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Comparative Evaluation of the Sealing Efficacy of Zinc-Free High-Copper Amalgam and Mineral Trioxide Aggregate used as Root-End Filling Material: An In Vitro Dye Penetration Study

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ABSTRACT

Background: The goal of endodontic therapy is removal of the irritants contained in infected root canals and total obliteration of the root canal system in three dimensions so as to obtain a fluid tight seal - both apically and coronally. Root-end filling should be deemed as a routine, inseparable procedure during apical surgery to improve the prognosis of teeth with apical pathology even in case of apparently well-obturated root canals, as even they may harbour infection[1].The objective of this study was to compare sealing capabilities of different filling materials when used as retrograde filling materials following apiceotomy (to check their sealing abilities as retro filling).

Materials and Methods: The root canals of 44 extracted single rooted upper anterior human teeth were used in this study. Each tooth was apically resected at 90 degrees to its long axis and the root surface isolated with two coats of nail polish.The teeth were decoronated and the roots were obturated by lateral compaction of gutta-percha and sealer. Teeth were divided into 3 groups, the 1st group received Zinc free high-copper amalgam as retrograde filling, the 2nd group was retro filled with Mineral trioxide Aggregate (MTA).The third unlabelled control group received no retrograde root filling. All these teeth were suspended in 1% methylene blue dye at room temperature for 72 hours, the roots were sectioned and dye penetration measured by using stereomicroscope. The sealing abilities of these materials were determined by their ability to inhibit dye penetration.

Result: The result of this study has shown that zinc-free amalgam showed maximum mean leakage when used as a root-end filling material.

Conclusion: The Mineral trioxide aggregate is more effective as compared to zinc free amalgam which showed poor sealing abilities.

Keywords: Root-end filling, Zinc-free high-copper amalgam with varnish, Mineral trioxide Aggregate (MTA), In vitro, Sealing efficacy.

INTRODUCTION

Endodontic procedures have a reported success rate of 95%, failures do occur.[2] However, several clinical conditions such as anatomic deviations of root canal systems from the normal, procedural errors like ledging or perforation, separated instruments, extensive post-endodontic restorations like post and core and teeth being symptomatic even after conventional treatment,

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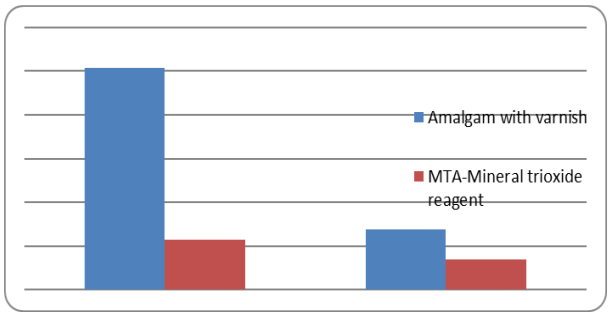
Table 1: Frequency distribution of amalgam in each leakage in groups 1 and 2 is tabulated in Tables 1 and 2 respectively.

Dye penetration (Depth in mm)	No. of specimens	Percentage (%)
0-1	1	5%
1-2	2	10%
2-3	10	50%
3-4	7	35%
Total	20	100%

Table 2: Frequency distribution of MTA in each leakage in groups 1 and 2 is tabulated in Tables 1 and 2 respectively.

Dye penetration (Depth in mm)	No. of specimens	Percentage (%)
0 - 0.5	11	55%
0.5- 1.0	7	35%
1.0-1.5	0	0%
1.5-2.0	2	10%
Total	20	100%



Graph 1: Comparison of mean dye penetration, Standard Deviation (SD) and range of dye penetration (in mm) in both Groups.

warrant surgical approach to save the tooth.[3] The basic surgical procedure for such cases includes resection of the root tip and periapical curettage.[4]. The exposed root canal may be treated from the apical retrograde direction by means of a simple filling - the root-end filling or by retrograde obturation of the entire root canal.

The purpose of the root-end filling is to provide a fluid-tight apical seal to an otherwise unobturated root canal or to improve the seal of an existing root canal obturation against the egress of irritants contained within the root canal into the periradicular tissues .[5]This procedure offers a great challenge to the materials scientists as the specifications of an ideal root-end filling material are quite exacting, and although a plethora of materials are available and have been used, no material has been found that conforms to all of the properties of an ideal root-end filling material.

The array of materials used includes silver amalgam with or without varnish, zinc oxide-eugenol cement and its modifications-Intermediate Restorative material (IRM), Super EBA cement, Cavit, polycarboxylate cement, zinc phosphate cement, Glass ionomer cements, resin composites, dentin bonding agents, gold foil, Teflon, Gallium alloy, cyanoacrylates, bone cements and recently introduced, Mineral Trioxide Aggregate (MTA).[3,6]Amalgam with or without the use of varnish had been the most widely used material since the last century. It is easy to manipulate, readily available and is not affected even when placed in a contaminated preparation. However, it has significant disadvantages like dimensional instability, eventual leakage, corrosion, release of mercury and tin ions and overlying soft tissue discoloration (argyrosis).[3, 7]Mineral Trioxide Aggregate (MTA), introduced in 1993 was suggested as a potential root-end filling material by

its developers- Dr. M. Torabinejad and his associates at the Loma Linda University in California.[8] Its clinical usage worldwide followed after it was subjected to a battery of *in vitro* and *in vivo* investigations, to test its physical and chemical properties, sealing ability, marginal adaptation, cytotoxicity, antibacterial effects and histological evaluation in animal studies, in which it has emerged as the most suitable root-end filling material.

Therefore, this study was thought of to evaluate and compare the sealing ability of Mineral Trioxide Aggregate with that of zinc-free high-copper amalgam with varnishwhen used as root-end filling materials using *in vitro* dye penetration

MATERIALS AND METHODS

Fourty-four extracted, intact, non-carious, single- and relatively straight-rooted teeth with fully formed apices, consisting of human permanent maxillary central and lateral incisors and canines were selected. Teeth with multiple canals, calcifications, root fractures or cracks were excluded from the study. The anatomical crowns of all selected teeth were removed at the cemento enamel.The pulp tissue was extirpated and working length was determined by subtracting 1 mm from the length at which # 10 K-file was just visible from the apical foramen.

All root canals were prepared using a step-back technique to a # 40 master apical file and stepped back upto # 80 file using K-files. All specimens were held in moist gauze while they were being instrumented to avoid dehydration of the specimen. After final irrigation with saline, the canals were dried using absorbent paper points.

The canals were obturated using AH Plus sealer cement (Dentsply,DeTrey,Germany) and standardized gutta-percha cones (Maillefer,U.S.A.) using lateral condensation technique. The canal walls were coated with sealer cement using the lentulo filler at slow speed. The teeth were radiographed to evaluate the obturation.

Apical root resection was done at all roots by removing 3 mm of each apex at 90 degree to the long axis of the tooth by using the fissure bur in high speed hand piece with water coolant. A 3 mm deep root end cavity was prepared by round diamond bur in highspeed

hand piece. Two coats of nail polish were applied on the whole surface of the root except the tip where root end filling have to be applied.

The teeth where divided in to 3 groups and root-end fillings were done using

1. Retro filled with zinc free high copper amalgam (20 roots)
2. Retro filled with MTA (20 roots)
3. Not Retro filled (4 roots), control group.

Dye immersion done by placing each root into a separate 20ml glass vial and immersed in 5ml of dye solution measured using a glass pipette. After 7 days, the roots were removed from the dye and rinsed with tap water for 20 minutes. They were allowed to air dry for 24 hours before removing the nail polish and sticky wax with a # 11 scalpel blade.

The teeth were sectioned in labiopalatal direction by cutting labial and palatal longitudinal grooves in the root with a carborundum disc. The amount of leakage was measured from the most apical part of the root-end preparation to the most coronal extent of dye penetration along the root-end cavity walls using a stereomicroscope (Wild, Heerbrugg, Switzerland). Observations were tabulated and subjected to statistical analysis, using the **unpaired Student's `t' test.**

RESULT

The leakage of the experimental materials are compared in chart-1 where vertical axis is representing Dye penetration in mm while horizontal axis showing both the samples. The statistical analysis was done with the `t' test with p value < 0.01 with 38 degree of freedom. The calculated value of `t' = 11.47 which is more than the table value of t = 2.58, meaning there is a highly significant difference in the leakage values between Group-1 and Group-2.

DISCUSSION

Microleakage is defined as clinically undetectable passage of bacteria, fluids, molecules or ions between a cavity wall and the restorative material applied to it.[9] The purpose of a root-end filling is to

establish a hermetic seal of all apical avenues in the tooth from the oral environment to the periradicular tissues.[10] The dye penetration method employed in the present study, has been the most widely adopted procedure. According to Delivanis and Chapman, dyes are simpler, cheaper, safer and easier to use than the other methods.[99] However, several factors like the size of the dye particles, the pH of the solution may influence the outcome of the study.[11]

High-copper amalgams are used because of their superior physical properties and greater corrosion resistance.[10] also, the modern high-copper alloys in use have been shown to have minimal cytotoxic effects by Tronstad.[12] The characteristics of zinc-free and zinc-containing amalgams have been studied extensively. There are two concerns about zinc in retrograde amalgam fillings- its cytotoxic effects and effects on sealing efficacy. The elimination of zinc in the retrograde amalgam fillings was based on the histopathological report of a single case of zinc carbonate precipitation by Omnell[10] and studies like those of Kaga et al.[13] However, Kimura J.T.,in his study to evaluate cytotoxicity of the two types of amalgams, found no evidence of zinc carbonate precipitation.[14] Therefore, cytotoxicity should not be a factor in determining whether zinc-containing or zinc-free amalgam should be used as retrograde filling materials as they have been shown to exhibit almost similar tissue response.[15] Recently, the predominance of silver amalgam as a root-end filling material has been challenged. Poor long-term success rates as reported by various workers like Frank et a1, [16] Dorn and Gartner, [17] were interpreted as evidence of poor biocompatibility, lack of long-term stability, inadequate adaptation to the cavity walls and late leakage of the amalgam. This coincided with the peak of the public awareness of mercury toxicity due to amalgam fillings and environmental concerns, which resulted in re-evaluation of all aspects of the use of amalgam in dental practice. The quest for a substitute to amalgam induced clinicians to attempt to use a great variety of materials.

These shortcomings have been tackled to a great degree by the use of the Mineral Trioxide Aggregate (MTA).This material was developed by Dr.Mahmoud Torabinejad and his associates at the Loma Linda University in California. It claims to seal off all the pathways of communication between the root canal system and the external surface of the tooth.[18] The use of MTA has many advantages: [19]

1. Least toxic of all the filling materials
2. Excellent biocompatibility
3. Hydrophilic
4. Reasonably radiopaque.

The results obtained in the present study exhibited a difference in the pattern of microleakage between both the groups studied. The negative control group showed no leakage at all, concluding that two coats of nail varnish and one coat of sticky wax was efficient enough to prevent dye penetration. The positive control group showed maximum dye leakage thereby confirming the efficacy of methylene blue dye penetration when the samples were subjected to vacuum in leakage studies. Group-1, which was root-end filled with high-copper zinc-free amalgam following varnish application, showed the highest score of leakage values with average leakage value of 2.54mm. This is significantly higher than the average leakage values of Group-2. This leakage data obtained is in agreement with the findings of Abdal et a1[20], Torabinejad M. et a1[18], Bates et al[21], and by Yasushiro et a1[22], Stabholz et a1[23] and Szeremeta-Browar[24] showing that all amalgam root end fillings leaked with the maximum dye leakage scores.

This substantial leakage in case of amalgam retrograde fillings perhaps can explain the low success rates of endodontic surgery using amalgam root-end fillings, in various long-term retrospective studies like that by Dorn and Gartner[25] and by Frank et al.[26]

Group-2 was root-end filled with Mineral Trioxide Aggregate. This group showed the least leakage as compared to amalgam and the average leakage value was 0.57 mm. The results of this study agree with the similar dye leakage studies by Torabinejad et al [28] and J.Agrabawi.[27] This sealing ability of MTA is probably due to its hydrophilic nature and slight expansion when it sets in moist environment.[95] The decreased leakage may also be due to superior marginal adaptation of Mineral Trioxide Aggregate as shown by Torabinejad et a1.[29]

CONCLUSION

Hence the present *in vitro* study corroborates the finding of significantly superior sealing efficacy of Mineral Trioxide Aggregate as compared to that of Intermediate Restorative Material and amalgam when placed as root-end materials.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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