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RESEARCH ARTICLE

COMPARATIVE EVALUATION OF FRACTURE RESISTANCE OF ENDODONTICALLY TREATED TEETH USING DIFFERENT TYPES OF ROOT CANAL SEALERS: AN IN-VITRO STUDY

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Abstract

Introduction: Obturation materials are considered the key elements in supporting strength of endodontically treated teeth. Hence, along with gutta percha (GP) use of sealers strengthen the remaining tooth structure, thus increasing fracture resistance.

Material and Methods: Eighty extracted single rooted mandibular premolar teeth were decoronated to standardized root length of 13mm. After confirming working length cleaning and shaping upto F2 file along with irrigation using 5ml 3% NaOCl, 5ml 17% EDTA and normal saline was done. Teeth were divided into 5 groups (n=16) depending upon type of sealer used for obturation along with gutta percha (GP) using lateral compaction technique. Group 1: Endoseal sealer, Group 2: AH Plus, Group 3: Apexit Plus, Group 4: Bio C Sealer, Group 5: Instrumented and unobturated (Control). Samples were stored for 7 days at 37 degree and 100% humidity for sealer to set completely. Samples were mounted vertically 3mm into acrylic resin block leaving 9mm of root length exposed. Fracture resistance was tested using Universal Testing Machine (UTM). Amount of force required for fracture was recorded in Newton. Data were analysed using SPSS 22.0 and oneway ANOVA and Post hoc Tukey test were used for statistical analysis.

Result: The maximum fracture resistance was obtained in Group 4 Bio C sealer i.e. 418.81±21.06 N, followed by Group 2, Group 3 and Group 1. Least fracture resistance was obtained in Group 5.

Conclusion: Bio C sealer provides the best fracture resistance to the endodontically treated teeth when compared with AH Plus, Apexit Plus and Endoseal.

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Introduction:-

Following root canal treatment, strength of the tooth to withstand fracture significantly decreases which has an impact on the tooth's lifespan [1]. As tooth bears the masticatory load it is very essential to provide proper strength even after root canal treatment to withstand these loads while maintaining the form and function.The intent behind obturation is to improve the mechanical bonding between obturating materials and dentin, as well as the strength of the root canal. One of the most popular filler for root canals is GP. When combined with a sealer, GP has a lower elastic modulus than dentin, therefore, to use a sealer with the ability to reinforce tooth against root fracture would be advantageous [2].

Endoseal (Prevest Denpro) is a zinc oxide-eugenol-based root canal sealer which has antibacterial, anti-inflammatory properties including longer working time, and extended setting time[3].

Apexit Plus (Ivoclar) a calcium hydroxide sealer is biologically stable, has a composition that flows easily which makes the material suitablefor intricately shaped canals and enables good and durable sealing of canal along with antimicrobial activity and promotes bone and cementum formation [4].

AH PLUS (Dentsply Maillefer), an epoxy resin based sealer is known to set agold standard for obturation system with GP because of their capacity to enter dentinal tubules[5]. It has various advantages which feature excellent long-termdimensional stability and a good periapical seal, as well as a short working time and miscibilitythat achieves a precise adaptation to the prepared canal and minimizes shrinking upon setting [6].

Bioceramic based sealers including Bio C (Angelus) are based on hydrophilicity. This material's two primary characteristics are its hydraulic nature and its reactivity as a result of calcium hydroxide production that is leached in a solution. Because of their hydrophilic qualities, they are perfect for treating naturally moist areas like root canals and tubules. Once they solidify, they turn hard and insoluble, offering superior long-term sealing [7].

The present investigation was carried out to evaluate the fracture resistance of endodontically treated premolars obturated using Bio C sealer compared with Endoseal, Apexit Plus and AH Plus sealer under mechanical loading.

Material and Methods:-

Eighty extracted human mandibular premolar with comparable radicular morphology were chosen using radiograph. Teeth were stored in 0.2% thymol for 24 hrs after extraction and then in distilledwater till their use in the study. Using a diamond disc, teeth were decoronated to produce a standard root length of 13 mm from the anatomic apex. A 15-k file (Denstply-Maillerfer, Ballaigues, Switzerland) was inserted into the canal until the tip of the file could be seen at the apical foramen in order to standardize the working length. The working length was set to be 1 mm less than the apical foramen. ProTaper Rotary instruments (Denstply-Maillerfer, Ballaigues, Switzerland) were used to prepare the root canals till F2 instrument. Upon completion ofeach instrument, copious irrigation using 5ml 3% NaOCl, 5ml 17% EDTA and normal saline solution was done.

After the instrumentation, all 80 teeth were divided into five groups (n=16) depending on the type of sealer utilized for obturation, Group 1: Obturation with GP using Endoseal, Group 2: Obturation with GP using AH Plus, Group 3: Obturation with GP using Apexit Plus, Group 4: Obturation with GP using Bio C Sealer, Group 5: Samples were instrumented and left unobturated (Control). Every root canal was sequentially dried using absorbent paper cones and obturation by lateral compaction technique with F2 GP (Denstply- Maillerfer, Ballaigues, Switzerland) as master cone with the assigned sealer was carried out. The samples were provisionally sealedwith a provisional restorative material(Orikam) and kept for seven days at 37°C and 100% humidity to permit sealer to set completely. Each tooth was then mounted vertically 3mm from the apex into an acrylic resin cylindrical block measuring 15mm in diameter and 20mm in height leaving 9mm of root length exposed coronally as seen in Figure 1.

Fracture resistance was tested utilizing a Universal testing machine. Block with mounted samples were placed on the lower part of testing machine with the coronal part facing upwards. A custom-made metal point with a diameter of 0.8mm was tightened to the upper section and force was applied vertically to the root's long axis. Each sample was

then loaded with a progressively increasing compressive force at adisplacement rate of 0.5mm/min until fracture occurred in the root shown in Figure 2.The magnitude of force necessary for fracture was measured in Newtons (N). The fractured fragment is seen in Figure 3.

Figure 1:- Grouping of sample.

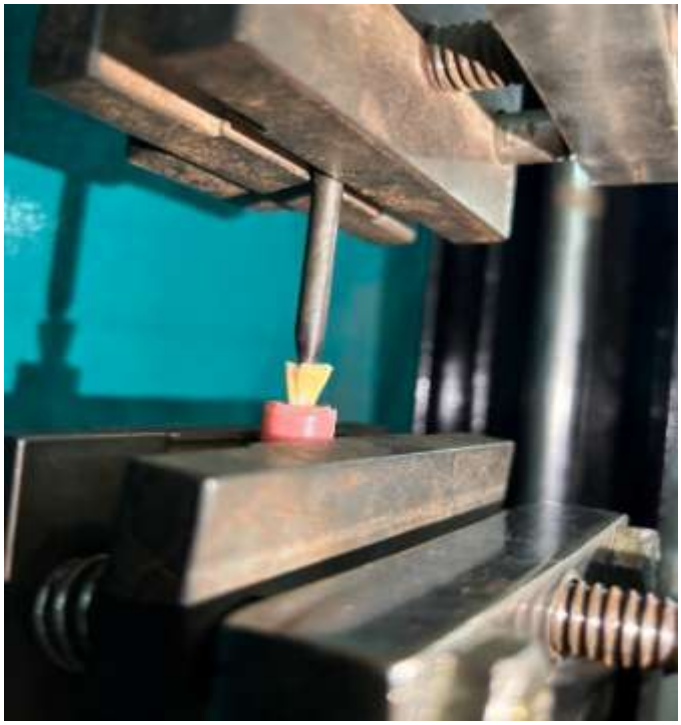

Figure 2:- Sample mounted on UTM for loading.

Figure 3:- Fractured Fragment.

The data were analysed using statistical package for social sciences version (SPSS) 22.0. The level of statistical significance was set at 95% (P=0.05). P-value > 0.05 was non-significant and P value < 0.05 was significant. The data were subjected to statistical analysis to interpret the differences and significance among groups. One-way Analysis of Variance (ANOVA) was used to compare mean resistance in various groups, and Post hoc Tukey were used for pairwise comparison of mean resistance observed in various groups.

Results:-

From the data obtained it was estimated that the maximum mean value of fracture resistance was obtained in Group 4 of Bio C sealer i.e., 418.81 N, followed by Group 2 AH Plus with mean value of 275.56 N followed by Group 3 Apexit Plus with mean of 176.38 N. Amongst the experimental groups, Group 1 Endoseal had lowest fracture resistance value of 152.56 N. The fracture resistance of Group 5 Control group was lowest with mean value of 86.44 N. The data is mentioned in Table 1 and Figure 4.

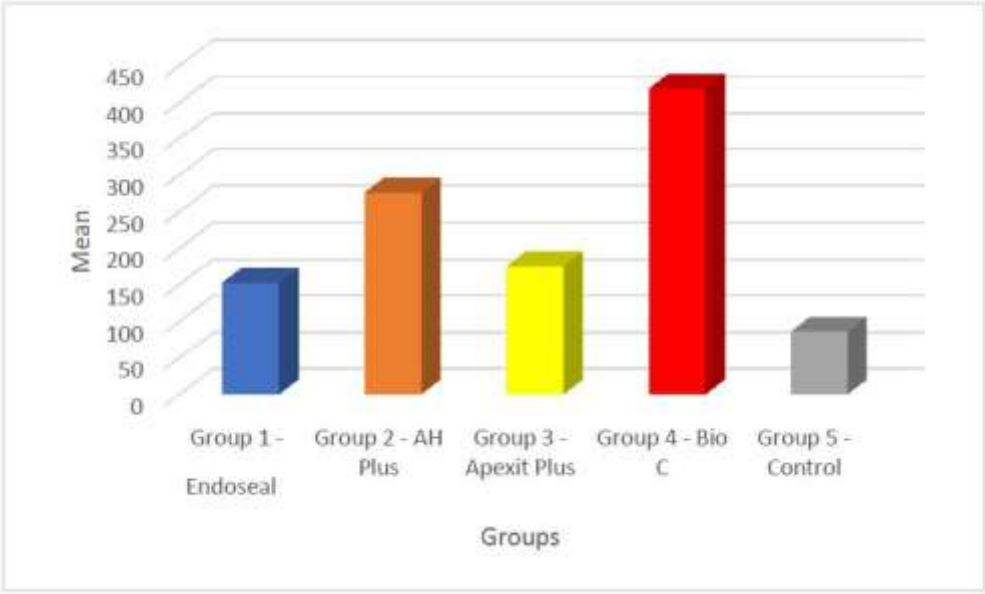

Figure 4:-Mean fracture resistance observed in samples of various groups.

Groups	Minimum	Maximum	Mean	Std. Deviation
Group 1 - Zinc oxide Eugenol	126.0	183.0	152.56	19.98
Group 2 - AH Plus	248.0	305.0	275.56	16.26
Group 3 - Apexit Plus	134.0	221.0	176.38	24.93
Group 4 - Bio C	389.0	457.0	418.81	21.06
Group 5 - Control	55.0	112.0	86.44	15.17

Table 1:-Descriptive statistics of fracture resistance observed in samples of various groups.

On comparison between the groups as mentioned in Table 2, the values were statistically significant. However, on comparison within the groups there was no statistically significant values found.

	Sum of Squares	df	Mean Square	F	p value
Between Groups	1070151.800	4	267537.95	682.959	<0.01*
Within Groups	29380.000	75	391.73		
Total	1099531.800	79			

*Statistically significant

Table 2:-Comparison of mean fracture resistance observed in samples of various groups using one way ANOVA.

Table 3 and Figure 5 represents that on comparison of Group 4 with other groups there was statistically significant difference with p value < 0.01. In pairwise comparison with Group 1 all the groups had statistically significant difference except with Group 3 with p value of 0.009. Comparison of the control group also showed statistically significant difference with all other groups.

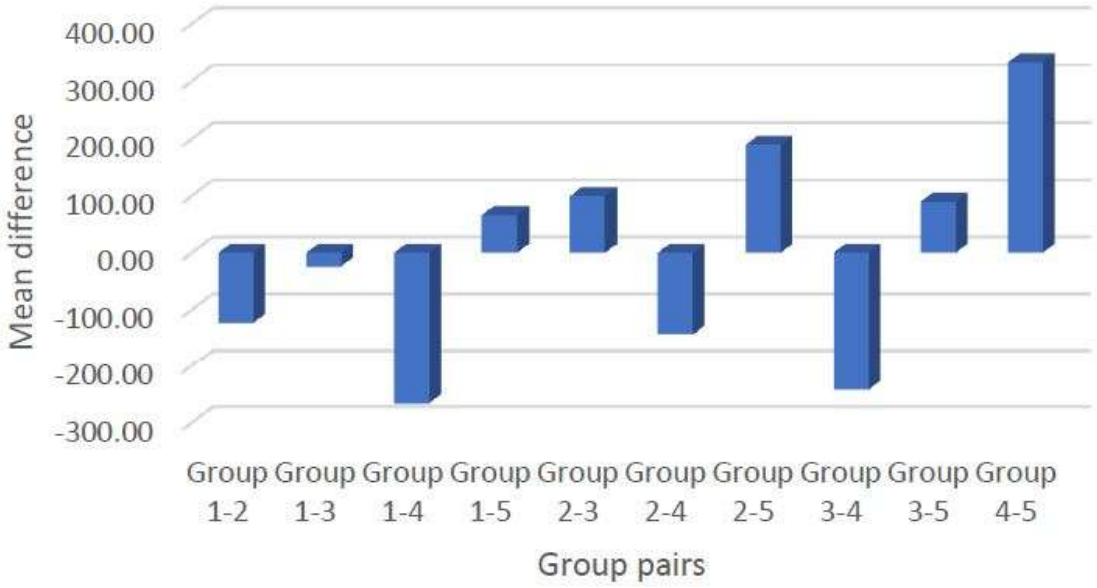

Figure 5:-Mean difference of fracture resistance observed in samples of various groups.

Groups		Mean Difference	p value	95% Confidence Interval	
				Lower Bound	Upper Bound
Group 1 - Zinc oxide Eugenol	**Group 2 - AH Plus**	-123.00	<0.01*	-142.560	-103.440
	Group 3 - Apexit Plus	-23.81	0.009*	-43.373	-4.252
	Group 4 - Bio C	-266.25	<0.01*	-285.810	-246.690
	Group 5 - Control	66.13	<0.01*	46.565	85.685
Group 2 - AH Plus	**Group 1 - Zinc oxide Eugenol**	123.00	<0.01*	103.440	142.560
	Group 3 - Apexit Plus	99.19	<0.01*	79.627	118.748

	Group 4 - Bio C	-143.25	<0.01*	-162.810	-123.690
	Group 5 - Control	189.13	<0.01*	169.565	208.685
Group 3 – Apexit Plus	**Group 1 - Zinc oxide Eugenol**	23.81	0.009*	4.252	43.373
	Group 2 - AH Plus	-99.19	<0.01*	-118.748	-79.627
	Group 4 - Bio C	-242.44	<0.01*	-261.998	-222.877
	Group 5 - Control	89.94	<0.01*	70.377	109.498
Group 4 - Bio C	**Group 1 - Zinc oxide Eugenol**	266.25	<0.01*	246.690	285.810
	Group 2 - AH Plus	143.25	<0.01*	123.690	162.810
	Group 3 - Apexit Plus	242.44	<0.01*	222.877	261.998
	Group 5 - Control	332.38	<0.01*	312.815	351.935
Group 5 - Control	**Group 1 - Zinc oxide Eugenol**	-66.13	<0.01*	-85.685	-46.565
	Group 2 - AH Plus	-189.13	<0.01*	-208.685	-169.565
	Group 3 - Apexit Plus	-89.94	<0.01*	-109.498	-70.377
	Group 4 - Bio C	-332.38	<0.01*	-351.935	-312.815

*Statistically significant

Table 3:- Pairwise comparison of mean fracture resistance observed in samples of various groups using post hoc tukey test.

Discussion:-

A key requirement for an optimal sealer is theability to construct an effective monoblock with the obturating substance. This monoblockhelps to strengthen the tooth against fracture [8].

Mandibular premolars were chosen because of their susceptibility to fractures, which can be attributed to factors such as crown size, anatomy, crown-to-root ratio, and function. Additionally, their position in the dental arch exposes them to both shear and compressive forces [9].

In the current study, the canals were obturated with GP by cold lateral compaction technique and finger spreader. Numerous investigations have employed this technique for obturation, solidifying its success and making it gold standard technique [10]. It is noteworthy that mandibular premolars exhibit oval canals, making them more effectively filled through lateral compaction rather than the single cone technique, thereby establishing a circumferential seal.

For investigating fracture resistance a universal testing apparatus was employed. The load was applied at a 0° angle, mimicking splitting pressure across the access cavity. This configuration resulted in lower stresses due to diminished flexural deformations and a concentration of maximum stresses closer to the crown's cervical portion. This design was deemed more clinically pertinent as it better replicates the support provided to a healthy tooth by the alveolar socket and leads to less abrupt stress concentration induced by unrealistic bending movements [11].

According to this study, the fracture resistance of Group 4 i.e, the Bio C sealer was highest when compared to other groups, this could be because of the mechanism of mechanical interlocking and formation of an infiltration zone by Bio C sealer. Zhang et al.,[12] proposed a micromechanical interlocking mechanism achieved by sealermolecules' infiltration inside the dentinal tubules.The reason which supports the result of this study could also be a chemical bond which exhibits between bioceramic sealer and radicular dentin. This study observed improvement in the fracture resistance of teeth obturated with Bio C sealer, potentially due to enhanced adhesive interaction. Additionally, the profound infiltration of sealer in the canal complexities and dentin tubules, facilitated by its nanoparticles, might be another contributing factor to the increased fracture resistance within this group.

Two most popular sealers nowadaysi.e., Bioceramic sealers and resin sealers were used but both had statistically significantdifference between the mean fracture resistance this can be attributed to the greater stiffness of calcium silicate sealers compared to epoxy resin-based sealers. Because calcium silicate mechanics are more similar to dentin, they improve the tooth's resistance to breakage [13].The results align with priorinvestigations, such as those conducted by Patil et al.,[14] yet divergefrom the conclusions of Dibaji et al.,[15] who observed diminished fracture resistance in thebioceramic group compared to AH Plus.

This investigation revealed that the AH Plus (epoxy resin) sealer exhibited superior resistance to breakage, demonstrating a statistically significant difference in fracture force values compared to the Apexit plus group sealer and ZOE group. The high fracture resistance valuefindings of AH Plus sealer agrees with the results acquired by Upadhyay et al.,[16] who attributed the enhanced resistance to fracture of AH Plus to the formation of covalent bonds between its reactive epoxide groups and any amine groups present on the surface of the dentinal collagen. Additionally, AH Plus exhibits superior infiltration into the microscopic irregularities due to its creep capacity and prolonged curing time, which strengthens the interlocking effect at the dentin-sealant interface [17]. It exhibits elasticity, and when combined with GP, it forms an effective seal with dentin walls, enhancing its overall strength and fracture resistance.

This investigation revealed that Apexit Plus exhibited a diminished fracture resistance compared to AH Plus and Bio C. This could be attributed to the curingprocess of this sealer. This process involves a reaction between calcium hydroxide and glycolsalicylate, resulting in a non-crystalline calcium disalycilate salt that lacks adhesion to dentin [18].

In this investigation, Apexit Plus and ZOE exhibited no significant difference. This aligns with findings of Siqueira et al.,[19] who reported that physical and chemical properties of Ca(OH)2-based sealers were comparable to or marginally greater to those of ZnO Eugenol sealer. Camilleri et al.,[20] demonstrated the formation of calcium hydroxide during the sealer's initial setting phase. The marginally superior fracture resistance observed with Apexit Plus might be attributed to the inherently lower microleakage associated with $Ca(OH)_2$-based sealers compared to ZOE. Furthermore, the primary dissolution of the sealer, accompanied by the release of hydroxyl ions, could potentially stimulate the biological closure of the apical foramen through the formation of hard tissue, thereby minimizing long term dissolution.

This study revealed that ZOE sealer exhibited the weakest resistance to fracturing among the four sealers evaluated. These findings align with prior research by McComb and Smith,[21] who reported an absence of adhesive properties, negligible bonding and internal strength in ZOE sealer. In this study the control group i.e. the unobturated group had the least fracture resistance values, which is inaccordance with many studies and also Zandbiglari et al.,[22] showed that enlarged roots but lacking filling material were considerably more prone to breakage compared to filled roots. However, this contradicts with the result of Chadha et al.,[17] who demonstratedthat the zinc oxide eugenol and control groups exhibited statistically non-significantdifferences. Thus, leaving the root canals unfilled is not recommended.

The possible limitations of this in vitro investigation was that periodontal ligament simulation was not carried out. Given the significant role of periodontal ligaments in preventing tooth fractures by the distribution of stresses, the outcomes might have varied with simulation.

Conclusion:-

From the study it can be concluded that Bio C sealer provides the best fracture resistance to endodontically treated teeth when compared with the other experimental groups. Employing a bioceramic sealer may improve the long-term viability of compromisedroot structures by augmenting their resistance to fracture, both vertically andhorizontally.

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