</sup>

The present study showed that using the 0.02- and 0.04-tapered gutta-percha master cone causes more leakage in teeth with a curvature of 20°–40° compared to 0°–20°. Similarly, 0.06-tapered gutta-percha master cone causes more leakage in teeth with a curvature of 0°–20° compared to 20°–40°.

Nagas *et al.*, 2009, in a study compared two technique of root canal obturation. After preparation, all root canals of incisor teeth were obturated by rotary NiTi files with a taper of 0.06 up to no. 30. The apical leakage was measured by dye penetration method, and no significant difference was observed between the groups.<sup>[12]</sup> The results of this study concerning 0.02 and 0.04 gutta-percha are similar to the results of Bidar and the present study, but despite the use of taper 0.06, there was no significant leakage difference between the obturated teeth, which is contrary to the results of the present study. This difference could be explained by different methods of evaluating

**Table 3: The mean, median, maximum and minimum days, number of specimens leaked, and percentage of each group leaked**

Group	The means and medians for survival time							
	Mean				Median			
	Estimate	SE	95% CI		Estimate	SE	95% CI	
			Lower bound	Upper bound			Lower bound	Upper bound
1	52.200	5.587	41.250	63.150	70.000			
2	45.150	6.230	32.939	57.361	50.000			
3	29.300	5.375	18.765	39.835	13.000	8.944	0.000	30.531
4	47.100	5.163	36.980	57.220	50.000	14.534	21.512	78.488
5	46.550	5.542	35.687	57.413	45.000	12.671	20.165	69.835
6	37.350	5.587	26.399	48.301	33.000	11.180	11.087	54.913
Overall	42.942	2.366	38.304	47.579	45.000	5.170	34.867	55.133

SE: Standard error; CI: Confidence interval

**Table 4: Runtime leakage analysis**

Overall comparisons			
	$\chi^2$	df	Significant
Log-rank (Mantel-Cox)	13.245	5	0.021

**Table 5: The comparison of microleakage between the study groups at each time interval**

Group	1	2	3	4	5	6
1		0.828	0.003	0.510		
2	0.828		0.021		0.596	
3	0.003	0.021				0.273
4	0.510				0.815	0.228
5		0.596		0.815		0.321
6			0.273	0.228	0.321	

the leakage (using only just dye leakage and apical leakage methods).<sup>[12]</sup>

Hembrough *et al.*, 2002, compared the root canal filling feature and efficacy of lateral condensation using different tapered master gutta-percha cones. After preparation of single-rooted canal with 0.06- and 0.02-tapered rotary files, they found that 0.06-tapered gutta-percha cones were more efficient than 0.02-tapered gutta-percha cones concerning the number of accessory points used, while the filling quality was not significantly different for both methods.<sup>[19]</sup>

Gordon *et al.*, 2005, reported an analogous percentage of gutta-percha-filled areas between single cone and lateral condensation techniques. They compared the area filled by the gutta-percha/cement or the empty spaces in curved canals simulated in resin blocks with curvatures of 30° and 58° and in mesial-buccal canals of extracted maxillary first molars. The specimen preparation was executed using the ProFile

0.06 system, and the obturation was performed using size 0.06 single cone and size 0.02. The authors concluded that the size 0.06 single-cone technique was comparable with the lateral condensation on the subject of amount of gutta-percha inhabiting the curved canals simulated in resin blocks with curvatures of 30° and 58°.<sup>[13]</sup>

Bal *et al.*, 2001, compared the quality of the seal in canals prepared in a standardized manner and obturated with a 0.06- or 0.02-tapered gutta-percha master cone using lateral condensation technique. The result showed that when a 0.02-tapered master cone was used, the spreader penetrated significantly closer to working length than when a 0.06-tapered master cone was used and concluded that the penetration depth of spreader in the lateral compaction technique affects the quality of the apical seal; however, the difference between two groups was not significant regarding bacterial penetration.<sup>[2]</sup> The result of Bal *et al.*'s study was inconsistent with the result of present study. The difference could be explained due to using anterior teeth with single straight canal which has less curvature complexity and using one type of bacteria (*Proteus vulgaris*) for microleakage measurement.<sup>[2]</sup>

## CONCLUSION

The lateral condensation filling technique using 2% and 4% master cones is more effective in minimizing microbial leakage in straight canals than 6% tapered master cone (RaCe system). Furthermore, 0.02-, 0.04-, and 0.06-tapered master cone are equally effective in preventing microbial contamination of curvature canal.

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## Conflicts of interest

The authors of this manuscript declare that they have no conflicts of interest, real or perceived, financial or nonfinancial in this article.

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