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Original Article

Dentistry Section

Comparative Evaluation of Apical Fit of Various Corresponding Gutta-percha Cones in Prepared S-shaped Canals of Simulated Mandibular Premolars: An In-vitro Study

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ABSTRACT

Introduction: The goal of root canal obturation is to completely seal the root canal system in three dimensions, in order to stop the recurrence of bacterial infections. Root canal curvatures may be apical, gradual, sickle-shaped, severe-moderate-straight curve, bayonet/S-shaped curve and dilacerated curve. Curved root canals exhibit great difficulty in cleaning, shaping and obturation of the root canal system. Normally, corresponding Gutta-percha (GP) as per the file systems are used but what is seen is that GP's don't fit properly sometimes. So, this study was done to evaluate the apical fit of four corresponding size GP points by keeping the same/ standard endodontic file system in prepared simulated canals.

Aim: To evaluate the apical fit of various corresponding GP cones in prepared S-shaped canals of simulated mandibular premolars.

Materials and Methods: The present In-vitro study was conducted at Shree Bankey Bihari Dental College, Ghaziabad, Uttar Pradesh, India for a period of one month starting from August to September 2023. After the approval of the Ethical Research Committee at Shree Bihari Dental College. A total of 40 simulated mandibular premolar models, having S-shaped canal morphology were taken. E3 Azure Files (Endostar, Poland) were used to prepare root canals. The rotational speed was set to 300 rpm and 2.5 Nm of torque. Each model's orifice was widened with an orifice opener (30/08), and then a Glide file until the Working Length (WL) was determined. The sequence used for canal enlargement was 20/04, followed by 20/06 rotary file, in a Clockwise (CW) and Counterclockwise (CCW) motion. Every tooth was prepared from the crown down, with an apical size of 20 mm with 0.06 taper. To remove debris, saline irrigation was applied to the models in combination with an ultrasonic activator. Each time a file was changed, irrigation was performed. Paper points were used to dry the canals (Dentsply). The models were then divided into four groups based on the different GP points; Group 1 (n=10) Diadent, Group 2 (n=10) Hygenic, Group 3 (n=10) Dentsply, Group 4 (n=10) META. The apical fit of GP cones in all the models was assessed using Cone Beam Computed Tomography (CBCT). The obtained results were tabulated (One-way ANOVA and Post-hoc Tukey tests, p-value ≤0.0001, (highly significant) and subjected to statistical analysis using Statistical Package for Social Sciences (SPSS) Software.

Results: The apical fit of GP cones in all the models was assessed by distance vbetween the end of GP and the prepared canal (in mm) using CBCT. Highest mean value was present among group 3 Dentsply 0.58±18 and least mean value was among group-2 hygenic (0.03±0.04). Among the groups used, Group 2 hygenic GP points showed less discrepancy in apical fit followed by META, Diadent and then Dentsply where the p-value was ≤0.0001, indicating the result to be highly significant.

Conclusion: Based on the findings of this study, it can be concluded that Hygenic GP provided the best fit among the materials tested, followed by META, Diadent, and Dentsply. Further research with broader parameters may be necessary to validate these findings across different conditions.

Keywords: Diadent, Dentsply, Hygenic, Obturation

INTRODUCTION

The goal of root canal obturation is to completely seal the root canal system in three dimensions, in order to stop the recurrence of bacterial infections. In addition to preventing hazardous bacterial products from penetrating the periapical tissues, this treatment should entomb any remaining microorganisms in the root canal walls to prevent their growth into the periapical tissue and also to deprive them of nourishment. Micro leakage between the root canal and the periapical tissues and/or oral cavity occurs when the three-dimensional seal fails [1]. There are various types of root canal curvatures, including apical, gradual, sickle-shaped, severe-moderate-straight, bayonet/S-shaped, and dilacerated. Among which cleaning, shaping, and obturation of the curved root canals are extremely challenging [2].

Modern endodontics has benefited greatly from the development of numerous innovative rotary file systems and their corresponding single cones, of which Nickel Titanium (NiTi) instruments are the preferred option for root canal debridement because of their exceptional flexibility and shape memory. They are simpler to use, enable quicker preparation, and lower the risk of canal transit [3]. Before the advent of NiTi rotary instruments, only non-standardised GP cones in sizes such as fine-medium or medium were available for use with warm vertical condensation techniques. The introduction of NiTi alloy revolutionised root canal preparation by allowing the creation of instruments with either uniform or varying taper, resulting in more predictable shaping of the apical third of the canal. This advancement led to the development of GP cones with greater taper that correspond to the shapes created by NiTi instruments [4]. For effective obturation, it is crucial to choose a master cone that fits well within the canal to ensure a fluid-tight seal. Research has shown that using a matched-taper single cone for root canal obturation generally provides a superior apical seal compared to other types of master cones.

A plethora of materials and methods have been developed for three-dimensional root canal filling. Due to its favourable biologic,

chemical, and physical characteristics, GP has been the preferred material since the middle of the 1800s and continues to be the most often used material for obturation [1]. Gutta-percha is a word derived from the Malay language where 'gutah' means sticky gum and 'pertjah' is the name of a less valuable gutta tree [5]. It is a purified coagulate made from the latex of a tropical sapote tree [6]. Concerning the chemical structure, GP is a poly (trans-1,4 isoprene) thermoplastic polymer that can exist in three crystalline forms known as α (alpha), β (beta), and γ (gamma), associated with the stereochemistry of its spatial configuration between the methyl groups (-CH3) that are attached to the carbon atoms with double bonds, leading to different spatial configurations that give it specific characteristics. The composition of dental GP is approximately 18 to 22% of GP polymer, and 37 to 75% filled with zinc oxide (ZnO) and barium sulfate (BaSO4); with waxes, colorants, and antioxidants that differ according to each manufacturer [7,8].

In the present study, CBCT was used to gauge the distance between the GP tip and tooth apex in S-shaped mandibular premolar models as it is the most valuable adjunct to evaluate the 3D obturation at all levels of curved root canal [9,10]. In clinical scenarios corresponding GP's as per the file system are used but it is seen that sometimes GP's don't fit properly. Therefore, this study was done to evaluate the apical fit of four corresponding size GP points by keeping the same/standard endodontic file system in prepared simulated canals.

MATERIALS AND METHODS

An In-vitro study was conducted at Shree Bankey Bihari Dental College, Ghaziabad, Uttar Pradesh, India for a period of 1 month starting from August to September 2023 after the approval of the Ethical Research Committee (file no- EC/NEW/INST/2022/2707).

Sample size selection: A total of 40 simulated mandibular premolar models, having S-shaped canal morphology were taken in place for extracted teeth as natural teeth present themselves with varying anatomies and different canal configurations and also to achieve standardisation and for the ease of sample collection. For this study, 40 simulated mandibular premolar models bearing the model number L4-S lower premolar- S-shaped 1 canal (inVision 3D tooth models) were used. These models are created using specialised resin technology to approximate the radio density of real teeth and to endure contemporary endodontic obturation procedures.

Preparation of Samples

In all the 40 simulated mandibular premolar teeth after the access opening, WL was determined using a size #10 K-file. Then the canal space preparation was substantially improved with size #15 K-file. E3 Azure Files (Endostar, Poland) was used to prepare root canals. The rotational speed was set to 300 rpm and 2.5 Nm of torque. Each model's orifice was widened with an orifice opener (30/08), and then a Glide file was used until the WL was determined. The sequence used for canal enlargement was 20/04, followed by 20/06 rotary file, in a CW and CCW motion. On the motor, the CW and CCW revolutions were set at four-tenths and two-tenths of a circle, respectively. The file was employed in the canal with a gradual pecking action and an extremely light apical pressure. Every tooth was prepared from the crown down, with an apical size of 20 mm with 0.06 taper. To remove debris, saline irrigation was applied to the models in combination with an Ultrasonic activator. Each time a file was changed, irrigation was performed. Paper points were used to dry the canals (Dentsply).

The prepared samples were divided into 4 groups depending on the type of GP used, each including 10 models (n=10).

Group 1- (n=10) Diadent GP points

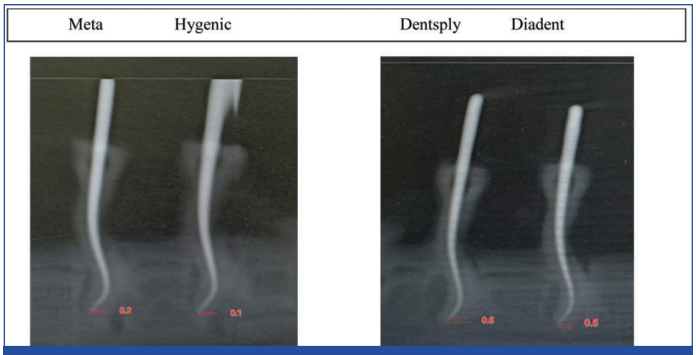
Group 2- (n=10) Hygenic GP points

Group 3- (n=10) Dentsply GP points

Group 4- (n=10) META GP points

In each group, above mentioned GP cones without using an endodontic sealer were placed into the root canal with digital pressure. The use of sealer was exempted as the purpose is to check the apical fit of GP and not the obturation quality. The samples were then mounted onto an arch made of wax and a model was created [Table/Fig-1]. CBCT was done to evaluate the fit of the GP [Table/Fig-2]. The distance between the end of GP and the prepared canal was evaluated (in mm) using CBCT.

[Table/Fig-1]: Wax model depicting the simulated tooth models mounted on wax rim, replicating the placement of teeth in the arch.



[Table/Fig-2]: CBCT images in saggital section of the evaluated samples.

STATISTICAL ANALYSIS

By measuring the distance between the end of canal preparation and the GP tip in results were documented, and statistically analysed using SPSS software (version 16). Mean comparison was found using one-way Analysis of Variance (ANOVA) and further intergroup comparison was done using post-hoc Tukey's test.

RESULTS

The mean difference among four groups was calculated using One-way ANOVA test [Table/Fig-3]. Present study was conducted to evaluate the apical fit of various corresponding GP cones in prepared S-shaped canals of simulated mandibular premolars. It was found that the highest mean value was present among group 3 Dentsply 0.58±18 and least mean value was among group 2 Hygenic 0.03±0.04. Intercomparison was done among all four groups which was found to be statistically highly-significant (p-value≤0.05)*, using One-way ANOVA test. Maximum and minimum are the observations in millimeter (SI unit) among 10 observations in each group.

Pairwise comparison among different groups was done using Post-Hoc Tukey's test [Table/Fig-4].

Pairwise comparison among different groups using post-hoc test was found to be statistically significant (p-value<0.05), however, pairwise mean difference between diadent and META (p-value-0.9), and hygenic and META group (p-value- 0.6) was found to be

Groups	Mean	Std. Deviation	Minimum	Maximum	p-value	F-value
Group 1 Diadent	0.2200	0.18738	0.00	0.60	p≤0.001	30.657
Group 2 Hygenic	0.0300	0.04830	0.00	0.10		
Group 3 Dentsply	0.5800	0.18738	0.40	1.00		
Group 4 Meta	0.1300	0.04830	0.10	0.20		

[Table/Fig-3]: Mean comparison (distance between end of GP and the prepared canal in mm) using One-way ANOVA.
Mean difference using One-way ANOVA was found to be statistically significant (p-value≤ 0.001 highly significant). Std.- standard

statistically non-significant (p>0.05) [Table/Fig-4]. Hygenic GP points showed significantly less discrepancy in apical fit followed by META, diadent and then dentsply.

Multiple comparisons		Mean Difference (I-J)	Std. Error	p-value	95% Confidence Interval	
					Lower bound	Upper bound
Diadent	Hygenic	0.19000*	0.06119	0.022	0.0192	0.3608
	Dentsply	-0.36000*	0.06119	≤0.001	-0.5308	-0.1892
	Meta	0.09000	0.06119	0.900	-0.0808	0.2608
Hygenic	Dentsply	-0.55000*	0.06119	≤0.001	-0.7208	-0.3792
	Meta	-0.10000	0.06119	0.666	-0.2708	0.0708
Dentsply	Meta	0.45000*	0.06119	≤0.001	0.2792	0.6208

[Table/Fig-4]: Post-hoc pairwise comparison of discrepancy among different groups.
Std.: Standard; *The mean difference is significant at the 0.05 level

DISCUSSION

Apical fit of GP is crucial for achieving a hermetic seal. The effectiveness of endodontic treatment largely depends on the ability of the obturation technique to properly fill the root canal system with GP and a minimal amount of resorbable sealer, ensuring good adaptation to the canal walls [9]. While straightforward, uncomplicated root canals are rare, most canals in human teeth are highly complex, often featuring significant curvatures in multiple planes [11]. Particularly challenging are dilacerated and S-shaped canals, which can be extremely difficult to manage. The preparation of these canals is especially problematic, with the apical curvature often being the most difficult aspect to handle [2].

The adaptation of master cones is evaluated through visual, tactile, and radiographic methods. To assess the fit of a GP cone to the established WL, a tug-back test is performed. Additionally, radiographs can be used to confirm the fit of the master cone. Tug-back is defined as a slight frictional resistance of a master point to withdrawal, which indicates a relative degree of adaptation at least in two dimensions, according to the American Association of Endodontists [12]. The adaptability of a single cone can be evaluated using methods like stereomicroscopy and CBCT. Clinically, adaptation of the GP cone is often assessed by the "tug-back" feeling during cone selection. Jamleh A et al., did a study where the degree of tug back was used to assess the adaptation along with the digital radiograph [13]. In the present study, cone adaptation is evaluated using CBCT technology, which provides comprehensive information about GP adaptation. The degree of tug-back was not considered due to its potential unreliability as an assessment tool [12].

Several studies [1,14] have highlighted standardisation issues with both root canal instruments and GP cones. Variability in diameter and taper exists even among GP cones of the same size from different brands. Additionally, inconsistencies in size and taper between NiTi instruments and GP cones have been observed within the same manufacturer's system [9].

While comparing different GP's in S-shaped canals prepared with Endostar rotary files it was found that, Hygenic GP's showed better apical fit followed by META, Diadent and Dentsply. According to Iványi I, et al., on comparison of GP points of different brands based on dimensional accuracy and rigidity, the most extreme deviations have been shown in META and Dentsply group [15].

The results of the present study show that GP points frequently deviate from the marked dimension. The most accurate fit was seen with Hygenic GP points. The reason for the same could be that Hygenic GP points are precisely produced by machine rolling for uniform taper and flexibility. It utilises natural raw materials to enhance its handling characteristics [16].

Limitation(s)

The results cannot be directly extrapolated to clinical scenarios hence more in-vivo studies are required to validate the findings of the present study. Moreover, this study was performed by a single researcher therefore a blinded study should be done in order to get better outcomes.

CONCLUSION(S)

Within the limitations of this study the following can be concluded that Hygenic GP showed better fit followed by META, Diadent and Dentsply. Further, more in-vivo studies are required to imitate clinical scenarios and hence evaluate the apical fit of different master GP cones with other file system.

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