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Review Article

EFFECT OF VARIOUS FACTORS ON THE PUSH OUT BOND STRENGTH OF MTA BASED ROOT CANAL SEALERS - A SYSTEMATIC REVIEW

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ABSTRACT

Background: A tooth during the normal course of its function is subjected to several stresses, the chief amongst which is the flexion generated on mastication. An endodontically treated tooth loses elasticity and hence materials which are used for obturation and post-endodontic rehabilitation of such teeth, need to replicate the Flexion of the tooth. Push Out Bond Strength (POBS) is an accurate way to assess the longevity of Root Canal Therapy.

Objectives: To analyze the effect of various Pre-Obturbative protocols on the Push Out Bond Strength of MTA-based sealers.

Data Sources: English language articles were retrieved from electronic biomedical journal databases. PubMed, Google scholar and Research Gate were used to complete the search for all full text articles available. The search was done till 31st August 2016. The last data search was conducted on 1st September 2016.

Study Eligibility Criteria: All articles that were published in English were included. Only those articles that were published between 1st January 2000 and 31st August 2016 using MTA based Sealers were selected.

Intervention: Effect of various Pre-Obturbative protocols on the POBS of MTA based sealers.

Results: Total of 34 articles were identified through electronic database searching. After duplicate removal, and full text reading, 13 articles qualified for qualitative synthesis in this systematic review.

Limitations: Few articles do not clearly mention the values of POBS which makes the interpretation difficult.

Conclusion: Procedures that are done routinely prior to the use of MTA as a sealer are found to affect the POBS.

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INTRODUCTION

The success of root canal treatment is multifactorial. It depends on completely shaping and cleaning, and then 3-dimensional obturation the root canal system.¹ Gutta-percha is used as a root canal filling material but lacks adhesive properties. So, to keep it in place, adhere it to the root canal wall, avoid any voids or gaps, root canal sealers are used.²

Root canal sealers are primarily classified as resin, zinc oxide-eugenol based, glass-ionomer and calcium hydroxide-based.³ An ideal root canal sealer should provide good adhesion to the root dentine to form an impermeable fluid-tight seal for the root canal system and efficiently avoid the ingress of bacteria post obturation.⁴

Dissolution of the sealing material rapidly will compromise the prognosis of the tooth in question. MTA based root canal sealers such as MTA Fillapex, Endo-CPM, etc. are newly introduced sealers on the market and are given special attention. It is very desirable to know their physico-chemical and biological properties for a better understanding of the material and to judiciously use them in various clinical situations. The literature draws a lot of importance to the adhesive properties of the root canal sealers.^{5,6,7}

Adhesion of the root canal sealers to the radicular dentine is a well-researched subject and holds a lot of clinical significance. Optimal adhesion of the root canal sealer with the root dentine is one of the important factors that decide the fate of the endodontic treatment and long-term success. A strong and good

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adhesion interface between the sealer and radicular dentine and the sealer and the root canal filling material will prevent microleakage and thus shall improve the longevity of the endodontically treated tooth.

MTA Fillapex (Angelus, Londrina, Brazil) is a new calcium silicate-based sealer presenting low solubility and disintegration,⁸ and good flow⁹ and alkaline pH,¹⁰ but has a reduced bond strength when compared with AH Plus which is considered as a gold standard.^{11,7} Interaction of MTA with dentine will cause incorporation of intratubular Ca and Si,¹² intrafibrillar apatite deposition over a period of time,¹³ and is also known to form tag-like structures in the presence of phosphate-buffered saline (PBS).^{14,12}

The bond strength of root fillings within the root canal is frequently assessed. Various tests are employed for the same which include shear bond strength, microtensile, pull-out and push-out tests. It has been made possible to determine the bond strength at different sections of the root canal and to evaluate the differences in these root segments using microtensile and push-out tests.¹⁵ It is a cumbersome and tedious task to prepare the samples for microtensile test as they have the tendency to fracture even before the test. On the contrary, push-out bond strength test eliminates this shortcoming of microtensile test, and has thus gained popularity for determining the bond strength with more accuracy and reliability.^{16,17,18}

In addition to the POBS, examining the Mode of Failure also gives pertinent data regarding the efficacy of the adhesive bond that is formed between the sealer and the root canal wall.

Various factors during the endodontic treatment potentially interfere with the adhesion of the root canal sealers to the root canal wall such as the presence or absence of smear layer, dentin moisture conditions, different irrigation protocols, irradiation, wide variety of obturating techniques, use of various solvents in retreatment cases, various dentine drying protocols to name a few. These factors will result in increased or decreased bond strength.

The aim of this study is to thus evaluate and qualitatively assess the effect of these factors on the push-out bond strength of MTA based sealers, to have a better understanding of the material and to use these sealers in various clinical situations. In-depth knowledge of these properties will enhance a clinician's judgment and will result in the predictable outcome and use of material as and when required.

MATERIALS AND METHODS

Focused question: Which are the factors that could affect the Push Out Bond Strength of MTA based Sealers used in Endodontics as evaluated in experimental in vitro studies?

This review was undertaken in 2015, where the last date of search is 1st September 2016. A literature search was conducted on three databases namely PubMed, Google Scholar and ResearchGate. Keywords used to search articles were (MTA based sealers OR Portland cement OR Angelus MTA OR MTA Fillapex OR MTA Plus OR Ortho MTA OR MTA Bio OR MTA Sealer OR Fluoride doped MTA cement OR nano-modified MTA OR light cured MTA) AND (Push-out bond strength) AND (Root canal sealers). All the articles

published till 2016 were included in this review. Two reviewers screened all the articles separately.

Eligibility criteria

Studies written in English language and which were published in between 1st January 2000 to 31st August 2016 were selected. Studies using specimen other than extracted teeth, narrative reviews, case reports, letter to editors were excluded. The following eligibility criteria was taken into account:-

- P-Participants : Freshly extracted human teeth.
- I-Intervention : Effect of different modalities on POBS.
- O-Outcomes : Increased or decreased value of POBS
- S-Study design : In vitro studies

Study Selection Process

In vitro and comparative studies were selected; however, only articles where the effect of various factors on the POBS of MTA based sealers was seen on freshly extracted human teeth were included. Using different search strategies from the above mentioned key words and their combinations; various electronic databases were searched. Firstly the titles which contained the primary or secondary keywords were selected. If there was no key word in the title the abstract was read in detail to search for the keywords. If the abstract was not clear, but the title seemed to be relevant the article was selected for full text reading. Also when there was no abstract available, but the title contained keywords, the article was selected for full text reading. All the studies scanned through the databases and other additional sources, were reviewed by two independent authors (IA, SA). Any disagreement in between the two authors was resolved by the third reviewer (DD).

RESULTS

Search and selection

The search on PubMed/ Google Scholar yielded total 34 articles were identified through the database searching. These records were assessed for any duplicates and 14 articles were removed. After thorough reading of titles, 3 articles were excluded and 17 articles were selected. These 17 articles were further screened for abstract reading and 4 articles were excluded and 13 were selected after reading the abstracts. Full texts for these 13 articles were obtained and were assessed for eligibility. All these 13 articles qualified and were selected. No exclusion was done after reading the full texts. 4 articles after reading the abstracts were excluded because those studies did not have a confounding or influencing factor. (Figure 1)

Study characteristics

Of all the 13 studies included 11 were in-vitro studies, while one was ex-vivo (3) and another simulated in-vivo study (7). Selection of extracted teeth was heterogeneous among studies. Only one study (13) used MTA Plus as their root canal sealer, while other 12 studies have used MTA Fillapex. All the studies used Push-Out test to check the strength of the sealers. All the studies have checked different factors to check out Push out bond strength. (Table 1)

Table 1 Study characteristics of each study

Study Id	Author, year, Place	Population	Intervention/exposure	Factors that influence the bond strength of MTA based Root Canal Sealers	Conclusions
1	Gokturk H <i>et al</i> , 2016, Turkey	Single rooted mandibular premolars	dislodgement resistance	Different Intracanal Medicaments	Use of Calcium hydroxide or Double Antibiotic paste as an Intracanal Medicament does not affect the POBS of MTA based Sealers.
2	Paula AC <i>et al</i> , 2016, Brazil	Maxillary canines	POBS	Drying Protocol(DP)	Root canals dried with Isopropyl alcohol showed the highest POBS
3	Araujo CC <i>et al</i> , 2016, Brazil	Maxillary canines	POBS	Obturing techniques	Roots obturated with Lateral Compaction Technique were found t show higher POBS than those obturated with Single Cone Techniques
4	Carvalho NK <i>et al</i> , 2016, Brazil	Maxillary incisors	POBS	Smear Layer Removal Agents	Removal of the smear layer had no discernible effect on the POBS of MTA based Sealers.
5	Martins CV <i>et al</i> , 2015, Brazil	Maxillary canines	POBS	Therapeutic Cancer Radiation	Roots that underwent irradiation prior to obturation showed lower POBS
6	Forough RM <i>et al</i> , 2014, Iran	Single rooted teeth	POBS	Smear Layer Removal	Removal of the Smear Layer had no discernible effect on the POBS of MTA based root canal sealers.
7	Tedesco M <i>et al</i> , 2014, Brazil	Not specified	POBS	Immersion in PBS	Immersion in PBS had a marginal effect on the POBS of MTA based root canal sealers.
8	Guiotti FA, 2014, Brazil	Canines	POBS	Calcium Hydroxide Dressing	Calcium hydroxide as an intracanal medicament had no discernible effect on the POBS of Root canal sealers.
9	Ok E <i>et al</i> ,2014, Turkey	Mandibular premolars	POBS	Irrigation protocol	Use of PAD for the disinfection of the root canal led to a decrease in the POBS of MTA based Root Canal Sealers.
10	Tasdemir T <i>et al</i> , 2014, Turkey	Single rooted teeth	POBS	Dentine Drying Techniques	Overdried or excessively moist dentin led to a decrease in the POBS of MTA based ROOT Canal Sealers.When adequate moisture was maintained there was a substantial increase in the POBS.
11	Topcuoglu HS <i>et al</i> , 2014, Turkey	Single rooted teeth	POBS	Various Solvents	When exposed to gutta percha solvents MTA based root canal sealers showed a marked decrease in POBS.
12	Nagas E <i>et al</i> , 2012, Turkey	Not specified	POBS	Dentin Moisture Condition	Overdried or excessively moist dentin led to a decrease in the POBS of MTA based ROOT Canal Sealers.When adequate moisture was maintained there was a substantial increase in the POBS.
13	DeLong C,2015, Texas	Single rooted teeth	POBS	Obturing Technique	ContinuousWave technique of Obturation led to the lower POBS of MTA based Root Canal Sealers, as opposed to SingleCone Technique.

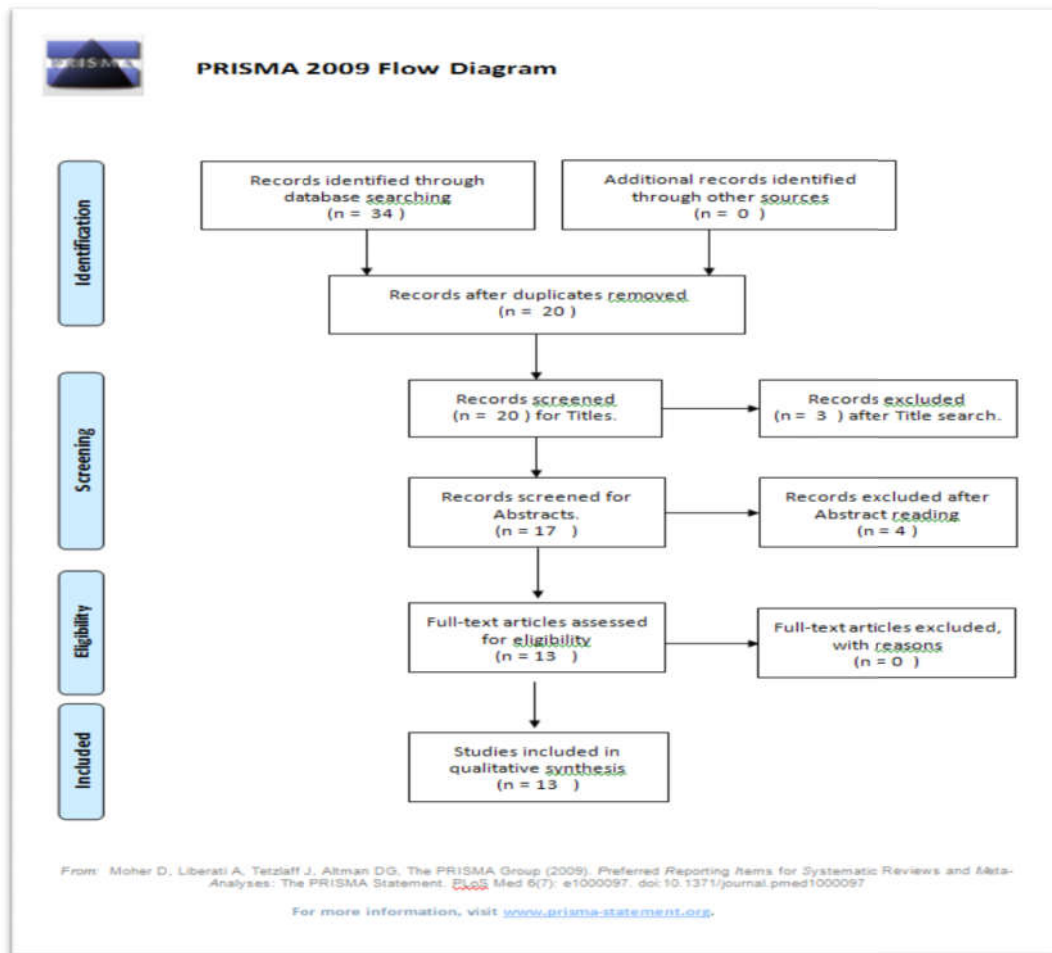


Figure 1 Systematic electronic search on PubMed

DISCUSSION

Longevity of any dental procedure is the lodestone desired by a clinician. One of the factors that contributes to the extended life of Root Canal Therapy is the tenacious bond between the root canal sealer and the radicular dentin, and also the bond between the root canal sealer and the obturating material. Distribution of the sealer is a primary cause of microleakage from the apical area into a treated root canal system. This distribution is facilitated and hastened by the formation and propagation of cracks within the root canal sealers.

The occlusal loading of a functional tooth is dynamic in nature, causing flexing of the tooth. This flexure is the leading cause of disintegration within the layer of root canal sealer. To simulate the clinical condition in the laboratory, the in-vitro experimental model is that of a Push-Out Bond Strength (POBS). These in-vitro studies used the parameter of POBS on radicular dentin, after having subjected the radicular dentin to standard operating protocol followed by clinicians globally.

This systematic review was undertaken in an effort to better understand the various variables that could impact the longevity of Root Canal Therapy. Studies that were published between 1st January 2000 and 30th September 2016, and had evaluated the bond strengths of MTA based sealers, under varying conditions were included. The MTA based sealers were considered for this systematic review, because they display superior clinical properties (Torrabinajad). As opposed to the other sealers, MTA based sealers are relatively new entrants in the field of endodontics.

Out of the 13 which were retained, three studies did not use GP as the core material, but instead obturated the entire canal with the MTA based sealer. These articles were retained because they have evaluated the interface between the sealer and the radicular dentin by applying the POBS test. Also, 4 of the articles which were included did not mention if the teeth were allotted to the different groups randomly, but these articles also have been retained due to the study design being in accordance with the requisites of this review. Of the 13 articles which were finally considered, 7 variable factors came to light. (Table 1)

1. Smear layer removal
2. Dentin drying techniques and dentin moisture conditions
3. Intracanal medicaments
4. Obturating techniques
5. Irradiation
6. Irrigation protocols
7. Solvents for Re-treatment

Reyhani MF *et al* (2014)¹⁹ compared the POBS obtained between resin based sealers and MTA based sealers on the radicular dentin in the presence and absence of Smear Layer. They concluded that there was significant increase in the POBS after elimination of Smear Layer. (Elaborate Smear Layer)

Carvalho NK *et al* (2016)²⁰ conducted a study to evaluate the effect of different chelating agents on the POBS of different calcium-silicate based sealers. They concluded that the different chelating agents do not influence POBS of endodontic sealers.

Nagas E *et al* (2012)¹¹ compared the POBS obtained between resin based sealers and MTA based sealers when subjected to

various dentin moisture conditions. They concluded that residual moisture has a significant effect on the adhesion of the sealers to the radicular dentin, the best being slight moisture on the canal walls before obturating.

Tasdemir T *et al* (2014)²¹ compared the POBS values between different calcium silicate based sealers, when the canal was subjected to different canal-drying techniques. They concluded that the technique of canal-drying influenced the adhesion between the sealers and the root canal wall.

Paula AC *et al* (2016)²² compared the POBS values between resin based sealers and MTA based sealers, when different drying protocols were applied. They concluded that drying the dentin before obturation positively affects the bond strength of the sealers, the best being the use of isopropyl alcohol.

Guiotti FA *et al* (2014)²³ compared the POBS between a resin based sealer, a calcium hydroxide based sealer and an MTA based sealer on the radicular dentin when pre-treated with a calcium hydroxide dressing as an Intra canal medicament. They concluded that the use of calcium hydroxide dressing had a negative effect on the POBS of the sealers and adhesive failure in the MTA based sealer.

Gokturk H *et al* (2016)²⁴ compared the dislodgement resistance between resin based sealers and calcium silicate based sealers on the radicular dentine after placing calcium hydroxide or double antibiotic paste (DAP). They concluded that the use of medicaments did not significantly affect the dislodgement resistance of root canal fillings.

DeLong C *et al* (2015)²⁵ compared the POBS between different calcium silicate based sealers when thermoplastic technique of obturation was used. They concluded that Single cone technique had favourable results as compared to Continuous Wave technique which resulted in decreased bond strengths.

Araujo CC *et al* (2016)²⁶ compared the POBS between resin based and calcium silicate based sealers when different obturating techniques were employed such as reciprocating file-matched single-cone obturation and lateral compaction. They concluded that the reciprocating techniques resulted in lowered bond strength values than the lateral compaction technique. Hence, the obturating technique does affect the POBS of the Sealer used.

Martins CV *et al* (2015)²⁷ compared the POBS between a resin based sealer and an MTA based sealer on the radicular dentin when the dentin was irradiated first. They concluded that radiation decreases the POBS of sealers to intraradicular dentin and forms more gaps and less tags at the sealer/dentin interface irrespective of the sealer used.

Ok E *et al* (2014)²⁸ compared the effect of PhotoActivated Disinfection (PAD) as an irrigation adjunct on the POBS of three different sealers. They concluded that the use of PAD affected the POBS of the endodontic sealers to the radicular dentin negatively.

Tedesco M *et al* (2014)²⁹ compared the effect of immersion in phosphate buffered saline (PBS) on the POBS of four different endodontic sealers to radicular dentin. They concluded that immersion in PBS does not have an effect on the POBS of the sealers used.

Topcuoglu HS *et al* (2014)³⁰ compared the effect of various gutta-percha solvents on the POBS of different endodontic sealers on radicular dentin. They concluded that the bond strength was affected significantly, depending on the type of solvent used and the duration of use. Out of all the solvents used, Chloroform had a negative effect on the POBS of all the sealers tested.

CONCLUSION

A point to be considered prior to drawing inferences from this article is that the mode of storage of the teeth post-extraction wasn't standardized. Also the time period that elapsed between the extraction and the experimental use of the teeth wasn't standardized, nor was the age group from where the teeth were derived. *In vitro* studies though excellent at replicating clinical conditions fail at the standardization of harvested teeth. Also the studies need quantifiable values for easy comparison. Barring these to sum up the articles reviewed in this systematic review, it is possible to state that obturating techniques affect the POBS of MTA based sealers. This POBS, showed a decrease when teeth were irradiated or Calcium hydroxide was used as an intracanal medicament. TAP had no discernible effect on the POBS. Whilst PAD, smear layer and chelating agents showed no effect this way or that, the wetness of the radicular dentin was key in the values obtained for POBS. It would be safe to conclude that extremes of moisture would decrease the POBS of MTA based sealers.

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