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Comparative Evaluation of Apical Sealing Ability of Three Different Endodontic Sealer: An In Vitro Study

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ABSTRACT
AIM *: Comparative evaluation of apical sealing ability of three different endodontic sealers : An in vitro study*
Materials and Methods*:- The study was conducted on 60 samples on single rooted teeth using three different sealers MTA fillapex, Apexit Plus, Bio C sealer. On the prepared samples access cavities and biomechanical preparation was performed using endodontic rotary system. The teeth were randomly divided into three groups of 15 each with control group having empty canal. All root surfaces except the apical 2 mm was covered with two layers of nail varnish and sticky wax and all samples were immersed in an aqueous solution of 2% methylene blue dye for 72 hours. Roots were longitudinally split using a diamond disc .*
STATISTICAL ANALYSIS *: The data was statistically analysed with One way ANOVA test and post hoc tukey test to compare the apical sealing ability between the experimental groups*
RESULTS *: In our study , least sealing ability was observed Apexit plus followed by MTA Fillapex and Bio C sealer .*
CONCLUSION *: Bio C sealer showed considerably good results compared to MTA Fillapex and Bio C sealer*
Keywords: Apexit Plus , BioC sealer, MTA Fillapex

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I. INTRODUCTION

The successful elimination of microorganisms from the root canal system is the goal of root canal therapy; however, because of anatomical complications in the root canal system, total eradication of bacteria is not always possible**.**Therefore, a perfect sealing of the root canal system is essential for preventing ingress of bacteria from the oral environment and entombing any residual microorganisms**.**[1]

In addition to filling accessory canals, voids, and abnormalities in the root canals, root canal sealers also act as lubricants during the obturation process and seal the area between the dentinal wall and the root filling material.[1]

The primary objective of root canal obturation was to eradicate all routes of leakage from the oral cavity or periradicular tissues into the root canal system.[2] Gutta percha is the most often utilized core filling material because it can be properly shaped to fit the walls of the root canal. However, due to canal irregularities and the size of the dentinal tubules, a root canal sealer is also essential. A root canal sealer not only assist in filling irregular spaces but also in enhancing the seal during compaction and penetration into small, normally inaccessible areas, i.e., the dentinal tubules**.** **[**3**]**Consequently, sealing the entire root canal system after cleaning and shaping is of utmost importance to prevent oral pathogens from colonizing and re-infecting the root and periapical tissues **.** [4]

The flow of endodontic sealers is related to their physical-chemical properties as well as to a good root canal sealing at the moment of root filling .Some properties of root canal sealers are well known. Zinc oxide-eugenol sealers have antibacterial activity, while presenting some toxicity when placed directly on vital tissues ; resin-based sealers have an efficient bond strength to root dentin ; calcium hydroxide-based sealers present biocompatibility, low cytotoxicity, and antimicrobial properties ; and recently MTA-based sealers present excellent physicochemical properties .[5]

Tricalcium silicat e based cements, universally referred to as mineral trioxide aggregate (MTA) cements have revealed interesting biological properties, both in the laboratory and in in vitro tests and are more biocompatible than common endodontic. In 2010, a new endodontic sealer based on MTA, MTA Fillapex , was developed by Angelus (Londrina/Parana/ Brazil) and was launched commercially**.** This product is more stable than calcium hydroxide, constantly releases calcium ions and maintains a pH which elicits antibacterial effects.[6]

MTA Fillapex is a sealer presented in a paste/paste system and is composed of MTA, resins, bismuth trioxide, nanoparticulated silica and pigment. Its manufacturer claims that it has excellent radiopacity, easy handling and a good working time . [7]

Bioceramics are inorganic, nonmetallic, and biocompatible materials that have mechanical properties similar to dental hard tissues. They perform well in their interactions with organic tissue and are noncorrosive and chemically stable. Because of the crystallization of hydroxyapatite, more recent bioceramic sealants have an extremely strong connection with dentin walls. Fillers, thickening agents, calcium hydroxide, zirconium oxide, calcium silicates, and calcium phosphate monobasic are the ingredients of bioceramic sealers. Contemporary studies on bioceramic-based sealer have found adequate characteristics, including its adhesive property**.** The Bio C is a novel bioceramic, nonresin sealer, which stimulates tissue regeneration.[8]

Apexit Plus is a calcium hydroxide based sealer, exhibited good antimicrobial effect but it is less than that of ZnOE sealer. This sealer's antibacterial properties is from the hydroxide ions that are released, elevating the pH above 12.5. This sealer's pH rise to above 12.5 and the release of hydroxide ions are what give it its antibacterial properties. The pH drops to roughly 9.14 as the calcium hydroxide sealer sets, which causes the sealer to lose its effectiveness. The low level of pH rise, the limited solubility, and the infusibility of calcium hydroxide into dentinal tubules could be the cause of the calcium hydroxide sealer's low antibacterial action and possibly by buffering ions present in the tubule.[9]

However, clearing techniques and dye penetration methods have been used for many years, and their results are useful to evaluate apical. A variety of techniques, including as silver nitrate, air pressure, dye studies, radioactive isotopes, and scanning electron microscopy (SEM), are employed to evaluate microleakage. The optimal sealing method and goods may be identified with the help of new techniques to examine microleakage. Radioisotope penetration, electrochemical tests, bacterial and toxin infiltration, and animal experimental studies may provide more evidence on the performance of the different sealers used in root canal treatment **.** [10]

II. MATERIAL AND METHODOLOGY

60 sample were be made of identical size and shape. Inclusion Criteria includes **:** Single-rooted extracted human permanent teeth with a single root canal were included in this study.
Exclusion criteria includes:

- Teeth with root fracture.
- Teeth with root caries.
- Teeth with open apices.
- Teeth with developmental anomaly.
- Teeth with external and internal root resorption.

These teeth were cleaned with hand scalers and soaked in 5.0% sodium hypochlorite for two hours and were stored in a solution containing thymol crystals. The teeth were decoronated uniformly at the cement-enamel junction using diamond disc. The root canal access was prepared using endo access bur and working length was determined using appropriate K-file. Then the biomechanical preparation was done by step back technique using NiTi rotary protaper gold files till size F2. The irrigation protocol was followed using 5.0% sodium hypochlorite in between each instrumentation and 17% Ethylenediaminetetracetic Acid (EDTA) was left in the root canals for four minutes, followed by final rinsing with normal saline. The root canals were then dried with paper points. The teeth were randomly divided into three groups and a negative control group. Obturation using cold lateral condensation method was done as follows :

- Group I: Gutta-percha and MTA Fillapex sealer.
- Group II: Gutta-percha and Apexit plus.
- Group III: Gutta-percha and BioC sealer.
- Group IV : Control Group- Gutta-Percha alone (no sealer)

Figure1 Teeth Samples

Figure 2: Armamentarium used

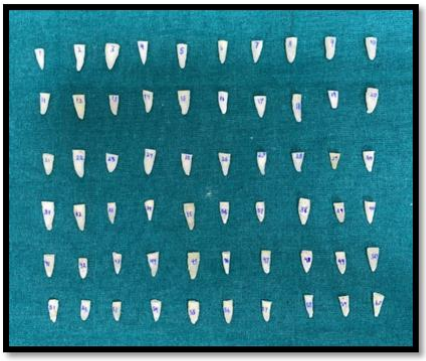


Figure 3: Decoronated Sample

Figure 4: Sealers Used

Apexit Plus sealer, MTA Fillapex and BioC was applied over the entire working length of the canal using lentulo spirals. The teeth were then stored at 37 °C with 100% humidity for one week under incubator to allow the sealers to get fully set. All the root surfaces, except the apical 2 mm were covered with two layers of varnish. In control group, the root surfaces including the apical foramen were completely coated with two layers of varnish, to test the impermeability of varnish to methylene blue and all the samples. After one week of incubation, sticky wax was then applied on the varnish area; teeth were immersed in 2% methylene blue dye and then stored again in an incubator for 72 h at 37 °C. The roots were rinsed in running water and dried with paper towels. The varnish and sticky wax coating were removed with a scalpel blade and a guide groove were prepared with a diamond disc in a crown-apex direction in middle of tooth till the depth of the canal and the roots were split longitudinally in two halves. The gap was compared in the area of apical third to check the sealing ability of respective sealers. The linear dye penetration was measured from root apex to the most coronal extent under Stereomicroscope. The data obtained was then subjected to statistical analysis.

Figure 3 : Decoronated Sample

Figure 4 : Sealers Used

Figure 5 Steremicroscopic image showing the apical dye peneteration of MTA Fillapex sealer , Apexit Plus , Bio C sealer and control group respectively

Figure 5 Steremicroscopic image showing the apical dye peneteration of MTA Fillapex sealer , Apexit Plus , Bio C sealer and control group respectively

III. RESULTS

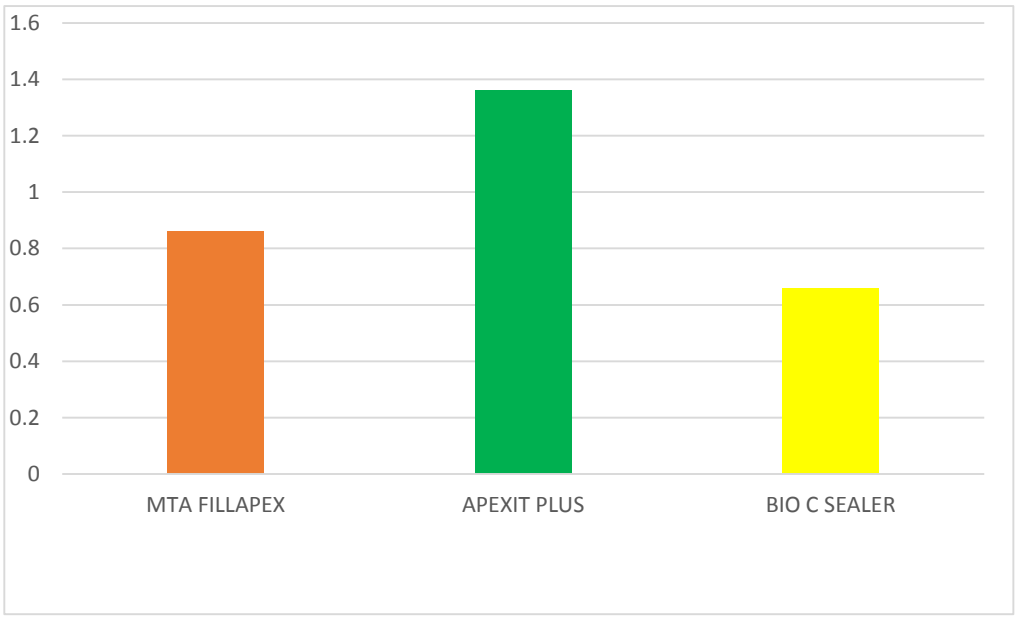
The present in vitro study was carried out with an aim of comparing the apical microleakage of three different endodontic sealers. The apical microleakage for study groups was evaluated and results obtained were subjected to statistical analysis. The depth of dye penetration was evaluated using scoring criteria given by Saunders et al. **(Table 1)**. The control group showed no dye penetration by confirming the insulating capacity of the nail varnish and sticky wax **(Table 2) (GRAPH 1) (Table 3)**. .

TABLE 1: SCORING CRITERIA

GROUPS	NO. OF SPECIMENS	0 (NO LEAKAGE)	1 (<1mm)	2 (1-1.5)	3 (>1.5)
MTA Fillapex	15	3	2	9	4
Apexit Plus	15	0	4	5	6
Bio C Sealer	15	3	5	7	0
Control	15	15	0	0	0

TABLE 2 : DESCRIPTIVE ANALYSIS

	MTA FILLAPEX	APEXIT PLUS	BIO C SEALER
Mean	0.86	1.36	0.666
Standard Deviation	0.570	0.476	0.632
Minimum	0	0.5	0
Maximum	1.6	2	1.5
Count	15	15	15



GRAPH 1 : MEAN LEAKAGE OF SEALERS

TABLE 3: ANOVA TEST

Source of Variation	SS	Df	MS	F value	P-value
Between Groups	3.840444	2	1.920	6.052	0.004
Within Groups	13.32533	42	0.317		
TOTAL	17.1657	44			

Using one-way analysis of variance (ANOVA), it was revealed that there was a statistically significant difference between the groups . $p < 0.004$ for microleakage evaluation. The mean values for apical microleakage, according to dye penetration test for all the three study groups was calculated. The maximum mean was found in Group II followed by Group I, Group III, and least in control group. There was a significant difference ($p < 0.05$) in mean microleakage evaluation values between group I (MTA Fillapex) and group II (Apexit Plus), tested using independent sample *t* test. There was no significant difference between mean microleakage evaluation between group I (MTA Fillapex) and group II (Bio C sealer) .

IV. DISCUSSION

Achieving a full hermetic seal of the root canal and preventing coronal and apical microleakage are the primary goals of endodontic therapy .Thus, the present study aimed to evaluate the apical microleakage of a three root canal sealer; MTA Fillapex ; Apexit Plus and Bio C Sealer using dye penetration technique under stereomicroscope at 40X magnification.[11]

The adequate and three-dimensional obturation of the root canal system is of prime clinical importance for the long-term success of endodontic treatment **.** This seal is developed mainly in order to minimize the leakage along the root canal filling and to protect the periapical tissues from bacteria and their byproducts.[12]

Ingle in 1956 stated that about 58% of the endodontic failures may be attributed to the incomplete obturation of the root canals . Hence, various researchers have tried numerous different materials to completely obliterate this space since the early 1800's. Of these, gutta percha is the most popularly used root canal obturating material which has got acceptance for more than 100 years. Obturation with Guttapercha along with a root canal sealer is considered to be the gold standard in root canal therapy . [13]

The most widely used root canal obturating material is gutta-percha because to its many benefits, including biocompatibility, non-toxicity, non-allergic properties, and ease of retrieval from the root canal in case of retreatment. In spite of various advantages, it has few demerits like, inability to bond with the root canal dentin and the hydrophobic nature of gutta percha tends to make the sealer pull away from it upon setting .[14]

However, this does not negate the importance of the quality of the obturation in which the sealer has a major role to play . For a hermetic seal, gutta-percha alone is not sufficient, as it has no adhesion to the root canal walls. Root canal sealers are needed to fill in the voids between the gutta-percha cones as well as those between the gutta-percha cones and root canal dentinal walls. Hence a complete hermetic sealing of the root canal seems to be difficult, even when using a combination of gutta-percha and a root canal sealer in the general clinical use. [15]

In the context of endodontics, microleakage is the flow of liquid and microbes through gaps in the root filling material or along the contact between the dentinal walls and the filling material. Many anatomical parameters and clinical considerations influence microleakage during the course of non-surgical root canal treatment, including root morphology, canal anatomy, patient co-operation, operator skill in preparation and obturation of the canal and the root canal sealing and filling materials .[16]

The result of this study clearly demonstrate that none of the materials completely sealed the root apex in vitro. Inadequate apical seals could result from the technique used to fill the canal system; for example, the use of a single-cone filling technique is often considered inferior to more sophisticated 3D compaction techniques The single-cone approach results in a large sealer volume compared to the cone's volume, which encourages void development and lowers seal quality. . However, it must be noted that the concept of the single-cone technique has been recently re-visited**,** and that the volume of the sealer used in the present study was minimized because ProTaper gutta-percha cones were calibrated to the preparation till size F2. Use of the single-cone technique also allowed a comparison of the performance of all materials under relatively standardized conditions.[17]

There have been several attempts to evaluate the sealing properties of root canal obturations.. The most widely used technique has been measuring the linear dye penetration along the root canal filling. Methylene blue dye was used as the leakage marker for this study because it is readily detectable under visible light, it diffuses easily, it is not adsorbed by the dentinal matrix apatite crystals and the most coronal limit of leakage was easily detectable. [18]

The specimens were placed into an incubator at 37°C at 100% relative humidity to avoid evaporative loss of water during measurements and to simulate the mouth temperature. They were stored in closed conditions for 72 hours to ensure complete setting of the sealer.

Mineral trioxide aggregate is a material that is often researched and has been shown to have good biocompatibility and good sealing ability . However, the deficiencies of MTA include fairly difficult manipulations and long hardening times.[5]

In the study done by stated that during the setting reaction, sealers containing salicylate in its composition showed initial volumetric shrinkage which caused an overall contraction of the sealer which may have a role in the MTA Fillapex study on minimum sealing of the dentinal walls.[1]

Also in the study done by they showed that MTA based and calcium hydroxide based sealer showed similar results as MTA can form calcium ions and hydroxyl ions important for stimulation of hard tissue deposition . When MTA settings are used, anhydrous mineral oxide compounds are hydrated to form calcium silicate hydrate and calcium hydroxide phases. This expansion against the constraining edges of the compound improves the seal and minimizes the leakage and also they stated that some sealers containing calcium hydroxide, It determines the biological sealing by encouraging the closure of the apical foramen by the deposition of mineralized tissue.[6]

However our results showed this material to be second best which is in accordance with the study done by the reason for the slightly higher microleakage of MTA Fillapex, which is a combined bioceramic resin□based sealer, could be because of low adhesion of the material that might be due to incomplete polymerization of its resin components leading to formation of poor microtags and shrinkage on setting.[19]

Furthermore, In our study the leakage was maximum with the Group II : Apexit Plus which was in accordace with the study done by **.** They showed that apexit plus based specimens had the most dye penetration among all the other groups. The possible reason would be attributed to the dimensional changes of the material upon setting & due to dissolution over the time of immersion. This is in concurrence with the findings of earlier study which reported a setting shrinkage of 0.3% to 1% with Apexit Plus based sealers. [20]

Apexit Plus, a calcium hydroxide-based endodontic cement, has been launched in an attempt to provide a flawless seal at the apical foramen without damaging periodontal tissues. This calcium hydroxide-based sealer has caused slight cytotoxicity when cultured with L929 fibroblasts and exerted good antimicrobial activity . It has been suggested that the high pH provided by this sealer may be responsible for its antimicrobial effect .[20]

Also in the study done by Apexit showed more leakage values compared to AH Plus and the reason could be attributed due to dissolution over the time of immersion and also they stated that the shrinkage related to setting and potential dissolution might risk the proper seal of the root canal leading to treatment failure.[21]

In our study Group III (Bio C sealer) showed minimum leakage compared to the other two groups . Bioceramic is one of the newest types of root canal sealers, which can be used in endodontic treatment. It consists of zirconium oxide, calcium silicate, calcium phosphate monobasic, calcium hydroxide, and various other fillers.[22]

There are two main advantages of using Bioceramic as root canal cement. First, its good biocompatibility can prevent rejection by the surrounding tissue. Second, the calcium phosphate in bioceramic material strengthens its link to root canal dentin when it hardens, giving it a structure and crystals that resemble those of teeth and bone apatite, increasing its adhesion to the root canal wall. However, one of the biggest disadvantages is that Bioceramic is difficult to remove from the root canal wall after it has hardened, making re□treatments difficult to perform **.** So when compared with other two experimental group i.e., MTA and Bioceramic sealer in the study done by the MTA Fillapex (Angelus) root canal sealer is mixed with salicylate resin, which might affect the level of shrinkage so that the leakage of this sealer is quite high when combined with a single cone obturation technique when compared to bioceramic sealer which is best among the two groups and is in accordance with our study. [23]

Furthermore in the study done by also explained that bioceramic sealers demonstrated their ability to induce biomineralization when in interaction with dentinal fluid and to create mineral infiltration zone in dentin. Furthermore, bioceramic sealers do not shrink during the setting because are monomer free, thus, allow the tight seal of the root canal. [24]

Hence in this study, on comparing the three different root canal sealers, MTA Fillapex , Apexit Plus , Bio C sealer it was found that Bio C sealer showed best sealing ability. MTA Fillapex and Bio C groups showed almost similar microleakage of which Bio C was better and also the Apexit Plus group showed the maximum leakage compared to both the groups indicating poor sealing ability. All the tested sealers showed better sealing ability than the control group.

V. CONCLUSION

Within the limitations of the study the results obtained after evaluation and comparison of the sealing ability of MTA Fillapex, Apexit Plus and Bio C sealer it could be concluded that:

- All three experimental groups showed comparable apical leakage.
- Dye penetration was observed in all the specimens except the control group. This demonstrates that none of the study's sealers were able to fully seal the apical foramen to create a fluid-tight seal.
- The lowest mean level of dye penetration was in Bio C group. This shows that Bio C sealer had best sealing ability compared to other sealers used in the study.

- Though Bio C sealer and MTA Fillapex showed no statistically significant difference in microleakage.
- Apexit Plus showed significantly more leakage when compared to the Bio C sealer and MTA Fillapex where as MTA Fillapex is better than Apexit Plus.

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