Effect of Intracanal Irrigants on the Push-out Bond Strength of Three Root Canal Fillings to Primary Teeth

F Abdelmegid[1], F Salama[2], S Altamimi[3], Z Alqobisy[3], O Alshammari[3]

ABSTRACT

Aim: This investigation evaluated the push-out bond strength (POBS) of three root canal filling materials: Zinc-oxide and eugenol (ZOE), calcium hydroxide (CaOH) and mineral trioxide aggregate (MTA) after application of two intracanal irrigants [3% Sodium Hypochlorite (NaOCl) or 2% Chlorhexidine Gluconate (CHX)] on primary anterior teeth.

Methodology: The roots of 60 primary anterior teeth were prepared and sectioned (3-4 slices/root) with 1.00 mm thickness. Each root slice was irrigated for 4 min with 3% NaOCl or 2% CHX, dried and filled with ZOE, CaOH or MTA. Then the push-out force was applied at a cross-head speed of 0.5 mm/min until bond failure occur and the mode of failure was recorded.

Results: There was significant difference between the POBS of all filling materiel ($p<0.05$). MTA showed the lowest bond for both NaOCl and CHX. However, CaOH and ZOE showed higher bond strength to root dentin when irrigated with NaOCl than CHX.

Conclusion: A combination of ZOE\NaOCl has the highest POBS to root dentin of primary teeth. While the use of CHX with all root canal filling materials showed lower POBS. MTA with either NaOCl or CHX showed the lowest POBS to root dentin of primary teeth.

Keywords: MTA, primary teeth, push-out bond strength, root canal irrigation

From: [1]Department of Oral Medicine and Diagnostic Sciences, [2]Department of Pediatric Dentistry and Orthodontics, and [3]College of Dentistry, King Saud University, Riyadh, Kingdom of Saudi Arabia.

Correspondence: Dr F Salama, Department of Pediatric Dentistry and Orthodontic, College of Dentistry, King Saud University, PO Box 60169 Riyadh 11545, Saudi Arabia.
E-mail: fsalama@ksu.edu.sa

INTRODUCTION

Smear layer is created from the surface constituents of dentin walls during instrumentation of the root canal, irrespective of the kind of instrument and instrumentation method (1). It represents a potential gap between filling materials and walls of root canal and prevents the penetration of irrigation solutions and medications into dentin walls and dentinal tubules (1). Additionally, it prevents thorough adaptation of the root filling materials to the surfaces of the canal; consequently, researchers believe that its presence is unfavorable and must be removed with auxiliary chemicals (2).

Several resorbable filling materials of root canal are used including nonreinforced ZOE (3). Nevertheless, ZOE cannot be considered the ideal root canal filling material because it presents limited antimicrobial action and it tends to resorb at a slower rate than the roots of the primary teeth (4). CaOH is easily resorbed when inadvertently forced beyond the dental apex and is considered to have some antimicrobial action associated with its ionic dissociation into $Ca^{2}+$ and OH-ions (5). MTA has proven to have numerous possible clinical uses due to its better sealing, biocompatibility, bactericidal and set in the existence of blood (6).

The Push-out test permits evaluation of bond strengths of root canal fillings at different levels of root canal walls (7). Several studies have investigated the adaptation of resin sealer to root canal dentin in permanent teeth, however, to the best of our knowledge and available data, there is no study evaluating the POBS of different fillings of root canal to intra-canal dentin of primary teeth. Therefore, the aim of this investigation was to evaluate the POBS of three root canal filling materials: ZOE, CaOH and MTA after application of two intracanal irrigants [3% NaOCl or 2% CHX] on primary anterior teeth. The null hypothesis was that no difference in the POBS of the three tested root canal filling materials of primary teeth after application of two intracanal irrigants.

MATERIALS AND METHODS

This study was approved by the Ethical Committee of Human Studies, College of Dentistry Research Center, King Saud University. Extracted 60 maxillary primary anterior teeth were collected and stored in 0.1% thymol solution and used. The power sample size was 0.83 with estimated standard deviation 1.0 and maximum difference 1.4, so the sample size must be at least 15. For the reliability Cronbach's alpha test was 0.869 with *p* value was 0.001 and it was significant.

Preparation of specimens

Teeth were horizontally sectioned to have approximately 12 mm root length. The pulpal tissue was removed using a barbed broach (DENTSPLY Maillefer, Tulsa, Oklahoma, USA) and root canals were irrigated using 10ml of saline solution (Normal Saline, Pharmaceutical Solution Industry, Jeddah, Saudi Arabia). The root canals were instrumented using ProTaper rotary files (ProTaper Universal, DENTSPLY Maillefer, Ballaigues, Switzerland). A parallel Peeso reamer drill size 2 (0.8mm diameter) (Pesso Enlargers, VDM GmbH, Munich, Germany) was applied to form parallel and identical canal space (0.9mm diameter/10mm length). The specimens were embedded in acrylic resin (Caulk, DENTSPLY Maillefer, Ballaigues, Switzerland). The roots were sectioned (3-4 slices/root) perpendicular to the long axis into 1.00 mm thick serial slices using a precision saw (IsoMet, Buehler, Illinois, USA). The canal of each root slice was irrigated for 4 min with the 5ml of following solutions: 3% NaOCl (Clorox, Abudawood & Partners for Industry, Jeddah, Saudi Arabia, Patch# P-33) or 2% CHX [CHX-PLUS, Vista Dental Products, Racine, USA, Patch#503900). The standardized root slices were dried and filled with ZOE (Zinc Oxide, Deeppak, Miami, USA, patch# Z600053), CaOH (Well-Pex, Vericom Co., Virginia, USA, Patch# WX533100) or MTA (ProRoot MTA, DENTSPLY Maillefer, Ballaigues, Switzerland, Patch# 13082005A) according to the instructions of the manufacturers. All specimens were stored in laboratory oven (100% humidity/37°C) (Universal Oven, Memmert GmbH, Schwabach, Germany) for one week.

Measurement of POBS

Loading was applied on the root filling material to measure POBS using three different diameter sizes of stainless steel cylinder-shaped plunger/rod depends on the size of the canal (0.8mm, 1mm, and 1.2mm) mounted on Instron push-out test machine (Universal Testing Machine, Instron, Norwood, USA). The force of push-out test was applied at a cross-head speed of 0.5 mm/min until bond failure occur. Calculation of the bond strength at failure was expressed in megapascals (MPa) by dividing the load in newton (N) by the area of the bonded interface. The bonded area was calculated as follow: "Area = 2πr x h (where π = constant value of 3.14, r = radius of the intra-radicular space and h = height in mm)." Each specimen was examined under a stereomicroscope using 30x magnification (Digital Microscope, Hirox, Union City, USA) to assess the mode of failure as: Adhesive, cohesive or mixed. Failure was recorded as adhesive if the filling was totally separated from dentin (dentin surface without filling material), cohesive if break occurred within the filling (dentin surface totally covered by the filling material), and mixed when a mixture of adhesive and cohesive modes (dentin surface partially covered by the filling material) resulted (8).

Statistical analyses

Descriptive statistics of the POBS and analysis of data was completed using two-way ANOVA and Tukey's post hoc test. Statistically significant differences among the groups was set at $p < 0.05$.

RESULTS

Bonding to root canal dentin wall was measurable for all specimens. None of samples had premature failure. Table 1 shows mean (±SD) of POBS values of different groups. There was significant difference between the POBS of all root canal filling materials ($p<0.05$) as shown in Table 2. Comparison between the two irrigants showed significant difference between NaOCl and CHX ($p<0.05$) as shown in Table 3.

Comparison of materials to irrigants showed that the MTA has the lowest bond for both NaOCl and CHX. However, the CaOH and ZOE showed higher bond strength to root dentin when irrigated with NaOCl than CHX. Table 4 shows the mode of failure of all groups after the POBS.

DISCUSSION

To our knowledge, no studies investigated the influence of POBS of filling materials of root canal on primary teeth. This type of investigations is critical for evaluation of root canal fillings on primary teeth. The null hypothesis of this study was rejected, as there was a dissimilarity in the POBS of the three tested root canal filling materials on primary teeth after application of the two-intracanal irrigants. In the present study, single investigator performed all the steps and the canal were prepared with the same instrument to standardize the procedures.

Irrigation is currently the method of choice for the smear layer removal (9). NaOCl is the most widely used irrigating solution for root canal (9, 10). It has excellent properties including dissolving organic constituents and necrotic tissues of the smear layer (10). CHX had been suggested as an alternative irrigating solution that could replace NaOCl. It has a bactericidal effect due to its ability to precipitate and coagulate bacterial intracellular constituents (9). CHX has minimal toxicity with broad-spectrum antibacterial properties, is absorbed to the dentin, and is released up to 48-72 hours after instrumentation (11).

In the present study, CaOH specimens showed more bond strength to root dentin of primary teeth when irrigated with NaOCl than CHX. However, another study on permanent teeth reported that CaOH has the highest mean value (36.94) for POBS with CHX only (11). The present study showed that the mean values of POBS of CaOH was 23.09 with NaOCl, which is similar to the study (22.62) on permanent teeth (11). In addition, in the present study, CaOH and ZOE showed higher POBS when irrigated with NaOCl than CHX which may be partially due to the composition and smaller particle size, which may enhance the penetration of the material into the dentinal tubules. This *in vitro* study compared the commonly used root canal filling materials of primary teeth to the well-established material such as MTA. This is may have some benefits as it shows how good the filling materials we use compared to MTA particularly in push-out bond strength studies. MTA have been used for the treatment of retained non-vital primary teeth with no permanent successors (12).

The push-out test is a reliable and consistent method for determining the bond strength of root canal filling materials to dentin (13). The geometric factors and materials used have definite influences on the push-out bonding test (13). Although comparisons between POBS data of filling materials of root canal of primary teeth is important. However, other studies are not available and if it is available, it should be taken with thoughtfulness due to differences in methods, settings, analysis and tested materials. An *in vitro* investigation evaluated the POBS of self-etch and total etch bonding systems to dentin of root canal of primary teeth concluded that all tested bonding systems can be used with composite posts (14). In the present investigation, the failure modes of all groups were predominately cohesive and mixed. The differences in failure modes and bond strengths of the tested materials may be due to the dissimilarities in the composition and particle sizes, which may affect their penetration into the dentinal tubules (15).

One of the limitations of this study was the use of only two intracanal irrigants and three root canal filling materials. It would be beneficial if more and different intracanal irrigants and root canal filling materials is tested. Furthermore, long-term aging of the specimens was not tested in this study. Furthermore, specimens were not stored in saliva or simulated oral condition or thermocycled to mimic clinical situation. Though every effort was made to standardize all experimental parameters, some restrictions occurred including the difference in the shape and size of the roots and dissimilarity in the setting expansion of the tested materials. However, despite these limitations, the research does describe a number of positive links between *in vitro* efficacy and possible clinical effects.

CONCLUSIONS

Under the experimental conditions of this *in vitro* study, we concluded: A combination of ZOE\NaOCl has the highest push-out bond strength to root dentin of primary teeth. Lower push-out bond strength to root dentin of primary teeth was shown with the use of CHX and all root canal filling materials. The lowest push-out bond strength to root dentin of primary teeth was evident with the use of MTA and either NaOCl or CHX.

ACKNOWLEDGEMENTS

Authors also would like to thank the College of Dentistry Research Center and Deanship of Scientific Research at King Saud University, Saudi Arabia for funding this research project. The authors gratefully acknowledge the help of Mr. Nasser Al Moflehi, for his statistical contribution.

AUTHORS' NOTE

F Abdelmegid participated in study design, oversaw data collection, data analysis and interpretation, manuscript writing. writing, review and final approval of the manuscript. F Salama participated in study design, data analysis and interpretation, manuscript writing. writing, review and final approval of the manuscript. S Altamimi participated in data collection and manuscript preparation. Z Alqobisy participated in data collection and manuscript preparation. O Alshammari participated in data collection and manuscript preparation. The authors declare that they have no conflicts of interest.

REFERENCES

1. Metzeger Z, Teperovich E, Cohen R, Zary R, Paque F, Hulsmann M. The self-adjusting file (SAF). Part 3: removal of debris and smear layer a scanning electron microscope study. J Endod 2010; **36:** 697–702.
2. Teixeira CS, Felippe MC, Felippe WT. The effect of application of EDTA and NaOCl on intracanal smears layer removal: an SEM analysis. Int Endod J 2005; **38:** 285–90.
3. American Academy of Pediatric Dentistry Clinical Affairs Committee. Guideline on pulp therapy for primary and young permanent teeth. Pediatr Dent 2016; **38:** 280–8.
4. Özalp N, Şaroğlu I, Sönmez H. Evaluation of various root canal filling materials in primary molar pulpectomies: an in vivo study. Am J Dent 2005; **18:** 347–50.
5. Mani SA, Chawla HS, Tewari A, Goyal A. Evaluation of calcium hydroxide and zinc oxide eugenol as root canal filling materials in primary teeth. ASDC J Dent Child 2000; **67:** 142–7.
6. Torabinejad M, Higa RK, McKendry DJ, Pitt Ford TR. Dye leakage of four root end filling materials: effects of blood contamination. J Endod 1994; **20:** 159–63.
7. Ungor M, Onay EO, Orucoglu H. Push out bond strengths: The Epiphany-Resilon endodontic obturation system compared with different pairings of Epiphany, Resilon, AH plus and gutta percha. Int Endod J 2006; **39:** 643–7.
8. Horiuchi ZH, Silva-Sousa YT, Raucci Neto W, Rached-Junior FJ, Souza-Gabriel AE, Silva SR et al. Effect of thermoplastic filling techniques on the push-out strength of root sealing materials. Braz Oral Res 2016; **30:** 1–7.
9. Wang CS, Arnold RR, Trope N, Teixeira FB. Clinical efficiency of 2% chlorhexidine gel in reducing intracanal bacteria. J Endod 2007; **33:** 1283–9.

10. Morris MD, Lee KW, Agee KA, Bouillaguet S, Pashley DH. Effects of sodium hypochlorite and RC-prep on bond strengths of resin cement to endodontic surfaces. J Endod 2001; **27:** 753–7.
11. Manicka MR, Kumar S, Alagarsamy V, Chakravarthy D. Evaluation of effect of various endodontic irrigants and intra canal medicaments on pushout bond strength to root canal dentin- an in vitro study. Int J Contemp Dent 2011; **2:** 128–39.
12. Tunc ES, Bayrak S. Usage of white mineral trioxide aggregate in a non-vital primary molar with no permanent successor. Aust Dent J 2010; **55:** 92–5.
13. Chen WP, Chen YY, Huang SH, Lin CP. Limitations of push-out test in bond strength measurement. J Endod 2013; **39:** 283-7.
14. Afshar H, Baradaran Nakhjavani Y, Rahro Taban S, Baniameri Z, Nahvi A. Bond strength of 5(th), 6(th) and 7(th) generation bonding agents to intracanal dentin of primary teeth. J Dent (Tehran) 2015; **12:** 90–8.
15. Saghiri MA, Garcia-Godoy F, Gutmann JL, Lotfi M, Asatourian A, Ahmadi H. Push-out bond strength of a nanomodified mineral trioxide aggregate. Dent Traumatol 2013; **29:** 323–7.

Table 1: Mean and standard deviation of bond strength of different groups

Filling Material	Irrigants	Mean	Std. Deviation	N
CaOH*	NaOCl*	23.09	8.10	15
	CHX*	13.90	6.75	15
	Total	18.49	8.69	30
ZOE*	NaOCl	33.24	15.45	15
	CHX	13.57	4.26	15
	Total	23.40	14.97	30
MTA*	NaOCl	4.34	1.42	15
	CHX	3.04	0.49	15
	Total	3.69	1.23	30
Total	NaOCl	20.23	15.62	45
	CHX	10.17	6.81	45
	Total	15.20	13.00	90

*CaOH= Calcium Hydroxide, ZOE= Zinc Oxide Eugenol, MTA = Mineral Trioxide Aggregate, NaOCl = Sodium Hypochlorite, CHX = Chlorhexidine

Table 2: Comparison of the POBS of all root canal filling materials and significance

Filling Material		Mean Difference	Std. Error	Sig.
CaOH*	ZOE	-4.91*	2.03	0.046**
	MTA	14.80*	2.03	0.0001**
ZOE*	CaOH	4.91*	2.03	0.046**
	MTA	19.71*	2.03	0.0001**
MTA*	CaOH	-14.80*	2.03	0.0001**
	ZOE	-19.71*	2.03	0.0001**

*CaOH = Calcium Hydroxide, ZOE = Zinc Oxide Eugenol, MTA = Mineral Trioxide Aggregate
**Significant

Table 3: Comparison between the NaOCl and CHX irrigants and significance

Irrigants		Mean Difference	Std. Error	Sig.
				0.0001**
CHX*	NaOCl	-10.056*	1.656	0.0001**

*NaOCl = Sodium Hypochlorite, CHX = Chlorhexidine
**Significant

Table 4: The mode of failure of all groups after the POBS

Groups	**Adhesion**	**Cohesive**	**Mixed**	**Total**
Group 1 - (CaOH*\NaOCl*)	0	10	5	15
Group 2 - (CaOH\CHX*)	0	6	9	15
Group 3 - (ZOE*\NaOCl)	2	2	11	15
Group 4 - (ZOE\CHX)	0	1	14	15
Group 5 - (MTA*\NaOCl)	0	1	14	15
Group 6 - (MTA\CHX)	0	0	15	15
Total	2	20	68	90

*CaOH = Calcium Hydroxide, ZOE = Zinc Oxide Eugenol, MTA = Mineral Trioxide Aggregate, NaOCl = Sodium Hypochlorite, CHX = Chlorhexidine