Original Article

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MARGINAL ADAPTATION OF BONE CEMENT COMPARED WITH AMALGAM AND MTA AS ROOT END FILLING MATERIALS - A STEREOMICROSCOPIC AND SEM STUDY

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ABSTRACT

Objective: Acrylic bone cement occupies a distinctive place in the hierarchy of synthetic biomaterials. It has many characteristics that make it well-suited as a root-end filling material. The purpose of this study was to evaluate the marginal adaptation of polymethylmethacrylate (PMMA) bone cement, mineral trioxide aggregate (MTA), and amalgam as root-end filling materials. **Materials and Methods**: Thirty extracted human single-rooted teeth were cleaned, shaped, and obturated with gutta-percha and AH 26 sealer. The roots tips were removed; root-end cavities were prepared and filled with the 3 tested materials (bone cement, MTA, and amalgam). The original roots were longitudinally sectioned into 2 halves and longitudinal sections were studied under scanning electron microscope to measure the gaps at the material/dentin interface. Half of the sections were observed for depth of dye penetration under stereomicroscope. **Results**: The obtained data revealed that both bone cement and MTA exhibited a better adaptation to the dentinal walls than that of amalgam. **Conclusions**: PMMA bone cement could be considered as a promising root-end filling material.

KEYWORDS: Amalgam; bone cement; cytotoxicity; marginal adaptation; MTA

INTRODUCTION

Most endodontic failures occur as a result of leakage of irritants from pathologically involved root canals. When it is not possible to obtain a hermetic seal between the periodontium and root canal foramina by an orthograde approach, surgical endodontic therapy with apical root resection and root-end filling is needed to save the tooth.[1] The primary function of retrograde filling is to seal the root canal system when an adequate seal does not exist even after root resection. This prevents leakage of irritants from the root canal into the periradicular tissues, which could eventually cause a treatment failure. The root-end filling material should provide an apical seal to an otherwise unobturated root canal or improve the seal of existing root canal filling material and be biocompatible with the periradicular tissues. Johnson[2] expressed concerns about the potential relation between long-term clinical success and critical properties for an ideal root-end filling material, namely biocompatibility, sealing ability, and handling properties. According to Gartner and Dorn[3] an ideal material to seal the root-end cavities should prevent leakage of microorganisms and their by-products into the periradicular tissues. It should also be non-toxic, non-carcinogenic, and biocompatible with the tissue fluids and dimensionally stable. The presence of moisture should not affect its sealing ability. For practical purposes, it should be easy to use and be radio-opaque, to be recognizable on the radiograph. Throughout the dental history, wide varieties of materials have been used for retrograde fillings. Although a plethora of materials are available, no material has been found that fulfills all or most of the properties for ideal retrograde filling material. Amalgam has been used as a root-end filling for many years. Its potential disadvantages include initial leakage, mercury and tin contamination, moisture sensitivity, and need for an undercut in the cavity preparation.[1] Mineral trioxide aggregate (MTA) is considered as an alternative to amalgam as a root-end filling material. Positive histologic and radiographic outcomes showed that

Table 1: Dye penetration test for microleakage

Sample No.	AMALGAM	MTA	BONE CEMENT
1.	2.9mm	1.6mm	1.2mm
2.	2.5mm	0.99mm	1.0mm
3.	2.8mm	1.55mm	0.62mm
4.	2.0mm	1.8mm	0.88mm
5.	1.99mm	1.2mm	1.1mm
6.	2.7mm	1.3mm	0.98mm
7.	2.0mm	1.9mm	0.61mm
8.	1.89mm	1.1mm	1.4mm
9.	2.8mm	0.99m	1.5mm
10.	2.6mm	1.4mm	1.3mm

Table 2: Marginal Adaptation Test

Sample No.	AMALGAM	MTA	BONE CEMENT
1.	4.40 ±0.388µm	2.16± 0.564µm	1.95 ± 0.399µm
2.	3.20 ±0.388µm	2.00± 0.564µm	2.01 ± 0.399µm
3.	4.02 ±0.388µm	2.01± 0.564µm	1.86 ± 0.399µm
4.	4.00 ±0.388µm	1.99± 0.564µm	1.90 ± 0.399µm
5.	3.91 ±0.388µm	2.04± 0.564µm	1.99 ± 0.399µm
6.	3.01 ±0.388µm	2.03± 0.564µm	2.00 ± 0.399µm
7.	4.11 ±0.388µm	2.15 ± 0.564µm	1.55± 0.399µm
8.	3.88±0.388µm	2.11± 0.564µm	1.88± 0.399µm
9.	2.99 ±0.388µm	1.98± 0.564µm	2.00± 0.399µm
10.	3.39 ±0.388µm	2.12 ± 0.564µm	1.77 ± 0.399µm

MTA is a suitable root-end filling material for periradicular surgery, providing appropriate healing response from periapical tissues.[4] MTA has been shown to be bioactive because of its ability to promote a biomineralization process.[5] However, MTA has been criticized in relation to the requirements of an ideal root-end filling material in two regards, difficulty to handle and very slow setting reaction,[6] which might contribute to leakage,[7] surface disintegration,[8,9] loss of marginal adaptation, and continuity of the material.[10] One of the new materials that might potentially provide the necessary properties of a root-end filling material is polymethylmethacrylate (PMMA) bone cement. It is widely used in orthopedic surgery, mainly for fixation of the prosthesis but also for stabilizing compressive vertebral fracture or filling bone defects.[11] Commercial acrylic bone cements are supplied as 2 components, a powder polymer and a liquid monomer that are mixed at the time of application. One of the problems of methylmethacrylate bone cement is the exothermic reaction of curing, and as a result, high temperature might be generated during its polymerization. Another problem is the component of bone cement that might be toxic, especially the residual methylmethacrylate monomer. However, many studies have investigated the effect of free monomer on tissue, and they indicated little toxicity.[12,13] Other studies suggested long-term compatibility of bone with bone cement, which allowed excellent interlocking of the cement with the soft and hard tissue of bone without bone necrosis.[15] Blinc *et al.*,[16] suggested a negligible thermally induced effect of Palacos bone cement exothermic reaction with a small mass of the cement. In addition, bone cement tolerates a moist environment very well; blood contamination of bone cement resulted in no differences in mechanical penetration of the cement into the bone–bone cement interface.[17] These characteristics might potentially make bone cement a suitable rootend filling material. Therefore, this study aims to accomplish the following: I) To investigate the marginal adaptation of bone cement, MTA, and amalgam by using longitudinal sections of teeth under scanning electron microscopy (SEM); II) To study the degree of microleakage with tested materials with dye penetration test under stereomicroscope.

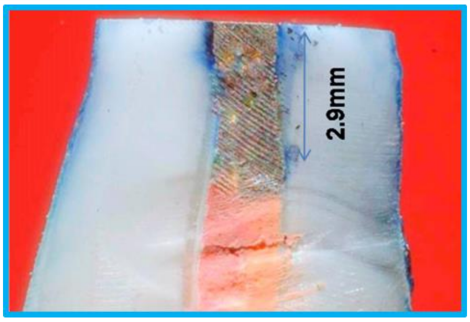

Fig. 1: Dye Penetration with Amalgam

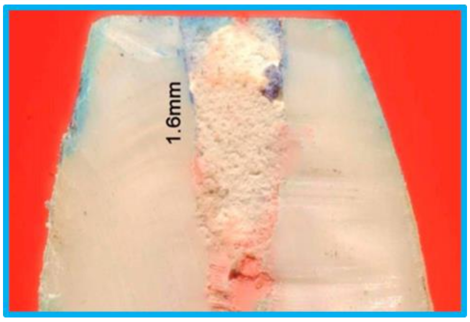

Fig. 2: Dye Penetration with MTA

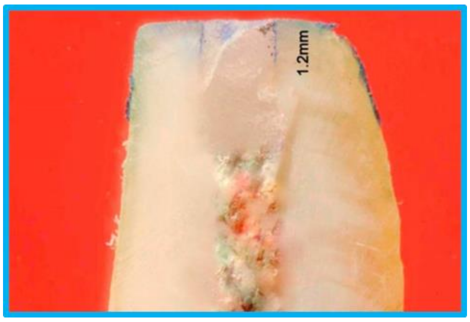

Fig. 3: Dye Penetration with Bone Cement

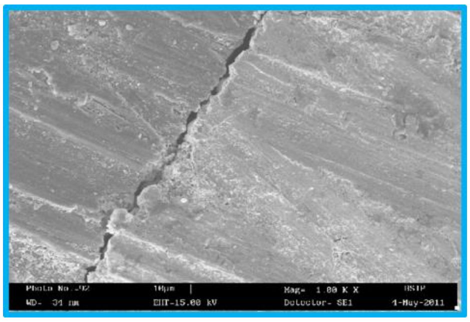

Fig. 4: Marginal Gap with Amalgam

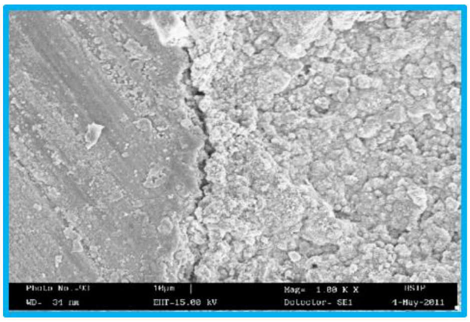

Fig. 5: Marginal Gap with MTA

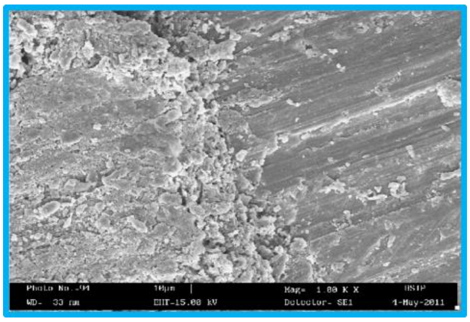

Fig. 6: Marginal Gap with Bone Cement

MATERIALS AND METHODS

Thirty freshly extracted single-rooted human teeth were used for this study (10 for each group). After extraction, the teeth were fixed in thymol. The root canals were cleaned, shaped, and obturated with gutta-percha and AH 26 root canal sealer. Then the apical 3 mm of the root tips was removed perpendicular to the long axis of the tooth with a 556 bur (S. S. White, Philadelphia, PA) in high-speed handpiece under water spray. A 3-mm-deep root-end cavity was prepared on each resected root end with the use of 170L fissure bur (S. S. White). The cavities were filled with PMMA bone cement (Palacos; Heraeus Kulzer, Wehrheim, Germany), gray MTA (ProRoot; DentSply, Tulsa Dental, Tulsa, OK) and amalgam (World-Cap; Ivoclar Vivadent, Solna, Sweden) and stored in 100% humidity at 37ºC for 48 hours. The specimens were subdivided into sub groups A, B, C with 10 teeth each and filled with amalgam, MTA and bone cement respectively.

DYE PENETRATION TEST

Thirty samples were coated with nail varnish except for the apical 3mm .then these samples were immersed in 1% aqueous Methylene blue dye & placed in an incubator at 37ºC for 3 days. After that, the roots were longitudinally sectioned into 2 halves using diamond disc. The depth of dye penetration was examined under a stereomicroscope with magnification of 20x. The greatest depth of dye penetration along one of the cavity walls was measured in millimeters (Table 1). The results were tabulated and subjected to one way ANOVA and multiple range test by TUKEY –HSD procedure.

MARGINAL ADAPTATION TEST

The roots sections were dehydrated in a gradient series of aqueous ethanol (30%, 50%, 70%, 90%, and 100%) for 10 minutes at each concentration.

Each half was mounted on an aluminum stub and sputter-coated with gold. The distances between the root-end filling materials and cavity walls were measured directly by the SEM at 4 points of the material/dentin interface (Table 2). The means standard deviations were calculated; one-way analysis of variance (ANOVA) and Tukey test were used to determine statistical differences among the studied groups.

RESULTS

For the longitudinal section specimens, SEM examination of the interface showed that bone cement group had the least gap measurements (1.855 ± 0.380 µm) (Fig. 6), whereas maximum gaps were found in samples filled with amalgam (4.48 ± 0.396 µm) (Fig. 4). Mean gap measurement between MTA and dentinal wall was 2.141 ± 0.530 µm (Fig. 5). One-way ANOVA showed that there were significant statistical differences between the 3 tested materials ($P < .05$). Tukey test showed that no significant difference was found between bone cement and MTA, whereas significant difference was found between both materials and amalgam. ($P < .05$). Representative photomicrographs of the interface between the filling material and dentin for longitudinal sections are shown in Fig. 4, Fig. 5 & Fig. 6. All the retrograde root fillings showed leakage with dye penetration test. Although none had a score of zero, the scores were less in MTA (Fig. 2) and bone cement (Fig. 3) than those for amalgam (Fig. 1). The dye leakage scores were lowest in specimens retrofilled with bone cement.

DISCUSSION

Marginal adaptation constitutes an indirect method to compare the sealability of root-end filling material.[4] SEM has been used to determine the marginal adaptation of various root-end filling materials to the surrounding tooth structure by using longitudinal sections of the tooth. However, this method has several shortcomings; conventional preparation of biologic samples before the SEM examination might be associated with the introduction of many artifacts. High vacuum evaporation can cause artifacts such as cracks in hard tissue samples and separation and lifting of the filling material from the surrounding tooth. In addition, there might be expansion or contraction of the tooth and/or filling material. To reduce the likelihood of artifacts, several resin replication methods have been suggested. The good adaptation of MTA to cavity margins might be intrinsically linked to the nature of the material. MTA powder consists of fine hydrophilic particles that absorb water during hydration. Therefore, the material expands during solidification, which must have played a role in its superior adaptation to cavity margins.[19] The superior adaptation of MTA has been shown in previous reports as well.[18,20,21] The poor adaptation seen in cavities filled with amalgam might be due to its contraction on setting. However, when amalgam is used as a restorative material, its seal improves with time as a result of accumulation of corrosion products. The obtained results indicated that PMMA Palacos bone cement had an excellent adaptation to the cavity margins in both the longitudinal sections and resin replicas. These results are in accordance with the previous results of the dye diffusion study performed by High and Russell,[22] which proved a satisfactory marginal seal by the use of bone cements (CMW and Palacos with gentamicin) as root-end filling materials. In addition, Holt and Dumsha[23] showed that Simplex P bone cement provided an acceptable retrofill seal in their leakage study. The proper adaptation of bone cement to the dentin wall in spite of the well known polymerization shrinkage of acrylics might be explained by the results of previous investigations of Charnley,[24] who used a fluid displacement model and observed that the volume of cement increases to a maximum during polymerization before shrinking slightly, although not to its initial volume. Therefore, SEM examination of marginal adaptation of bone cement to dentin in this study can provide information that might indicate the proper sealing ability of this material when used as a root-end filling material. The dye leakage scores were also lowest in specimens retrofilled with bone cement indicating its superior marginal adaptation compared to amalgam and MTA. Bone cement has been studied mainly in relation to its use in medicine; it does not seem to have any negative effects, even in the large quantities needed during total hip arthroplasty. This claim is supported in the literature and by 20-year use in surgical applications.[25] The amounts required in endodontics are much less than what would be needed in orthopedics. The lesser amounts required would produce a much lower exothermic reaction and a much reduced amount of free monomer. Thus, bone cement might be alternated from medical to dental use. Antibiotic loaded bone cements are also available. It has been shown that after the surgery, the antibiotics leak from the bone cement into the tissues around the total hip. The local concentration of antibiotics is sufficient to kill the bacteria left in the operative wound. On the other hand, the quantity of antibiotics that come into the circulation is low, so that the risk for general allergic reaction against the antibiotics is low.

CONCLUSION

From the results of this study, it appeared that bone cement might be considered as a promising material for use as a root-end filling. Further animal and human studies are needed to evaluate bone cement as a root-end filling material.

CONFLICT OF INTEREST & SOURCE OF FUNDING

The author declares that there is no source of funding and there is no conflict of interest among all authors.

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