RESEARCH ARTICLE

Effectiveness of apical sealing ability of Gutta-Percha with resin AH Plus Sealer measured by apical microleakage in lateral condensation compared to single cone techniques: an in vitro study

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ABSTRACT

Introduction: Root canal therapy means filling pulp space three-dimensionally after disinfecting, cleaning, and shaping. We have many techniques for obturation. Each has its characteristics and drawbacks, defining its effectiveness in clinical practice.

Objective: This study aimed to compare the apical sealing ability of gutta-percha and resin AH Plus sealer using lateral condensation and single cone obturation techniques.

Methods: Fifty human straight palatal roots of freshly extracted maxillary 1st molars were cleaned and disinfected using 5.25% NaOCl. After preparing the accessed cavities, the pulp tissue was removed from the pulp chamber, and then size #10 K-file was introduced into the canal until it was seen at the tip of the apical foramen. The specimens were randomly divided into two groups. Group 1: The roots were prepared with stainless-steel K-File, starting from #10 till #40. Step-back is performed with the following three sizes. 1 ml of 5.25% NaOCl was used as an irrigant during preparation and between each instrument. All samples were filled with gutta-percha and AH Plus sealer using the cold lateral condensation technique. Group 2: Biomechanical preparation of the canals was done using hand ProTaper instruments from SX to F4. All samples were filled with gutta-percha and AH Plus sealer using the single cone technique. All samples were incubated at 37°C for 7 days. Apical microleakage was evaluated using dye penetration methodology.

Results: Means microleakage among specimens of group 1 and group 2 were 1.29 mm and 1.17 mm, respectively. Significant results were obtained when the mean microleakage between the groups was compared.

Conclusion: Obturation with tapered single cone technique of gutta-percha and resin AH Plus sealer provides a superior apical seal than the lateral condensation technique.

Key words: Apical microleakage, lateral condensation technique, single cone technique, AH Plus sealer.

INTRODUCTION

The main objective of root canal therapy is to fill the pulp space three-dimensionally after disinfecting, cleaning, and shaping it. The chief goal of this filling is to hermitic seal all the exit portals of the pulp space to hinder the transportation of microorganisms along the pulp system and periapical tissue.[1]

In the world of endodontics, many techniques for obturation are presented, like cold lateral compaction, vertical condensation, thermoplastic gutta-percha, and, more recently, single-cone obturation techniques.[2] Although it is the oldest obturation technique, lateral compaction is still widely used; nevertheless, it needs more skill, requires further time, and may extrude the filling materials apically.[3] Yet, some side effects of the lateral condensation procedure have been demonstrated as the inability to copy the internal anatomy of the pulp system, vertical traces of spreaders, lack of the fusion of GP cones, voids and inadequate adaptation to the root canal walls.[4]

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There is a growing demand for prompt and effective obturation techniques that enhance practice and reduce anxiety for the dentist and patient. The single-cone obturation technique has been more common due to the extensive use of rotary Nickel-Titanium (NiTi) systems and corresponding GP cones.[5] In addition, obturation using a single cone technique takes less time. Gordon et al. (2005) stated lateral condensation required more time than the single cone technique.[5] It was confirmed that the GP cones of the ProTaper system that matched the final NiTi file can be successfully applied for a single cone filling procedure.[6]

Studies define microleakage as the ingress of oral cavity fluids lengthways the interface between the restoration and tooth substrate, cement or root canal filling materials.[7] Recently, it has been confirmed that apical and coronal leakage have significantly adverse effects on the long-term success of root canal management.[8]

Hence, the present study aimed to evaluate and compare the apical sealing ability of gutta-percha and resin AH Plus sealer on two different obturation techniques: lateral condensation and single cone obturation techniques.

METHODS

Study design and setting: In vitro experimental non-randomised controlled study conducted 2022 jan to july, Al-Muthanna Specialized Center of Dentistry

Ethical consideration: The research ethics committee of Al-Muthanna Health Directorate has approved the research protocol of this study. We agreed with Al-Muthanna Specialized Center of Dentistry to do the study on its facility.

Inclusion and exclusion criteria: Fifty human maxillary first molars, extracted from mixed population due to various therapeutic purposes were selected for the present research. The study specifically experienced the sound straight palatal roots of the selected teeth, which have fully formed apices and without restorations, resorption, caries or fractures.

The enrolled teeth were cleaned under running tap water and then disinfected using 5.25% sodium hypochlorite. Pre-operative periapical radiographs were documented in mesiodistal directions to assess the anatomy of the roots. Then, the samples were saved in 0.2% thymol solution (Sigma, Poole, UK) till they were used.

Procedure:

Samples Preparation: The samples were decoronated with a diamond disc (Mani, Utsunomiya, Japan) under water cooling to get a final length of 12 mm. Then, A stainless-steel K-File #10 (Dentsply, Maillefer, Swiss) was introduced into the root canal to eliminate pulp tissue till the tip was seen just exiting at the apex. The working length was determined by subtracting 1mm from this length. The apical foramen was closed with sticky wax (GC, Chemical Co, Japan) to prevent the extrusion of irrigant solutions out of the apical foramina.

Samples Grouping: The samples were separated into two groups, each with 25 teeth.

GROUP 1 using lateral condensation obtration technique: The samples of this group were prepared with stainless-steel K-File (Dentsply, Maillefer, Swiss), starting from # 10 till # 40 (as master apical file). The step-back was performed with the next three sizes, subtracting 1mm for each instrument. We used 1ml of 5.25% NaOCl (Chloraxid, Pawlowski, Poland) as an irrigant during preparation and between each instrument.

GROUP 2 using single cone technique: Biomechanical instrumentation of the samples was done using hand ProTaper files (Dentsply, Maillefer, Swiss) in a serial order from SX to F4 rendering to manufacturer's advice. As for group 1, during instrumentation and between each file, 1 ml of 5.25% NaOCl was used as an irrigant.

Protocol Of Final Irrigation: The sequence of final irrigation of the canals was as follows:

- 1 ml of NaOCl (5.25%) with sonic activation for 30 sec.

- 5 ml of DW and dried with absorbent paper point (#40).
- 1 ml of EDTA (17%) and sonic activation for 30 sec.
- 5 ml of DW and dried with absorbent paper point (#40).
- 1 ml of NaOCl (5.25%) with sonic activation for 30 sec.
- 5 ml of DW and dried with absorbent paper points (#40).

Root Canals Obturation:

Group 1 (Lateral Condensation Technique): An ISO size 40 GP cone was checked for a tug back at working length. Just before the obturation, the canal was coated with a thin layer of AH Plus sealer (Dentsply, Konstanz, Germany) with the help of a lentulo spiral by rotating counter-clockwise and then up and down motion twice throughout the length of the canal. Then, the master cone was coated with sealer and inserted slowly into the canal to the full working length. Lateral condensation with accessory gutta-percha cones was performed by NiTi finger spreaders (Dentsply, Maillefer, Swiss).

Group 2 (Single Cone Technique): The samples were obturated with ProTaper F4 GP (Dentsply, Maillefer, Switzerland), using a single cone technique by inspection for tug back. The sealer application was the same as group 1. The apical master cone was seated at the working length.

The excess GP was eliminated with a hot instrument for all samples in both groups. The canal access was restored with a temporary restorative filling. Periapical x-ray films were taken to confirm the absence of voids in the obturating materials. The specimens were preserved in an incubator at 37 °C and 100% humidity for one week to set the sealer.

Microleakage Test: All the specimen surfaces, excluding the apical 2 mm, were coated with two layers of nail varnish, and then a sticky wax (GC, chemical MFG. Co, Japan) was applied to the varnished area.

Each root was bound to a rubber cap of a glass vial containing 2% methylene blue dye (Sparks, USA) and the apical 4mm of each root was immersed in this dye and then stored in an incubator for 14 days at 37°C. At the end of this period, the roots were removed from the dye and washed under running tap water for 30 minutes to remove the dye on the external root surface. The sticky wax was scraped from the sample surface with a lacron carver and washed again under running water.

The roots were grooved in a bucco-palatal direction with the water-cooled diamond disc (Mani, Utsunomiya, Japan) in a micromotor straight handpiece (W&H, Austria) without penetrating the root canal to split longitudinally with a chisel in two halves, taking care to include the apical foramen in the fracture line. Then, the filling material was removed by pulling it out using tweezers.

The linear measurement was measured from the apex to the most coronal extent of dye penetration by stereomicroscope (Olympus, USA) at 40x magnification with a calibrated scale ocular grid, and the readings were measured in millimetres. The degree of dye penetration was recorded for both the walls of the section, which showed relatively greater leakage and the mean was recorded.

To eliminate inter-observer bias, the level of dye infiltration was measured independently by two examiners, who were uninformed of the materials and techniques applied in this test. Still, they trained in the assessment procedure and recording the amount of dye diffusion. The final degree documented was the arithmetic means of the measures gained by the two examiners.

Statistical analysis: Data was processed and analysed using SPSS software version 22 and Microsoft Excel. Data are shown by mean ±SD and histograms. We used ANOVO to test the statistical significance of the difference in means. The p-value of ≤0.05 was used to define the statistical significance.

RESULTS

Table 1 and **Figure 1** summarise the

Table 1 | Apical microleakage (mm) in both groups.

Groups	Number	Mininum	Maximun	Mean	±SD	F-test	P-value
Group1 (SS)	25	1.04	1.58	1.29	0.11	10.886	0.001
Group 2 (PT)	25	0.96	1.46	1.17	0.14		

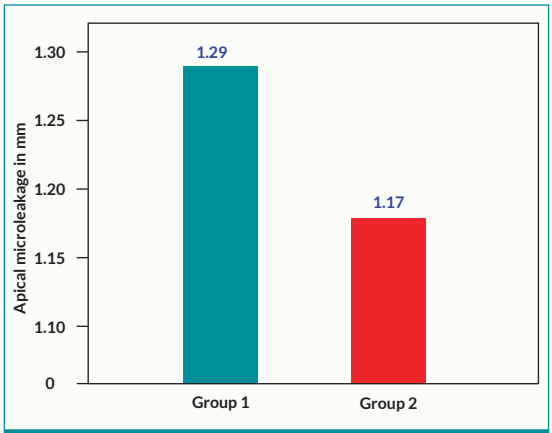

Figure 1 | Mean apical microleakage (mm) of experimental groups

effectiveness of the Apical Sealing Ability of Gutta-Percha with Resin AH Plus Sealer measured by apical microleakage in both groups.

Regarding the data mentioned above, both experimental groups demonstrated apical leakage of variable measurements, and none of the obturation techniques could eliminate the microleakage.

One way ANOVA test was applied to inferential statistics was to find differences between both groups. ANOVA test revealed that there was a statistically significant difference between the groups. See **table 1**

Statistical analysis showed that obturation techniques significantly affect the apical microleakage of endodontically treated roots.

DISCUSSION

Root canal treatment is successful if the pulp system is adequately prepared, sterilised and filled in three dimensions. The main goal of obturation is to make watertight seal lengthways for the root canal system from the coronal orifice to the apical foramen.[9]

The obturation of the root canal using GP with sealer has historically been successful.[10] Numerous obturation procedures have been documented, e.g., lateral cold compaction and single cone technique were considered to be efficiently adapted to the internal walls of the pulp system.[11]

Lateral condensation (frequently called cold lateral compaction or lateral condensation) is the standard technique of root canal obturation learned in dentistry schools.[12] This technique can be applied in different cases, does not need special armamentariums, and is successful clinically. Additionally, lateral compaction is easy for undergraduate dental students to learn, a safe technique compared with others, and has more control of the working length, yet it is time-consuming.[13]

Recently, a single cone filling procedure has been more popular, with the production of GP with a taper that has been assorted with the same NiTi rotary system.[14] Currently, most GP cones are used with a high taper of 0.04 or 0.06, which corresponds to the NiTi rotary instruments, and this concept has become more common. Consequently, GP cones were formed to be the same taper of canals instrumented with .04 rotary files. Meanwhile, 3D filling of the prepared canal is the objective of obturation; using a master GP cone, which more thoroughly matches the dimensions of the space instrumented by NiTi files, would appear to be more effective in accomplishing this goal.[3]

Tapered cones provide 3D filling of the pulp canal along its whole length without the need for additional cones or the further time consumed on cold lateral compaction.[5] The most significant disadvantage of the single-cone method is when the GP cone does not match the canal's internal anatomy at the canal's coronal and middle thirds.[10] Accordingly, the sealer collects there, and the treatment turns unfavourably affected in the long term. Also, the amount of endodontic sealer necessary

for the single cone method is more significant than that needed to complete a compaction technique.[15]

American Association of Endodontists define microleakage as the entrance of the fluids of the oral cavity along the way of the boundaries between a tooth substrate, restoration, cement or pulp system obturating materials. This definition is also valid for ingressing periapical tissue fluids coronally lengthways or any interface between the internal canal wall and root canal filling materials.

In this study, we applied passive dye penetration, the most commonly used test in coronal and apical leakage research. It is cheap, easy to use, and has extensive staining capability. [16] Thus, according to the results mentioned above, the study at hand was done to assess and evaluate the apical sealing capability of GP by two different root canal procedures: cold lateral condensation technique and single cone root canal obturation technique.

Concerning the present study's data, the maximum apical leakage was observed in group 1, where the samples were obturated with the lateral condensation technique. These results are in harmony with the results of previous researchers.[17,18]

According to Tasdemir et al.,[17] the sealing ability of a single technique was better than cold lateral compaction. These results related to the GP master cones used in this technique are the same dimensions as the final file used for preparation.

In 2000, Wu et al. demonstrated that using a final cone with a greater taper, which maximises the amount of gutta-percha (GP) in the canal and minimises the sealer volume around the cones, creates an optimal condition for improving the 3D obturation of the pulp system.[10] Furthermore, in 2000 Von Fraunhofer et al.[18] compared the microleakage of root canal filling prepared by SS and NiTi instruments. They stated that the samples prepared by the NiTi system were better sealed than those prepared by SS instruments. These results are coinciding with the study at hand.

Along the same line of thought, Holland et al. [19] estimated the effect of the type of endodontic cement and the filling method on the apical microleakage. They stated that the single cone technique attained superior root canal sealing over cold lateral compaction. The investigators revealed that the single cone technique showed fewer marginal leakage than the lateral condensation technique. Still, it was classified as over-obturating, which was displayed in all cases, which did not happen with the lateral condensation technique.

Different from these data, other authors presented that the microorganism infiltration in the canals filled with the single cone procedure was greater than in samples filled with the cold lateral compaction method.[15] These outcomes disclosed that there were no significant discrepancies between single and lateral methods in the case of periapical microleakage. These contradictory data might be due to the dissimilarity of methods applied to evaluate apical leakage under different laboratory settings. In their research, E. faecalis was utilised to assess the bacterial infiltration, and the calculation was carried out over two months. Similarly, Kumari et al. [20] documented that the lateral compaction sealed the apical foramen significantly better than the single cone procedure. These conflicting results with our study may be related to the variation in the time of immersion in the blue dye, which was twenty-four hours, but in the study at hand, it was two weeks. The literature reveals inconsistencies among the researchers, which indicate a high percentage of microleakage in the short term and those that exhibited a minor rate of specimens with leakage in the long term.[21]

Likewise, Nouroloyouni et al. presented that lateral compaction must continue to be ideal compared to the single cone technique. These various data might be because of differences in procedures, as their study used our bond strength test instead of the dye infiltration applied in our study.[2]

Two studies[22,23] indicated that lateral compaction and single cone produced

comparable leakage. According to these studies, the penetration of the spreader in lateral condensation produces acceptable filling. At the same time, in the single cone procedure, the GP master cones are similar in the tapering that corresponds to the NiTi file, offering perfect apical sealing.

The current research data suggest the single cone obturation technique is an effective alternative to the cold lateral compaction technique as it offers satisfactory sealing at the apical foramen, is easy, and requires less time.

CONCLUSION

Despite the limitations of this study, the data indicate that the single-cone obturation technique with ProTaper hand instrumentation provides a better apical seal, as measured by linear dye infiltration, compared to the lateral condensation technique. However, further clinical research is needed to confirm these findings and assess their implications for treatment outcomes.

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Abbreviations list: Analysis of variance (ANOVA), Distilled water (DW), Ethylenediaminetetraacetic acid (EDTA), Fisher test (F-test), Gutta-Percha (GP), Nickle-titanium (NiTi), ProTaper (PT), Sodium hypochlorite (NaOCl), Standard deviation (SD), Stainless-steel (SS). Statistical Package for Social Sciences (SPSS), Size (#).

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