Obturation Quality of Chitosan-Modified Glass Ionomer Cement in Root Canals (In Vitro Study)

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Abstract

Background: Many materials are used for root canal obturation but all of them possess certain drawbacks. In the present study compared the obturation quality of Glass ionomer cement containing chitosan root canal filling material with other regularly used materials by using dye penetration.

Material and Methods: Thirty-six human roots were chosen for this study. After de-coronation of the teeth and separation of the desired roots, they were instrumented by the Protaper Universal system from S1-F4 and then divided into three major groups: Group 1, filled with experimental material (glass ionomer cement/ Chitosan); group 2, filled with gutta-percha with zinc oxide eugenol sealer; group 3, filled with gutta-percha with AH26. The evaluation was performed by radiographs post-obturation and by dye leakage test.

Results: There was no significant difference between root canal obturation materials.

Conclusions: The use of glass ionomer cement with chitosan root canal filling material improves the obturation quality of root canals.

Key words: *Chitosan , Glass ionomer cement, Obturation material.*

Introduction

Filling a root canal through cold lateral compaction requires the removal of the infected dentine in the apical few millimeters by shaping to at least a size 30 file, which widens the apical part of the canal to a reasonable size to allow effective obturation [(1)] . Another root canal filling materials has been proposed as resins in combination with adhesives. These materials may improve seal, but still cause difficulties because of polymerization shrinkage. Another difficulty is the accessibility of adhesive systems and curing light (for dual types of cement) into the deep parts of the root canal system. Moreover, resin removal is difficult or impossible in the retreatment of curved root canals[(2)] .

ProTaper Universal rotary system instruments (Dentsply Maillefer, Ballaigues, Switzerland) were designed to possess increasing percentage tapers along their length, therefore making each file shape a specific area in the root canal. This design decreases torsional load, instrument fatigue, and possible separation[(3)] .

Many root filling materials and techniques were used to obtain a tight root canal seal and be a dense, homogeneous mass that fills the entire instrumented root prepared canal[(4)] .

One available alternative to the conventional root canal filling materials is the glass ionomer cement (GIC) root canal sealer. This GIC sealer is biocompatible in the osseous environment, and it bonds chemically and mechanically to the root canal dentin. This bond may

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reinforce the root against fracture and enhance the seal of the root canal[5] .

GICs are interesting materials because of their good adhesion to the calcified tissues, their ability to release fluoride, and relatively low cost. However, they are brittle materials with relatively poor mechanical performance [6] . Considerable improvements have been achieved since the invention of GIC, and further improvements are required to enhance their physical properties[7] . Polymers as cement modifiers improve some properties, such as fracture toughness, impermeability, durability, and bond strength to various substrates[8] . Hayashi et al. investigated the effect of chitosan (CH) which is a biocompatible polysaccharide biopolymer, on the flexural strength of glass ionomer restoratives (GIRs) and leaching of fluoride ions from GIRs. The addition of 0.0044wt% of CH to a commercial GIRs improves the mechanical properties and catalyzes the leaching of fluoride ions. This study concluded that CH can be easily added to the traditional formulations to induce synergy effects. CH possesses mucoadhesive properties due to the molecular attractive forces formed by electrostatic interaction between positively charged CH and negatively charged mucosal surfaces[9] . Debnath et al. and Ibrahim et al. concluded that modifying the liquid phase of a conventional GIC with10% v/v CH significantly improves the antibacterial property of GIC[10] . Mishra et al. studied the physical properties of GIC/Ch and found superior results over the traditional GIC[11] .

Material and Methods

Sample preparation:

The collected 36 extracted single-straight rooted human teeth with a single canal (mandibular 2nd premolars) were used for this experimental study without any anatomical abnormality or calcification, extracted for orthodontic or periodontal purposes. They were decoronated at the cementoenamel junction using conventional high-speed turbine with cutting diamond fissure bur and water-air coolant. The root sample was 16mm in length. The roots were checked by a stainless steel k-file (size # 15) to verify the canal patency. The stainless steel k-file (size # 15) had to reach the apical terminus and appear from the root apex slightly and tightly (just seen). Any root that did not fulfill this criterion was discarded. Immediately after extraction, the specimens were cleaned of all periodontal attachments and then each root was stored in isotonic saline in small glass vials.

Sample Instrumentation:

Working length was established 1 mm short of the 16mm length. Protaper Universal rotary Ni-Ti instruments (Dentsply Maillefer, Ballaigues, Switzerland) and crown down technique were used with an endodontic handpiece. Instrumentation was done to all the root canals starting with lubricating the canal with 0.2 ml of 17% EDTA solution then shaping file (S1) was inserted to the coronal one-third of the canal length and rotated until the file was found to be snug at this length. The shaping file (S2) was inserted into the coronal two-thirds of the canal. Then finishing files F1-F4 were inserted just to the full working length and rotated for 3 seconds. After each file, the canal was irrigated with 0.2 mm of %17 EDTA for 1 minute combined with 1ml of 5.25% prepared NaOCl to remove the organic and inorganic remnants. Apical patency was verified after root canal preparation using a size 15 K-File (Dentsply, Ballaiges, Switzerland).

Sample Grouping:

The 36 selected roots were divided randomly into 3 groups:

Group A: Twelve roots obturated with experimental material (GIC+CH).

Group B: Twelve roots obturated with Thermafil with ZOE sealer.

Group C: Twelve roots obturated with Thermafil with AH26 (Denstply, Germany).

Obturation techniques:

For group A (injectable experimental material) the experimental material was mixed in a 2:1 liquid/ powder ratio (Promedica dispenser droplet and spoon). The powder was conventional glass ionomer filling with 5% bismuth oxide and the liquid was 1:4 volume/ volume of chitosan solution and (phosphonate modified glass ionomer liquid) on a glass slab by cement metal spatula for about 45 seconds. The mixture was aspirated by using a sterile 1ml size syringe with needle gauge

25. The needle was pre-fitted into the canal about 3 mm shorter of the working length and established with a rubber stopper on the needle. The backfill technique was used until the canal was overfilled. The excess material was wiped with clean absorbent paper. In groups B and C, Thermafil size # 40 was used for obturation. The rubber stopper was adjusted to the previously verified working length for each root and then placed in the oven (ThemaPrep plus Oven) until the gutta-percha softened. The sealer was mixed on a glass slab with cement metal spatula in accordance with the manufacturer's instructions. A thin coat of sealer was applied to the internal canal walls with the aid of a finger spreader (size #40). Immediately after sealer placement, the warmed ready obturator was removed from the ThermaPrep Plus heater and carried slowly to the full working length in the canal by a pair of tweezers. Prepi bur with a non-cutting metal ball was used to trim off the shaft of the obturator with the coronal orifice, and then a heated hand plugger size #4 was used for vertical adaptation. A zinc oxide-based sealer, Endofill (PD, Switzerland), was used in group B, and AH 26 sealer was used in group C.

All obturated samples were stored for 7 days at room temperature (37 °C) in an incubator. The samples were radio-graphed in the buccolingual and mesiodistal aspects. In all obturation groups, complete obturation of the canal was verified by x-ray film to ensure dense obturation of the canals with the absence of the voids.

Dye penetration study:

With the exception of the apical and coronal 2 mm of the root, the rest of the root surface was covered with three layers of nail polish. Subsequently, the samples were placed in India ink solution (BDH, England) at room temperature (37 ℃) for 72 h. During this period, each sample was shaken every 6 hours to allow all surfaces of the root to be available to the dye solution. After this period, the roots were removed and washed under tap water thoroughly and allowed to dry for 48 hours at room temperature (37 ℃). Each root was cleaned from the nail polish using acetone solution and surgical blade no. 11. The roots were decalcified by placing them in 5% nitric acid, which was prepared by adding 1 part of 70% nitric acid (Scharlab S.L. Spain) to 14 parts of distilled water. Each vial containing the samples was added to the prepared nitric acid and then shaken every 8 h to allow the decalcification of all surfaces. The nitric acid solution was changed daily for 4 days. The decalcified roots were washed under running tap water for 4 h (to remove any trace of nitric acid). Dehydration was performed by using ascending grades (80%, 90%, 95%, and 100%) of isopropyl alcohol (Scharlab S.L. Spain). To prepare 80% isopropyl alcohol solution, 80 ml of absolute isopropyl alcohol was added to 20 mL of distilled water. In the same way, 90% and 95% of alcoholic solutions were prepared by adding 90 and 95 ml of absolute alcohol to 10 and 5 ml of distilled water, respectively. First, 80% isopropyl alcohol was added to the vials for 12 hours, and then the prepared 90% alcohol was added to the samples and remained in it for 1 hour. Subsequently, the solution was changed, and the prepared 95% alcohol was used for 1 hour. Finally, absolute (about 100% isopropyl alcohol) was added to the samples for another hour. Finally, the roots were rendered transparent by immersion in methyl salicylate (Scharlab S.L. Spain) for 3 hours. The roots were stored in the clearing solution until the time of examination under the stereomicroscope.

Stereomicroscope evaluation:

The cleared roots were fixed on a glass slide with epoxy resin and then viewed under a stereomicroscope at 20× magnification. Apical and coronal dye penetration was evaluated by two independent examiners to detect the maximum dye penetration in apical and coronal directions, and scoring was made as follows:

Score 0: 0 no dye penetration

Score 1: 0.1–1 mm

Score 2: 1.1–2 mm

Score 3: 2.1–3 mm

Score 4: 3.1–4 mm

Score 5: 4.1–5 mm

Score 6: >5 mm

Results

Table 1 and Figure 1 show that the lowest mean scores of dye penetration microleakage and the standard deviation were for the Thermafil-ZOE apical (1.25±0.91)

and Thermafil-AH26 coronal (1.25±1.50) and the highest mean scores of microleakage and the standard deviations were for the GIC+CH material coronal (2.27±1.61). However, ANOVA test results showed no significant differences between the tested materials at the apical and coronal regions at P>0.05(Table 2).

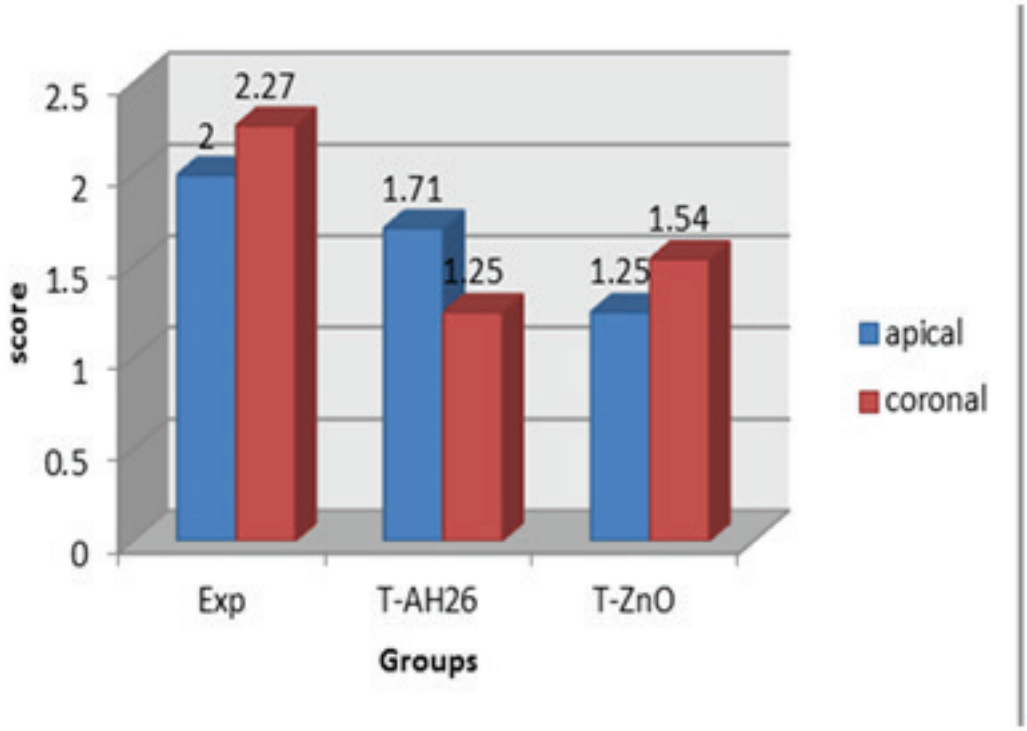

Fig. 1: Microleakage scores of the tested materials at apical and coronal areas of the root canals

Table 1: Descriptive statistics of dye penetration of the different groups at apical and coronal areas

Area of root canal	Group	N	Min.	Max.	Mean	Std. Deviation	Std. Error	Variance
Apical	GIC / Chitosan	12	1.00	5.00	2.00	±1.459	.211	2.128
	Thermafil-ZOE	12	.00	4.00	1.25	±.911	.131	.830
	Thermafil -AH26	12	.00	5.00	1.71	±1.429	.206	2.041
Coronal	GIC / Chitosan	12	.00	5.00	2.27	±1.608	.232	2.585
	Thermafil -ZOE	12	.00	5.00	1.54	±1.336	.193	1.785
	Thermafil -AH26	12	.00	4.00	1.25	±1.495	.216	2.234

Table 3:ANOVA test for comparison of microleakge among the different groups at apical and coronal areas

ANOVA-apical					
	Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
Between Groups	12.111	3	3.327	1.114	.135
Within Groups	96.512	141	1.415		
Total	108.623	144			
ANOVA-coronal					
	Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
Between Groups	12.805	3	2.360	.904	.488
Within Groups	108.617	141	2.611		
Total	121.422	144			

Discussion

The three-dimensional tight seal of the prepared root canal is imperative toprevent apical and coronal leakage in the root canal system[5] . Fluid movement may occur due to inadequate filling which may form defects in the filling material, therefore forming periapical chronic inflammation and decrease the prognosis of the whole the endodontic treatment[6] . Numerous methods were advocated to evaluate the sealing quality of obturated root canals against any external fluid. Dye penetration test has been used extensively because they are easy to accomplish and do not require many materials and expensive devices[5] .

The dye used in the present study allows easy and quantitative measurement of the degree of dye penetration by linear measurement techniques. Its molecular size resembles that of bacterial byproducts, such as butyric acid, that may be extruded out of infected root canals and irritate the periapical tissues[7] .

Debridement of the internal wall of the prepared root canal by dissolving the smear layer is imperative to ensure success to root canal treatment[8] . In the present study, the smear layer was removed by EDTA to expose the dentinal tubules' orifices and maximize an adaptation of the cement to the canal wall but some studies showed that leaving the smear layer may decrease apical leakage of MTA fillings[12] .

ProTaper Universal instruments are used in the crown-down technique to avoid stress on files by the early opening of the coronal part of the root canal. The apical area of all root canals was prepared to F4 because apical preparations for large instruments facilitate proper irrigation and obturation with gutta-percha[13] .

The Thermafil system resulted in dense and well-adapted root canal fillings throughout the entire canal system than lateral condensation with standard gutta-percha. An excellent adaptation was observed when comparing ThermaFil with System B.

The experimental material may be an acceptable alternative to the Thermafil technique as indicated by the non-significant difference with the most accepted resin sealer-based AH26 obturating material. This result might be attributed to the effect of GIC and its chemical adherence to tooth structure or the chitosan as polymer

adherent. Many studies concluded that the physical strength of a commercial glass ionomer restoration can be considerably improved by adding a small amount of CH[11,14] .

Finally, as Abraham et al. concluded, chitosan-modified GIC may show many benefits when used in dentistry as a restorative material to decrease microleakage [15] .

Conclusion

The use of the chitosan-GIC material did not negatively affect the obturation quality of root canals when compared with conventional types of materials.

Ethical clearance: All experimental protocols were approved under the College of Dentistry, University of Baghdad, Baghdad, Iraq and all experiments were carried out in accordance with approved guidelines.

Source of Funding : Self.

Conflict of Interest: nil.

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