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RESEARCH ARTICLE

THE EFFECT OF THERMOCYCLING ON MARGINAL SEALING ABILITY OF MTA PLUS AND BIODENTINE WHEN USED AS ROOT-END FILLING MATERIALS

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Abstract

Background: Marginal microleakage occurs when restorations are poorly adapted to the cavity walls which leads to penetration of bacteria, fluid and nutrient into the marginal gap.

Aim: The study aimed to evaluate the effect of thermocycling on marginal sealing ability of two root-end filling materials i.e. MTA Plus and Biodentine.

Materials and Methods: An in vitro study was conducted at Department of Conservative Dentistry and Endodontics in Institute of Dental Sciences (IDS), Jammu, Jammu and Kashmir, India. Forty extracted teeth with single root were decoronated maintaining a standardized length of 16mm. Biomechanical preparation and obturation was done for all the teeth. Samples were stored at 37°C and 100% humidity for seven days. Apical 3mm was resected and cavities were prepared which were randomly divided into two experimental groups with twenty samples each. The cavities were filled with MTA Plus in group I and Biodentine in group II. These groups were further divided into two subgroups of ten each (n=10). The second subgroup of both the groups did not receive any treatment and the first subgroup samples were subjected to 500 thermocycles in water bath at temperature ranges between 5°C and 55°C with a dwell time of 30 second. The samples were immersed in methylene blue dye and after through washing they were sectioned longitudinally. Examination was done under stereomicroscope to measure the depth of penetration.

Statistical Analysis: The data collected were put to statistical analysis by one-way ANOVA (analysis of variance) and post hoc tests.

Results: The average depth of dye penetration was least for Biodentine when thermocycling treatment was not given (0.13mm) and maximum value was depicted by MTA Plus when undergone thermal cycles (0.57mm). It is also noted that no significant difference is seen in Biodentine with or without artificial aging procedure.

Conclusion: Biodentine showed least amount of microleakage, thus a better sealing ability. Also there was little effect of thermocycling on microleakage of both the materials.

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Introduction:-

Root canal treatment (RCT) is a non-invasive and a conservative mode of treating any endodontic disease. The main objective of any endodontic treatment is to create fluid tight seal to prevent failure of root canal treatment¹. Some periapical lesions require a surgical intervention which includes hard and soft tissue removal, exposure of root tip, periapical curettage, if required, root-end resection, and followed by retrograde filling². Other disorders which require surgical treatment are calcified canals, endodontic instrument separation, dilacerated root canal anatomy³. A good apical seal prevents entry of microbes from periapical region to the root canal, thus increasing the longevity of the endodontic treatment⁴. A good root-end filling material should have characteristics like radiopaque, non-absorbable, easy manipulation, non-toxic, easy adherence to the tooth structure and promote healing⁵. Earlier the root-end filling materials used were amalgam, glass ionomer cements, Cavit, composite resin and Super ethoxy benzoic acid⁶. With the advancement in dentistry, newer materials are emerging which has enhanced the quality of dental procedures. One of the material which has shown a success rate over other root-end filling materials is Mineral Trioxide Aggregate (MTA)⁷. MTA was developed in 1993 by Dr. Torabinejad for endodontic procedures like pulp capping, root-end filling, repair of perforation in furcation, apexification and obturation⁸. Besides its many clinical uses, MTA had many disadvantages like discoloration of the tooth, difficulty of handling, expensive, long setting time and comparatively lower compressive and flexural strengths⁹.

In order to overcome these drawbacks of MTA, in 2012 MTA Plus (Avalon Biomed, Houston, Texas, United States) was marketed which was said to have a finer particle size and a shorter setting time than MTA⁸. Another material which came into light was Biodentine (Septodont, Saint-Maur-Des-Fosses, France), which was developed in 2010 with better physical properties than MTA. Biodentine has said to have superior qualities than MTA like better handling properties, shorter setting time, early mineralization, biocompatibility, elastic modulus quite similar to dentine and greater bond strength¹⁰.

Nearly all dental materials show some kind of dimensional changes on placement into the cavity. Marginal microleakage occurs when restorations are poorly adapted to the cavity walls which leads to penetration of bacteria, fluid and nutrient into the marginal gap¹¹. Microleakage is basically the clinically undetectable passage of bacteria, fluids, molecules or ions between a cavity wall and the restorative material applied to it¹². Microleakage has a major adverse effect on the tooth-restoration interface leading to total failure of the restoration¹³. To study the relationship between marginal microleakage and sealing ability of the materials many in vitro and in vivo studies are being conducted. In order to simulate the clinical setting in vitro conditions, reliable techniques are being used to carry out to imitate thermal changes in the oral cavity during eating and drinking¹⁴. According to International Standardization Organisation (ISO) a standard protocol should be followed to test the sealing ability of dental materials to the tooth structure. To stimulate the thermal changes in the oral cavity, a marginal microleakage assessment should be done by placing the samples for thermocycling in a water bath at 5°C and 55°C temperatures¹⁵.

However, very few studies have been done in order to evaluate the effect of presence and absence of thermocycling on the microleakage and dentin bond failure of newer root-end filling materials. Therefore, this study aims at evaluating the effect of thermocycling on sealing ability of two root-end filling materials.

Materials and Methods:-

Study Samples

Forty extracted single-rooted human teeth were selected for the study. All the samples selected had the following features: mature apices, straight canal, absence of fractures/cracks, no signs of root resorption and no indication of canal calcification.

Sample Preparation

All the samples were thoroughly cleaned using ultrasonics to remove any kind of dental deposits over the surface. The teeth were decoronated to standardize the root length to 16 mm. Canal orifice was located and patency was obtained using a 10k file (Mani inc, Takenzawa, North of Tokyo, Japan). The samples were thoroughly irrigated with 5% sodium hypochlorite (5% Hyposol, Pervest Denpro Ltd., Jammu, India). Root canal preparation was carried out using step-back technique and 40k file was used as master apical file. Canal was dried using absorbent paper points and obturation was done with gutta-percha and AH plus sealer (Dentsply, Konstanz, Germany). The canal orifice was sealed by Glass ionomer cement (Fuji II LC, GC America Inc.). Samples were stored at 37°C and 100% humidity for seven days. All the samples were 3mm resected apically perpendicular to the long axis of the tooth by a

straight fissure bur (SS White). Standardize root-end cavity preparation was done keeping the depth of 3mm and a diameter of 0.8mm using a straight fissure bur(SF 41, Mani, Japan).

Sample grouping

All the samples were initially divided into two experimental groups (n=20):

Group I: MTA plus(Avalon Biomed, Houston, Texas, United States)

Group II: Biodentine (Septodont, Saint-Maur-Des-Fosses, France)

The materials were manipulated according to manufacturer's instructions and cavities were filled using MTA carrier and compacted using a smaller plugger (Dentsply, York, PA-USA). These groups were further divided into two subgroups of ten each (n=10). The second subgroup of both the groups did not receive any treatment and the first subgroup samples were subjected to 500 thermocycles in water bath at temperature ranges between 5°C and 55°C with a dwell time of 30 seconds. This was done in order to stimulate temperature range of oral cavity. The specimens were then coated with nail varnish leaving the apex, it was allowed to dry.

Microleakage Evaluation

Following this all the samples were immersed in methylene blue solution (Fisher scientific by Thermo Fisher Scientific, Mumbai, India) at normal room temperature for 24 hours. After this procedure, the samples were rinsed for 5 mins to remove extra dye over the root surface. The teeth were sectioned longitudinally by using diamond disc attached with micromotor under water coolant. The depth of dye penetration was observed under stereomicroscope at 30x magnification (Nikon SMZ 1500 Zoom Stereomicroscope). **The depth was measured in millimetres along one of the cavity walls where more dye penetration was observed.**

Statistical Analysis:

The data for each sample was analysed by calculating mean. The data was statistical analysed using analysis of variance (Anova) and Post hoc comparisons were performed using Turkey test. The level of significance was 0.05.

Result:-

Table 1 shows microleakage values for different groups. The average depth of dye penetration was least for Biodentine when thermocycling treatment was not given (0.13mm) and maximum value was depicted by MTA Plus when undergone thermal cycles (0.57mm).

Table 1:- Microleakage values for different subgroups in millimeters.

Sample	MTA Plus + Thermocycling (mm)	MTA (mm)	Biodentine + Thermocycling (mm)	Biodentine (mm)
1	0.43	0.33	0.24	0.16
2	0.36	0.5	0.17	0.12
3	0.59	0.46	0.21	0.11
4	0.52	0.39	0.16	0
5	0.77	0.31	0	0.14
6	0.56	0.27	0.15	0.23
7	0.73	0.32	0.22	0.13
8	0.8	0.36	0.29	0.26
9	0.51	0.3	0.2	0.11
10	0.46	0.41	0.17	0
Average	0.573	0.401	0.181	0.134

Abbreviations MTA, Mineral trioxide aggregates; mm, millimetres.

Table 2 below presents the ANOVA of both root-end filling materials with or without thermocycling treatment. It is clear from the significance column that in terms of the microleakage there is a significant difference between the subgroups as the p-value of all the factors is 0.000 which is less than 0.005. Hence, Post Hoc test was applied to identify the homogeneous subsets of means of sub groups.

Table 2:- One way-Anova test.

Microleakage	Sum of Squares	df	Mean Square	F	Sig.
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Between Groups	1.198	3	.399	38.845	.000
Within Groups	.370	36	.010		
Total	1.568	39			

Abbreviations: df, degree of freedom; F, frequency; Sig., significance probability

It is only the mean difference between the Biodentine subgroups that has not reached significance. The p-value is .729, which is greater than the standard .05 alpha level. Rest for all the sub groups the significance level has been reached as the value is less than 0.5 (Table 3).

Table 3:- Multiple Comparisons: Tukey HSD (Honestly significant difference).

(I) SubGroup	(J) SubGroup	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	95% Confidence Interval
					Lower Bound	Upper Bound
MTA Plus + Thermocycling	MTA Plus	.20800*	.04534	.000	.0859	.3301
	Biodentine + Thermocycling	.39200*	.04534	.000	.2699	.5141
	Biodentine	.43900*	.04534	.000	.3169	.5611
MTA Plus	MTA Plus + Thermocycling	-.20800*	.04534	.000	-.3301	-.0859
	Biodentine + Thermocycling	.18400*	.04534	.001	.0619	.3061
	Biodentine	.23100*	.04534	.000	.1089	.3531
Biodentine + Thermocycling	MTA Plus + Thermocycling	-.39200*	.04534	.000	-.5141	-.2699
	MTA Plus	-.18400*	.04534	.001	-.3061	-.0619
	Biodentine	.04700	.04534	.729	-.0751	.1691
Biodentine	MTA Plus + Thermocycling	-.43900*	.04534	.000	-.5611	-.3169
	MTA Plus	-.23100*	.04534	.000	-.3531	-.1089
	Biodentine + Thermocycling	-.04700	.04534	.729	-.1691	.0751

Abbreviation: MTA, Mineral trioxide aggregate; Sig., significance probability

*The mean difference is significant at the 0.05 level.

Once it was determined from ANOVA table that there exist differences among the means, Tukey's Honestly Significant Difference (Tukey's HSD) test which is a post hoc test was used to determine which means differ. This test recognizes homogeneous subsets of means that are not different from each other at an alpha value of 0.05.

Table 4 depicts that in terms of marginal sealing ability, MTA Plus with thermocycling treatment is having the maximum apical leakage i.e. 0.573 as compared to other subgroups. Also, it is evident that Group IV has least apical leakage i.e. 0.134. It is also noted that no significant difference is seen in Biodentine with or without artificial aging procedure.

Table 4:- Means for groups in homogeneous subsets. Tukey HSD^a

SubGroup	N	Subset for alpha = 0.05		
		1	2	3
Biodentine	10	.1340		
Biodentine + Thermocycling	10	.1810		
MTA Plus	10		.3650	
MTA Plus + Thermocycling	10			.5730
Sig.		.729	1.000	1.000

Abbreviation: N, number of samples in each subgroup

Discussion:-

Root canal treatment aims at removal of microbial contents and complete sealing in three dimensions¹⁶. In some cases where conventional endodontic treatment is a failure, surgical endodontics is required. The common surgical procedures are root-end resection and root-end filling with a biocompatible material¹⁷. Studies have shown that apical 3mm of the root contains 98% apical ramifications and 93% of lateral canals which are said to be responsible for root canal therapy failure¹⁸. Resection of root-end should be done at 90 degrees as it conserves root structure and also provides a proper crown/root ratio, whereas if the root-end is resected at 30 and 45 degrees it causes removal of unnecessary root structure and exposes dentinal tubules to periapical area¹⁹. All the material used for the root-end filling should have properties like adherence to the dentin walls, non-toxic, non-irritant to periapical tissues, promote healing, non-corrosive, easy to manipulate, dimensionally stable and impermeable to moisture²⁰. Endodontic therapy failure is caused by apical microleakage. Marginal seal of the filling material can be disrupted due to thermal, chemical or mechanical causes which can occur in the tooth/restoration interface^{21,22}. One of the most common methods to evaluate apical leakage is by dye penetration²³.

Thermal cycle procedure is important to determine marginal sealing ability of a material during laboratory studies^{24,25}. Thermocycling has been introduced in science of dental materials as artificial aging methodology. In literature thermocycling has been defined as the in vitro process of subjecting an extracted tooth carrying a restoration to temperature changes that are found in oral cavity²⁶. The procedure of thermal cycling provides two kinds of stresses: firstly, extreme temperature changes can cause mechanical stresses which lead to crack formation through the bonded interfaces. Secondly, the gap created by debonding is associated with movement of fluids in and out of the gaps²⁷. The appropriate thermocycling procedure includes minimum of 500 cycles in water between 5°C and 55°C for artificial aging of any material²⁸. The method of temperature changes has been tested by many researchers to evaluate marginal fluid movement in restorations in vitro. This technique has been combined with the use of dyes, air pressure, isotopes which help for detecting the microleakage of the dental materials²⁹. In the present study both the materials were subjected to thermal cycles in order to determine the effect of thermal shocks on the sealing ability to root canal dentin.

In this study, the mean marginal sealing ability of Biodentine was more than MTA plus in the experimental groups. Many studies have similar microleakage values where Biodentine had significantly lower apical leakage as compared to other root-end filling materials³⁰⁻³². The mechanism of Biodentine which makes it superior in sealing ability compared to other groups is that when it comes in contact to the dentin of the tooth, it forms mineral tag like structures at the surface of interface, this is called as “mineral infiltration zone”. There occurs biomineralization which is said to be formed due to degradation of interfacial dentin by the alkaline nature of the product, all this process leads to a better sealing ability when placed over the surface of the tooth³³. Another study determined that Biodentine exhibits less porosity and increase density on complete setting as compared to MTA³⁴. The sealing ability of Biodentine was greater than MTA Plus when used as furcal repair material in molars³⁵.

The finding of this study has indicated that the untreated samples of both the groups (MTA Plus and Biodentine) have shown lower microleakage in comparison to those who have undergone thermocycling. Many studies have suggested that microleakage is significantly increased when dental materials are subjected to thermal cycles³⁶⁻³⁸.

Conclusion:-

MTA Plus and Biodentine, the root-end filling materials showed a significant amount of microleakage with or without treatment to thermocycling. There was little effect of thermocycling on microleakage of both the materials. However, Biodentine showed minimum apical leakage even when subjected to artificial aging thus better marginal sealing ability. Hence Biodentine is a suitable root-end filling material in terms of sealing ability.

Source of Funding:

Nil.

Conflicts of Interest:

Nil.

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