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Comparison of Coronal Leakage in Tooth Preparation with Two Single File Systems and Three Obturation Techniques

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ABSTRACT

Aim and objectives: In endodontics, root canal preparation and obturation are crucial. Its goal is to eradicate periradicular and pulpal diseases. This study compared coronal bacterial microleakage in prepared root canals utilizing single cone gutta-percha, hybrid (tapered cone/lateral compaction), and Neoniti A1 and Reciproc files that obturated with lateral compaction.

Materials and Methods: In this study, a total of 140 single-rooted mandibular first premolars were choose and randomly divided into two study groups A and B (each 60) that one group was prepared with Reciproc and another with Neoniti A1 and negative and positive control groups (each 10). Each group divided into three subgroups of 20 each and obturated using a single cone technique, lateral compaction technique, and hybrid (tapered cone/lateral compaction) techniques. To assess coronal leakage, a "two-chamber setup" was employed. After being injected into the upper chamber, the enterococcus faecalis culture fluid was incubated. The lower chamber turns turbid if the bacteria are able to get past the obturation materials and channel. Every day, the incidence of turbidity in the TSB medium in the bottom chamber (apex) was examined, and the length of time that leaking occurred was noted. The data were analyzed using Chi-square test.

Results: Data analysis showed that in each group the difference in percentages between subgroups was statistically significant ($P = 0.003$). So that the highest and the lowest amount of leakage in both groups were related to lateral compaction and hybrid techniques, respectively.

Conclusion: Regardless of the instrument used for canal preparation, the hybrid method and single-cone technique were more successful than the lateral condensation technique in preventing coronal leakage under the study's conditions.

Key Words: Dental leakage, single-cone obturation technique, lateral compaction, tooth preparation

INTRODUCTION

The quality of root canal preparation, the ability of filling materials to create a fluid-tight seal, and the appropriate coronal restoration all have a role in the outcome of endodontic treatment. New concepts for cleaning and obturating root canal systems have been influenced by technological advancements in the production of nickel-titanium (NI-TI) rotary devices. According to studies, using single file rotary devices for preparation speeds up the process and reduces procedural errors.[1–3]. The recently introduced Neoniti A1 (NEOLIX, Châtres-la-Forêt, France) rotary file is composed of M-Wire alloy, which prepares the canal with continuous rotary motion [4] and the VDW (Munich, Germany) reciprocal file, which has an S-shaped cross section, a non cutting tip, and sharp cutting edges that shape the canal through reciprocal motion (30° clockwise and 150° counterclockwise) are two examples of single-file system.
.[1] Studies that used these systems have shown that like other rotary systems, these files can maintain the original shape of the canal.[5,6] Obturation with warm gutta-percha systems is hard and time-consuming; so many dentists prefer to use the systems that obturate the root canal in less time. Using the single-cone gutta-percha that matches the NiTi rotary instruments can fulfil three-dimensional filling in less time compared to conventional methods.[7,8] If the diameter and taper of gutta-percha exactly matches the shape of the prepared canals, the quality of root filling will be superior to conventional methods.[9]

Several studies have emphasized the issue of standardization problems both in instruments and gutta-percha cones while others have pointed to dimensional variability of gutta-percha in two dimensions.[9,10]

Amanda Rodrigues et al. concluded that single-cone technique provided greater percentage of gutta-percha area than the lateral compaction in the apical third of mesial root canals of mandibular molars.[11]

Gordon et al. compared the percentage of gutta-percha, Sealer, and voids between the two single-cone and lateral condensation techniques. They found that at the 2.5 mm distance from the apex percentage of occupied area with single-cone gutta-percha was significantly more than the lateral condensation technique while no difference is seen in other levels.[12]

In contrast to variable tapered single-cone gutta-percha, Schäfer et al. found that lateral compaction and single-cone procedures employing constant tapered gutta-percha produced a higher percentage of gutta-percha area at the apical levels.[13]Since there aren't many studies comparing the coronal leakage of canals obturated with single cone prepared with single-file systems, the purpose of this ex vivo study was to compare the leakage of E. faecalis in root canals prepared with two single-file rotary systems, Neoniti A1 and Reciproc, using three different obturation methods: lateral compaction, single cone, and hybrid.

MATERIALS AND METHODS

In this ex vivo study, a total of 140 single-rooted mandibular first premolars were studied which were extracted due to periodontal or orthodontic reason in surgical department of Rama Dental college.

Inclusion criteria were single-rooted teeth with a round cross section and approximately the same length. All specimens were examined using a stereomicroscope (×25) to confirm the lack of cracks. Radiographs of teeth in both buccolingual and mesiodistal directions were taken to exclude the samples with more than one canals, severe curved, internal or external root resorption, calcification, or apical size more than No. 15 K file. Teeth were cleaned of adhering soft tissue and debris and stored in physiologic saline solution at 4°C before the study.

All tooth crowns were cut using a high-speed handpiece and coolant at a distance of 16 mm from the apex. No. 15 k file was used to achieve patency, and the working length was found to be 1 mm less than the apical foramen.

Comparable research were used to calculate the sample size.[14,15] Based on the instrumentation technique, 140 teeth in total were taken into consideration for the experimental groups. The teeth were then randomly split into two groups of 60 each.

Using an electric motor (RECIPROC silver, VDW, Japan) with torque control, full rotation, and up/down motion, the root canals in group N (n = 60) were prepared using NEONITI A1 single-file (25/0.08) (NEOLIX, Châtres-la-Forêt, France) along the working length in accordance with the manufacturer's instructions. In group R (n = 60), the electric motor with torque control (RECIPROC silver, VDW, JAPAN) and the device on the Reciproc All button were used to prepare the root canals along the working length using RECIPROC single file (25/0.08) (VDW, Munich, Germany) in accordance with the manufacturer's instructions.

Five samples were prepared using the Reciproc file and obturated using the single-cone technique, while five samples were prepared using the Neoniti A1 file and filled using the lateral compaction technique. Ten teeth were used as a negative control group. To stop leaks, two layers of nail varnish were applied to every tooth in this group. Out of the ten positive control group samples, five were created using the Reciproc file, while five were prepared using Neoniti A1 and without obturation.

After every removal, the files in every group were cleaned with fresh gauze to remove any debris. A 27-gauge needle was used to irrigate the canals with physiologic saline during preparation. Once the instrumentation was finished, the patency was controlled by passing a #15 K file 1 mm through the apex to the foramen. Five milliliters of 5.25% NaOCl, five milliliters of 17% EDTA (Biodinamica, Ibipora, Brazil) for one minute, and ten milliliters of distilled water were used as the last irrigation for every root canal. After that, sterile paper points were used to dry the canals.

The prepared canals in both groups were split into three subgroups (n = 20) at random based on root canal obturation methods. Subgroup SC (single-cone technique): Gutta-percha No. 25/0.08 (Gapadent, Republic of Korea) was used as a single cone and AH plus sealer to obturate the canals. A heated tool was used to remove extra gutta-percha.
Subgroup LC (Lateral compaction): No. 25/0.02 gutta-percha was used to obturate the canals as a master cone covered with AH plus sealant, and a finger spreader was used to compact the accessory cones next to the master cone. Subgroup H, hybrid (single cone/lateral compaction): The canals were obturated using gutta-percha No. 25/0.08 (Gapadent, Republic of Korea) as a master cone coated with AH plus sealer, and then at least two 2% gutta-percha cones were placed next to the master cone to use the lateral compaction technique. The whole process of preparation and obturation was performed by an endodontist.

The obturated teeth were checked buccolingually and mesiodistally using X-ray to check the quality of obturation. The teeth were kept in 100% humidity at 37°C for 1 week to allow the sealer to set.
To assess the bacterial leakage, a double chamber setup was employed. Initially, two coats of nail varnish were applied to the outside of the roots, excluding the apical foramen and the orifice areas, in order to stop lateral leaking [16]. A hole was created at the end of the 2 ml syringes to create the two chamber leaking setup, and the tooth samples were inserted into the hole so that the apex was outside the syringe and the origin area was within. It creates the upper chamber into which the injected bacterial suspension was placed. The penicillin vial, which would hold the cell culture media, was utilized for the lower chamber. The vials' silicone bonnets were perforated in accordance with the size of the syringe end. The syringes pressed into the vials. The gap between the roots, syringes, and the vials bonnets were sealed with adhesive and nail varnish.

Under the sterile conditions using a micropipette equivalent to 0.5 McFarland suspensions of 24-h growth of Enterococcus faecalis (ATCC = 29212) in BHI broth (Difco, Detroit, MI, USA) containing 1 × 108 bacteria was injected into the upper chamber (the coronal) and the set up incubated at 37°C. Bacterial leakage to BHI broth in the lower chambers was checked daily for 8 weeks. The turbidity of BHI broth in the lower chambers was recorded daily. A new 24-h growth of E. faecalis was added each 3 days. The bacterial growth in the lower chambers was cultured to ensure that the reason of turbidity is just E. faecalis. Data were entered to SPSS 20 (IBM Corp., Armonk, NY, USA) and were analyzed using Chi-square test at 0.05 significance level.

RESULTS

The results of data analysis into two experimental groups: (Neoniti A1 and Reciproc) and six subgroups of 15 teeth (with three obturation technique: lateral compaction, single cone and hybrid) and both positive and negative control groups are listed in
Table 1. All samples of the positive control group were turbid within 24 h from the base line while all samples of negative control group showed no turbidity by the end of the project
According to Table 1, during the study in both preparation groups, the highest percentage (100%) of leaks to the lateral compaction and the lowest amount was pertinent to hybrid technique.
The Chi-square test showed that the difference in percentages between the 6 subgroups of the study is statistically significant

($P = 0.003$). The test also showed that in each group the difference in percentages between subgroups was statistically significant

($P < 0.05$) So that in both groups, the highest leakage was associated with lateral compaction, and the lowest amount was related to hybrid subgroups.

In comparison of similar subgroups in both groups, Chi-square test showed that the percentage of turbidity between the two subgroups of SC (P = 0.624), two subgroups of LC (0.713) and between the two subgroups of H (P = 1) was not statistically significant. This finding means that the method of instrumentation had no effect on the coronal leakage.

TABLE 1.Comparision of bacterial leakage if studied samples in different groups and subgroups

Group	Subgroup	n	Domain	Turbidity positive (%)	Turbidity negative (%)	Chi-square test*
Neoniti(N)	Single C Lateral C Hybrid	15 15 15	11-41 3-52 12-43	13(86) 14(100) 9(60)	2(14) 0 5(40)	P=0.014
Reciproc(R)	Single C Lateral C Hybrid	14 15 15	8-43 4-44 10-52	12(80) 15(100) 8(53)	4(40) 0 7(45)	0.009
Control Positive		10	1>	10(100)	0	
Control Negative		10	-	0	10(100)	
Chi-square test*			-			

*Comparision of leakage between subgroups of each group,**Comparision of leakage between all subgroups

DISCUSSION:

Post-endodontic coronal leakage can permit bacterial penetration in the filled root canal system, leading to recontamination and treatment failure, according to both in vitro and in vivo studies. Knowing how long it takes for germs to infiltrate the root-canal obturation material and re-infect the entire canal length following preparation with two single rotary files is a significant concern for all clinicians: Neoniti A1, as well as obturation and reciprocation using these three techniques: Techniques such as single cone, lateral condensation, and hybrid. Numerous techniques, such as dye penetration, bacterial leakage, bacterial metabolites, electrochemical methods, radioisotope, and fluid filtration, have been proposed to evaluate coronal bacterial leakage. Coronal leakage of Enterococcus faecalis was selected for this study because it somewhat mimics clinical conditions. In addition, this bacterium is a common component of the human oral flora and is often found in dental infections with facultative anaerobes and other aerobes [17,18]. It is also the most frequently isolated microbe from canals with post-treatment disease.[19] The purpose of using a single species in this investigation was to make setup and outcome interpretation easier. Models of the double-chamber approach, which Saberi et al. had previously employed, were employed.[20]

The results showed that regardless of preparation technique, in both Group N and R, maximum leakage was observed in lateral condensation technique (Domain: Reciproc: 4–44 days, Neoniti A1: 3–51 days) then single cone (Domain: Reciproc: 8–43 days, Neoniti A1: 11–41 days) and at the end hybrid technique (Reciproc: 10–52 days, Neoniti A1: 12–43 days) due to the fact that 40%–47% of hybrid group and 14%–20% in single cone group remained free of l leakage by the end of the study. The differences between the various methods of obturation in both groups N and R were significant (P < 0.003), but there were no differences between the same subgroups, this finding indicates that preparation technique has no effect on bacterial leakage. Studies have shown that obturation following preparation with Ni-Ti rotary instruments had less microleakage than hand instruments, because the rotary files, making the smoother walls and these canals obturated more easily.[21]AH plus sealer was used in this study.

Although there were no changes between the same subgroups, the differences between the different obturation techniques in groups N and R were significant (P < 0.003), suggesting that preparation technique has no bearing on bacterial leakage. Because the rotary files make the walls smoother and these canals obturate more easily, studies have demonstrated that obturation after preparation with Ni-Ti rotary instruments had less microleakage than manual instruments.[21]

According to one study, because AH + is less soluble and shrinks less, it exhibits less apical microleakage than all ZOE formulations or calcium hydroxide base sealers. According to the results, AH Plus/gutta-percha and Epiphany/Resilon produced the same coronal seal

[22]. However, other research suggests that gutta-percha and AH-plus do not provide resistance to coronal leakage, and that when coronally challenged, gross leakage increases during the first four months after obturation.[23]

In the present study, 100% of the samples of in lateral compaction technique in two groups were infected within 3–51 days. Void formation in the body of the filling while using the spreader and the shrinkage of the sealer and gutta-percha are possible reasons for the relatively inferior results obtained with lateral compaction techniques.

The lateral compaction technique required a minimum of less than a week for leaks to start. Two experiments on bacterial leakage by Saberi et al. also demonstrated that leakage happens in a week when the coronal seal is absent and the lateral condensation approach is used.[20, 24] According to Kersten et al., the effectiveness of gutta-percha's cold lateral compaction, which is commonly utilized in root canal therapy, varies based on the canals' various morphologies.[25]

In single-cone subgroups during the study period, 84% and 81% were infected in group N and R, respectively.

This noncompaction, single-cone filling of root canals has been introduced to minimize the sealer component with gutta-percha cones closely match to the geometry of NI-TI rotary instrument and ensure 3-dimensional obturation of the root canal without necessitating accessory cones and with less time spent.[12] However, its success depends on the canal geometry to create a rounded tapered canal with a strict adaptation of gutta-percha cones to the prepared canals.

However, the filling material cannot penetrate the irregularities in the canal wall due to one gutta-percha cone and lack of compaction. This will result in the formation of voids between the gutta-percha and sealer, and the coronal seal will not be produced.

Robberecht et al. compared tapered single-cone method versus warm vertical condensation and injection system and concluded that a better apical adjustment of gutta-percha and a greater number of filled lateral or accessory root canals was perceived with the combined-system filling technique whereas low voids were observed in single-cone group in the coronal two-thirds.[26] Yilmaz et al. reported that cold laterally compacted gutta-percha and the single-cone technique had similar sealing properties with the BeeFill system, which all were better than that of System B/Obtura II.[15]

In several studies, both cold laterally compacted and single-cone gutta-percha have been compared with vertical compaction techniques, demonstrating better,[27] similar,[28] or inferior[29] sealing properties. Such inconsistent results may be due to differences in tooth preparation, time, protocols of experiment, storage conditions, and the type of sealer used.

Another point that should not be ignored is adaptation of gutta-percha with the last file used in the canal.

Chesler et al. showed that all intra manufacturer diameters and tapers were significantly different from each other. For example, the diameter tolerance of #30 files is 0.02 mm and for gutta-percha cones is 0.07 mm. Discrepancy between files and cones can be 0.09 mm or nearly 2 ISO file sizes.[30]

Obviously, a single technique is unable to establish a complete seal although the mass of gutta-percha used in this technique is more than lateral condensation.

Only 60% and 53% of the samples in the N and R groups, respectively, were infected during the analysis, indicating the hybrid group had the lowest leakage in this investigation. The coronal leakage was greatly decreased by using supplementary cones and the tapered cone technique. Even though the tapered cone/accessory cones method greatly reduced coronal leakage in the current investigation, the results also demonstrate that none of the three obturation techniques could produce an optimal sealing.

CONCLUSION

Dentists should refrain from oversimplifying their procedures. A thorough understanding of the root canal's anatomy, adherence to preparation guidelines, and three-dimensional filling are crucial, and it is advised to use strategies that help achieve these objectives.

Although the results of in vitro studies cannot be fully extended to clinical conditions, the shortcomings of various techniques could be realized and resolved based on these studies. For instance, control of working length, use of sealer and accessory cones, master cone fit to the apical size, and warm vertical compaction of gutta-percha to fill voids and irregularities can be mentioned.

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