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APICAL SEALING ABILITY OF DIFFERENT OBTURATION TECHNIQUES USING TWO ROOT CANAL SEALERS - AN IN VITRO STUDY.

Endodontics

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ABSTRACT

This study aims to compare the apical sealing ability of different obturation techniques, i.e., lateral compaction, injectable thermoplasticized gutta-percha, and cold flowable gutta-percha using two different root canal sealers, i.e., AH Plus sealer and GuttaFlow2. **Materials And Methods:** Eighty-five extracted single-rooted mandibular premolar teeth were selected, and canals were cleaned and shaped with ProTaper rotary files till size F2. The teeth were randomly divided into seven groups comprising five experimental groups of 15 teeth and two control groups of 5 teeth. The apical microleakage was checked by dye penetration method using India Ink followed by clearing technique. An evaluation was done using a stereomicroscope under 20X magnification. The one-way analysis of variance (ANOVA) test was used for the data analysis, followed by Tukey's post hoc test. **Results:** The mean dye penetration value for all the root canals obturated with cold flowable obturation technique (GuttaFlow2) was found to be minimum, i.e., 91.5 µm. In contrast, the maximum extent of dye penetration up to 317.6 µm was showed by Obtura II using AH Plus as a sealer. **Conclusion:** The best apical sealing ability was observed in the cold flowable gutta-percha obturation technique (GuttaFlow2), as shown by the minimum extent of dye penetration.

KEYWORDS

AH plus, Apical microleakage, GuttaFlow2, Lateral compaction, Thermoplasticized gutta-percha.

INTRODUCTION:

Complete cleaning and shaping of root canals followed by sealing of both coronal and apical aspects of the tooth are the main objectives of a successful endodontic treatment, hence impeding the apical seepage and secondary infection of bacterial substrates.[1,2]

Various studies have been conducted to evaluate the endodontic failures, and one of the most pioneers is the "Washington Study," which reported that nearly 60% of the endodontic failures were due to incomplete obturation of the root canal, whereas 3.85% of endodontic failures were due to over obturation.[3]

The obturation technique, which is the oldest and most commonly used, instructed, and accepted globally, is the cold lateral compaction. It has been regarded as the criterion for the evaluation of other techniques.It has some benefits like being economical, easy to learn and master, and controlling the fill length. However, it also has shortcomings such as lack of surface adaptation, voids, spreader tracts, time-consuming, less homogenous mass, less ability to seal intracanal defects and lateral canals, inadequate penetration in the curved canals, and incomplete fusion of gutta-percha cones.[4,5]

The limitations of the lateral compaction, as mentioned earlier, were overcome after the introduction of thermoplasticized injectable gutta-percha obturation technique. Obtura II is a thermoplasticized injectable obturation technique that is considerably better than lateral compaction and provides better acclimatization to the root canal system.[6]In addition to this, it can flow and successful in filling lateral canals.[7]Nevertheless, it also has the disadvantage of apical extrusion because of low viscosity due to plasticization on heated state and shrinkage upon cooling.

GuttaFlow2 has been introduced as a self-cure shrinkage-free material, which combines the properties of both sealer and obturation material to overcome the drawback of shrinkage of thermoplasticized gutta-percha systems.

GuttaFlow2 is a combination of sealer and gutta-percha in powder form with a particle size of <30 micrometers. It contains gutta-percha powder, polydimethylsiloxane, a platinum catalyst, zirconium dioxide, and a micro-silver that imparts defense against the canals' reinfection. GuttaFlow2 had been introduced in 2012, which is an advancement of earlier GuttaFlow. The primary difference between the two is the form of silver particles present as the antibacterial component. GuttaFlow and GuttaFlow2 incorporate nanosilver and micro silver, respectively. It creates a better seal because of adhesion to gutta-percha points, dentinal walls due to its flowability since cold so non-shrinkable and rather expands by .2%, as stated by manufacturers. It is supplied in two forms; a capsule which is triturated for 30 seconds, and an auto mix syringe.[8,9]

The present study had been undertaken to compare the sealing ability of different obturating techniques; cold lateral compaction, thermoplasticized gutta-percha (Obtura II), and cold flowable gutta-percha technique (GuttaFlow2) using AH Plus and GuttaFlow2 as root canal sealers. Apical microleakage was evaluated by dye penetration method using India Ink as leakage detector. After that, the teeth were demineralized and cleared using Robertson's clearing technique, and the maximum extent of microleakage was measured using a stereomicroscope at 20X magnification.

Materials And Methodology:

The present study was appropriately presented to the Institutional Review Board and authorization was obtained (Ref. No.:HIDS.PS-4184A).

Eighty-five extracted human mandibular premolar teeth were selected for this study. All teeth were stored in 0.9% saline and immersed in 5.25% sodium hypochlorite (NaOCl) for 8 hours to remove surface-adhered organic material. After that, conventional access cavities to the pulp chamber were prepared using Endo access bur and EndoZ bur (Dentsply). Pulp was extirpated from the root canals. Gates Glidden drills were used to flare the coronal third of each canal. The working length was determined by inserting a size 15 K-file and was adjusted at 0.5mm short of the point at the file just appears at the apical foramen. After working length determination, the root canals were prepared using a crown down pressure less technique with rotary Protaper files (Dentsply) up to size F2 (ISO size 25) using Endomotor (X-Smart™ endodontic micromotor, Dentsply) set at 300 rpm and recommended torque.

During cleaning and shaping, irrigation was performed with 5 ml of 3% sodium hypochlorite followed by saline after each instrumentation. The dentinal smear layer was removed from the canal wall using 17% EDTA (ethylene diamine tetra acetic acid). Then washed finally with saline and dried with paper points. Afterward, the teeth were randomly divided into seven groups comprising of 5 experimental and two control groups. The experimental groups had 15 teeth each, and the control groups had five teeth each. The experimental groups were divided as follows:

Group 1: Lateral Compaction with gutta-percha using AH Plus sealer (n=15 teeth)
Group 2: Lateral Compaction with gutta-percha using GuttaFlow2 sealer (n=15 teeth)
Group 3: Obtura II using AH Plus sealer (n=15 teeth)
Group 4: Obtura II using GuttaFlow2 sealer (n=15 teeth)
Group 5: Cold flowable gutta-percha (GuttaFlow2) obturation technique (n=15 teeth).
Group 6: Positive control group-Lateral compaction of gutta-percha without sealer (n=5 teeth).
Group 7: Negative control group (n=5 teeth). Sample teeth were intact teeth with no access preparation and were completely covered with nail varnish all around.

The obturation for each group was done following the manufacturer's instructions. In all experimental and positive control groups, access cavities were sealed with Cavit G and covered with a paraffin wax layer to achieve an adequate coronal seal. All the teeth were stored at 37°C for 72 hours under 100% humidity to allow the root canal sealers to set.

For Evaluation Of Apical Microleakage:
All root surfaces of experimental and positive control teeth were covered with two coats of nail varnish except the apical 2 mm. The negative control intact teeth were fully coated with nail varnish, including the apical region.

Subsequently, the teeth were then immersed in an India ink (HIMEDIA Laboratories Pvt. Ltd) for 72 hours. After removing the dye, the samples were washed under running tap water and then stored in acetone for 2 hours to remove the nail varnish. Roots were curetted to remove any remaining nail varnish.

After that, samples were cleared using Robertson's clearing technique to visualize dye penetration three-dimensionally.[10]The extent of apical dye penetration into the root canal system from anatomic apex to the deepest area of dye penetration in a coronal direction in all the groups was analyzed using a stereomicroscope at 20x magnification (Nikon SMZ 745 T). The measurements were noted to the most coronal extent of dye penetration in the root canal using Vimage 2013 Beta Software.

Statistical Analysis:
All the readings were noted, tabulated in the master chart and subjected to statistical analysis using the one-way ANOVA (analysis of variance) and the multiple comparisons by Post Hoc Test.The calculations were performed using SPSS-Statistical Packages for the Social Sciencesversion 17 (SPSS Inc., Chicago, IL, USA).The level of significance was set at value of $p < 0.05$.

RESULTS:
Table1 summarizes the mean values, standard deviation, and standard error for linear dye penetration for all obturation techniques used. The mean of dye penetration was highest in group3 (317.667µm) and the lowest in group5 (91.533µm) among experimental groups. No dye penetration was observed in the negative control (0.00µm), while the positive control showed maximum dye penetration (905.030µm). Figure1 shows a bar diagram showing the distribution of depth of dye penetration between various experimental groups.

When all the groups were compared using one-way ANOVA, the difference was found to be highly significant with the value P<.000, as shown in Table 2. Therefore, the "Null Hypothesis" of no difference between the groups is rejected.

On comparing means of the various groups using post hoc test, the difference was found to be statistically insignificant between the groups except with the positive control group.

DISCUSSION:
The root canal obturating material has several objectives. Firstly, it acts as a barrier to prevent the reinfection of the canal space. Secondly, to seal and entomb the leftover surviving microorganisms and their substrates deep into the dentinal tubules. Lastly, stop the inflow of periapical tissue fluid from forming a fluid-tight seal. Failure to achieve one of these could lead to endodontic treatment failure and reoccurrence of the infection.[11]Thus, studies based on apical microleakage are crucial to evaluate the different obturating materials and techniques.

The apical seal plays an essential role in the success of endodontic treatment. Poor apical seal during root canal obturation may lead to voids in an apical area where residual tissue fluid stasis can occur, acting as a culture medium for any residual bacteria in the root canal. Subsequently, result in the perseverance of the current periapical lesion or the development of a new lesion.[12,13] Therefore, in the present study, the apical sealing ability by various obturating techniques and materials was evaluated.

Several methods have been proposed to evaluate obturating materials' sealing ability, such as colored dye penetration, bacterial penetration, radiolabeled tracer penetration, dissolution of hard tissue, clearing of teeth, spectrometry of radioisotopes, electrochemical methods, and gas chromatography.[2]

The dye penetration technique was used in the present investigation because of its ease of performance compared to other available methods. However, the dye penetration method has certain drawbacks, including the smaller molecular size of the dye molecules compared to the bacteria.[14] But it has been justified by Torabinejad, Watson, and Pitt Ford[15], who stated that a material that can prevent the penetration of small molecules (dye) should also prevent larger substances like bacteria and their byproducts.

Methylene blue dye, a commonly used indicator in micro-leakage studies, can be dissolved in the nitric acid solution used for clearing. Therefore, it would result in an inaccurate assessment of apical dye penetration. Thus, India ink was chosen for the dye leakage evaluation as its particles remain stable during the clearing technique during decalcification by nitric acid.[16]

A clearing technique is used in the current investigation described by Robertson et al.[10]because the method produces a transparent specimen that can be viewed three-dimensionally. The maximum extent of dye penetration can then be recorded. Any lateral canals or cracks can also be viewed through the cleared teeth.[17] Though the time required is a bit longer, but dye penetration can be visualized more accurately in all the dimensions.

GuttaFlow2 is the first flowable, non-heated modified gutta-percha obturating material that does not shrink but instead expands slightly by 0.2%, as stated by manufacturers. Moreover, it has excellent adhesion to gutta-percha points and dentin walls. This combination of expansion and adhesion creates a superior seal. In addition to this presence of small-sized gutta-percha particles of 30 µm and the thixotropic property provides more flowability and flows into the smallest canals. Hence results in three-dimensional obturation without compaction. These reasons could have resulted in low mean leakage values in group 5 and lower values of microleakage where it is used as sealer compared to AH Plus, which has a shrinkage of 1.76.

The results of the present study are per Rana et al.[18] and Dash et al.[19], who reported that the cold free-flow obturation technique (GuttaFlow2) showed good sealing ability and minimum dye penetration.

The apical sealing ability of GuttaFlow2 has been further authenticated by Sayed et al.[20], who evaluated the microleakage along the root canal using the glucose leakage model and showed the lowest mean values for glucose leakage of GuttaFlow2.

A high value of mean leakage score observed in the thermoplasticized gutta-percha injection technique (ObturaII/AH Plus as a sealer) (Gp3) can be explained due to the phase transformation that is induced by heating of the gutta-percha. The material expands when heated from beta to the alpha or gamma phase from less than 1% to almost 3%. When cooled down to the beta phase, the shrinkage takes place of similar percentiles, but the degree of shrinkage almost always is greater than the degree of expansion.[21] Moreover, this shrinkage cannot be compensated by AH Plus since it also shows a polymerization shrinkage of 1.76%. Only with extremely slow cooling (0.5 ºC per hour) of gutta-percha, the original phase can be regained.

Any method manipulating gutta-percha using heat or solvent will result in some shrinkage (1-2%) of the material.[22]Thus, the percentage of shrinkage in Obtura II (1-2%) is more significant than expansion in GuttaFlow2 (.2%). Thus, this could explain more leakage in Group 4 (Obtura II /GuttaFlow2 as a sealer) compared to the cold flowable obturation technique (GuttaFlow2).

Cold lateral compaction using GuttaFlow2 as a sealer showed better results than using AH Plus as a sealer. This result can again be explained by the fact that GuttaFlow2 has excellent flow and post-setting expansion.

The finely ground gutta-percha powder of the sealer is claimed to create bonds with the master gutta-percha cone and dentine providing more fluid-tight seals. Similar findings have been reported by Cobankara et al.[2], Deus et al.[23], and Elias et al.[24], who concluded that root canal obturation with silicon-based sealer in combination with cold lateral compaction technique showed better sealing than those with AH Plus.

The present work's findings also indicate that GuttaFlow2 as an endodontic sealer was better than AH Plus sealer in all the groups, as already explained. Ebert et al.[25] also showed that the GuttaFlow2 showed outstanding and predictable sealing ability compared with the former versions of GuttaFlow and the established sealer AH Plus.

A study that had been done by Mandal et al.[9] also concluded that GuttaFlow2 is highly biocompatible as it showed the least cytotoxicity to human gingival fibroblast cells.

This is due to the presence of microparticles, where fewer atoms on the surface related to the volume, causing lesser reactivity compared to the greater number of atoms on the surface of nanoparticles in GuttaFlow.

The present study has the limitation that this is in vitro study that is used to predict clinical performance but cannot simulate clinical results exactly. Secondly, a larger sample size and in vivo analysis would be required to corroborate the apical sealing ability of obturating materials and techniques.

CONCLUSION:

As a result of this research, it can be concluded that the cold flowable obturation with the master cone has a better apical sealing capacity than thermoplasticized gutta-percha and lateral compaction techniques. GuttaFlow2 was also found to be a better endodontic sealer than AH Plus.

Further clinical trials are required to verify this study's findings to have the best obturation technique and sealer for more predictable success in endodontic care.

Table 1 Illustrates mean dye penetration values in micrometer, standard deviation and standard error.

Group No.	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Min Min	Max
					Lower Bound	Upper Bound		
1	15	225.707	220.1703	56.8477	103.780	347.633	.0	612.7
2	15	221.3.80	230.5601	59.5304	93.700	349.060	.0	724.2
3	15	317.667	289.7345	74.8091	157.217	478.116	.0	951.9
4	15	211.207	212.2354	54.7989	93.675	328.739	.0	558.0
5	15	91.533	162.0766	41.8480	1.778	181.288	.0	563.5
6	5	905.030	728.1310	325.6301	.936	1809.124	65.7	1674.9
7	5	.000	.0000	.0000	.000	.000	.0	.0
Total	85	241.618	321.0493	34.8277	172.370	310.867	.0	1674.9

Table 2 Analysis of variance (ANOVA)

ANOVA READINGS					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2940919.747	6	490153.291	6.687	.000**
Within Groups	5717182.757	78	73297.215		
Total	8658102.504	84			

N: Number of observations
Df: Degree of freedom
F: Variance ratio
P: <.05 significant.

Legends:

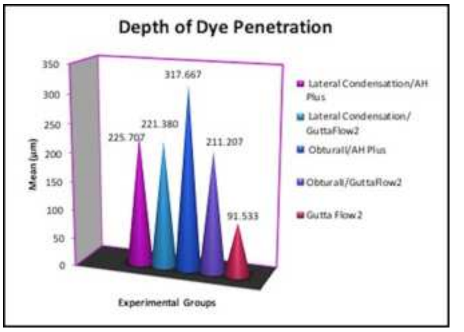

Figure1: shows a bar diagram showing the distribution of depth of dye penetration between various experimental groups.

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