



## Analysis of the sealing ability of Portland cement and mineral trioxide aggregate in molars furcation perforations

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### Abstract

**Objective:** To analyze the sealing ability of Mineral Trioxide Aggregate (MTA) and Portland Cement (PC) in furcation perforations of human molars through three techniques.

**Methods:** Ninety upper and lower extracted human molars with formed roots and not fused were selected. Perforations were performed on the floors of pulpal chambers by means of spherical burs. Specimens were randomly divided into two experimental groups of forty-five teeth each, using PC for Group I and white MTA for Group II. Group I was divided into 3 subgroups, called IA, IB, IC with fifteen samples each. Group II was also divided into 3 subgroups, called IIA, IIB, IIC with fifteen samples each. The checks of infiltration were carried out through a stereoscope with 5X magnification. The Kruskal-Wallis and Mann-Whitney tests were used for statistical analysis.

**Results:** The use of MTA and PC inserted by three different techniques did not prevent the occurrence of leakage into furcation of extracted human molars. It is also clear that the CP accommodated in furcation perforations through ultrasound had better performance.

**Conclusion:** Further studies should be carried out to improve the performance of the sealing material for application in critical dental regions.

**Key words:** Furcation defects; Dental leakage; Endodontics; Dental materials

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### Análise da capacidade seladora dos cimentos de Portland e agregado de trióxido mineral em perfurações de furca de molares

#### Resumo

**Objetivo:** Analisar a capacidade seladora do Mineral Trióxido Agregado (MTA) e do Cimento Portland (CP) por meio de três técnicas nas perfurações de furcas de molares humanos.

**Métodos:** Foram selecionados 90 molares humanos superiores e inferiores extraídos com raízes formadas e não fusionadas. As perfurações foram realizadas nos assoalhos das câmaras pulpares por meio de brocas esféricas. Os espécimes foram divididos aleatoriamente em 2 grupos experimentais, de 45 dentes cada, sendo que para o Grupo I – foi utilizado o CP e no Grupo II – utilizou-se o MTA branco. O Grupo I foi dividido em 3 subgrupos, denominados IA, IB, IC com 15 amostras cada. O Grupo II também foi dividido em 3 subgrupos, denominados IIA, IIB, IIC com 15 amostras cada. As verificações das infiltrações foram realizadas por meio de uma lupa estereoscópica com aumento de 5x. Os testes de Kruskal-Wallis e Mann-Whitney foram utilizados para análises estatísticas.

**Resultados:** O uso do MTA e CP inseridos por 3 diferentes técnicas não evitou a ocorrência de infiltração nas furcas de molares humanos extraídos. O CP acomodado em perfurações de furcas por meio de ultrassom teve melhor desempenho.

**Conclusão:** Novos estudos devem ser realizados visando a melhora do desempenho dos materiais seladores para aplicação em regiões dentárias críticas.

**Palavras-chave:** Defeitos da furca; Infiltração dentária; Endodontia; Materiais dentários

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## Introduction

Perforations in endodontics occur quite frequently and may involve up to 12.0% of teeth submitted to required endodontic treatment [1]. The mineral trioxide aggregate (MTA) was conceived from observational analysis with the Portland cement (PC). This first material was conceived and developed to seal all communications between the root canal system and the external dental surface [2].

MTA is biocompatible, it presents bactericide action by being alkaline and produces inflammatory reaction of low intensity, in addition to repair injuries and make surgical procedures more predictable [3-5]. Important findings relating to sealing ability of MTA has called attention from specialists in endodontics [6,7].

The criticism about this dental material was related to the difficulty of entering the MTA in dental cavities [8]. *In vitro* and *in vivo* studies have demonstrated that this weakness is being overcome, mainly by favorable reported prognosis [9,10,11]. Recently, a study found marginal infiltration in a furcation perforation of extracted human molars sealed through three cement insertion techniques of Portland and MTA types. However, those perforations where both cements were accommodated by inserts of ultrasound, the infiltration had lower scores when compared to those entered by vertical condensation and/or cotton pellet [10].

The aim of this study was to analyze the sealing ability of MTA and PC in furcation perforations of human molars through three techniques.

## Material and Methods

This research was submitted to and approved by the Research Ethics Committee of the University Center of Educational Foundation of Barretos (UNIFEB), whose protocol is N. 292.916/2013. The teeth used are from the Dentistry College of UNIFEB, Barretos, São Paulo, Brazil.

We selected ninety upper and lower human molars for this survey submitted to dental extractions with roots formed and not fused. The teeth were cleaned and disinfected by immersion for 24 hours in sodium hypochlorite 2.5% (Fórmula & Ação, São Paulo, Brazil), as determined by the protocol for handling of extracted teeth. Sequentially, the teeth were rinsed in tap water and stored in a humid chamber containing a Ringer's lactate solution of sodium (Fórmula & Ação, São Paulo, Brazil) until the time of use.

The surgical access to the pulp chamber was performed with spherical diamond drill number 4 (KG Sorensen, Cotia, São Paulo, Brazil) and complemented with Endo Z drills (Dentsply-Maillefer, Ballaigues, Switzerland) at high speed. The perforations made on the floors of pulpal chambers were constructed through spherical diamond drills number 1014 (KG Sorensen, Cotia, São Paulo, Brazil). The teeth were irrigated with a solution of sodium hypochlorite 0.5% (Pharmacy School of UNIFEB, Barretos, São Paulo, Brazil) and, soon after, irrigated with EDTA at 15% (Biodinâmica,

Ibiporã, Paraná, Brazil) for removal of smear layer. Finally, the teeth were washed with distilled water (Pharmacy School of UNIFEB, Barretos, São Paulo, Brazil) and dried at room temperature for 48 hours.

All specimens were waterproofed with the application of two layers of Araldite 10 minutes (Brascola, Joinville, Santa Catarina, Brazil) in the whole extension of the outer surface of the root and crown. On the same surface we applied three layers of fast drying colored nail polish. It should be noted that in coronary opening and 2 mm around the perforations we did not apply waterproofing agents. Small flakes of sponges were placed between the roots, in the furcation area, to simulate the periodontium. The roots were involved up to the limit of the anatomical neck with wax number 7 (Herpo Dental Products, Rio de Janeiro, Brazil) for the simulation of the alveolar bone. The teeth were then placed in a moistening chamber at 37 °C for 24 hours.

The specimens were randomly divided into two experimental groups of forty-five teeth each, where we used the Portland cement (Company of Portland cement Itau, Itau of Minas, Minas Gerais, Brazil) for Group I and in Group II it was used the white MTA (Angelus Dental Products Industry Corporation, Parana, Brazil). Group I was divided into three subgroups called IA, IB, IC with fifteen samples each. Group II was also divided into three subgroups called IIA, IIB, IIC with fifteen samples each. For each subgroup, the perforations were sealed using the following techniques:

IA: with a syringe of 10ml Plastipak® (BD, São Paulo, Brazil) with nozzle Luer-Lok® (BD, São Paulo, Brazil) fitted with a needle type 21g (BD, São Paulo, Brazil); the sponges placed in furcations were moistened with distilled water. Then, the Portland cement was inserted in the perforations through a dental amalgam door micro (Golgran Industria e Comércio Odontológica Ltda., São Paulo, Brazil) and the final accommodation was performed with absorbent paper cones Tanari® (Tanariman Industrial Ltda, Manaus, Amazonas, Brazil) number 60 until complete filling of the cavity.

IB: with the aid of a syringe of 10 ml Plastipak® with nozzle Luer-Lok® fitted with a needle 21g1; the sponges placed in furcations were moistened with distilled water. Then, the Portland cement was inserted in the perforations through a dental amalgam door micro and the final accommodation was performed with condenser type Paiva number 2 until complete filling of the cavity.

IC: with the aid of a syringe of 10 ml Plastipak® with nozzle Luer-Lok® fitted with a needle type 21g; the sponges placed in furcations were moistened with distilled water. Then, the Portland cement was inserted in the perforations through a dental amalgam door micro and the final accommodation was performed with an insert of ultrasound number 5AE (Gnatus Equipment Medical-Dental Ltda, Ribeirão Preto, São Paulo, Brazil) with no refrigeration enabled for 5 seconds, until the complete filling of the cavity.

IIA: with the aid of a syringe of 10 ml Plastipak® with nozzle Luer-Lok® fitted with a needle type 21g; the sponges

were moistened with distilled water. Then, the white MTA was inserted in the perforations through a dental amalgam door micro and the final accommodation was performed with absorbent paper cones number 60 until complete filling of the cavity.

IIB: with the aid of a syringe of 10 ml Plastipak® with nozzle Luer-Lok® fitted with a needle type 21g; the sponges were moistened with distilled water. Then, the white MTA was inserted in the perforations through a dental amalgam door micro and the final accommodation was performed with condenser type Paiva number 2 until complete filling of the cavity.

IIC: with the aid of a syringe of 10 ml Plastipak® with nozzle Luer-Lok® fitted with a needle type 21g; the sponges were moistened with distilled water. Then, the white MTA was inserted in the perforations through a dental amalgam door micro and the final accommodation was performed with an insert of ultrasound number 5AE with no refrigeration enabled for 5 seconds, until the complete filling of the cavity.

Four samples with all the areas involved with glue and nail polish were used as negative in Groups I (n=2) and II (n=2). Similarly four samples free of glue, nail polish and coronary sealing were determined as positive control in Groups I (n=2) and II (n=2).

The manipulation of the PC and white MTA used in Groups I and II was followed by the proportion of three parts of powder for one of deionized water. Both cements were prepared on sterile glass plates of 12mm.

After the insertion of the PC and MTA in the perforations, a little ball of cotton soaked in distilled water was placed (Pharmacy School of UNIFEB, São Paulo, Brazil) along the floor of pulpal chamber and the coronary openings were sealed with IRM (Dentsply, Petropolis, Rio de Janeiro, Brazil). After setting the IRM, the occlusal surfaces of the teeth were sealed with two layers of Araldite, around 10 minutes, and then three layers of nail polish were applied. After this procedure, the waxes of the roots and the foam flakes of the specimens were removed. The specimens were kept at room temperature for 4 hours for setting the MTA. After this procedure the waxes of the roots and the foam flakes of the samples were removed.

All specimens in Groups I and II were deposited in barrels with methylene blue dye buffered at 2% during 72 hours. After the time mentioned, the specimens were rinsed in tap water for 1 hour to remove any residues of the dye. The teeth were dried with a paper towel and the

glues and the nail polishes applied on the surfaces were removed with the aid of a scalpel blade number 12. After that, the specimens were fixed with Godiva (Lysanda Dental Products Ltda., São Paulo, Brazil) on wooden blocks to be longitudinally sectioned with double-sided diamond disc (KG Sorensen, Cotia, São Paulo, Brazil) in mesiodistal direction. The scores for the degree assessment of infiltration from the furcation of dental segments followed the pattern described by Belardinelli et al. [11].

The checks of infiltration were carried out through a stereoscopic magnifying glass with increase of 5X. The Kruskal-Wallis and Mann-Whitney tests were used for statistical analysis. The level of significance was set at p=5.0%.

## Results

The analysis values of infiltration in scores of insertion techniques of Portland cement can be seen in Table 1.

A Kruskal-Wallis statistical analysis was performed. The value of h=14.5718 and p=0.0007 for two degrees loose. This result shows that there was no statistical difference between the paper cone x ultrasound with Portland cement insertion techniques, as it can be seen in Table 2 and Figure 1.

The analysis values of infiltration in scores of insertion techniques of white MTA can be seen in Table 3.

A Kruskal-Wallis statistical analysis was performed. The value of h=0.1090 and p=0.9470 for two degrees loose. This result shows that there was no statistical difference between the insertion techniques when compared between them, as it can be seen in Figure 2.

When the Portland cement is compared to the white MTA ranging from the insertion techniques: paper cone, condenser and ultrasound, the Kruskal-Wallis statistical analysis shows the value of h=24.1290 and p=0.0002 for five degrees loose, as it can be seen in Table 4.

When the posts average of insertion techniques are compared for the white MTA (A) and Portland (P) cements, we found that there was a significant statistically difference at 5.0% level between the paper cone (A) x ultrasound (P), condenser (A) x ultrasound (P), ultrasound (A) x ultrasound (P), and paper cone (P) x ultrasound (P) techniques. After the Kruskal-Wallis analysis considering the value of H=8.3746 and p=0.0038 for one degree loose it was possible to notice significant statistically differences between Portland and white MTA cements.

**Table 1.** Value in scores of infiltration of insertion techniques of Portland cement.

Insertion Techniques	Scores														
Absorbent Paper Cone	3	4	2	3	3	0	4	0	4	0	4	1	1	4	2
Condenser	1	1	0	3	1	0	0	1	0	2	0	0	2	1	4
Ultrasound	0	0	0	0	1	0	0	1	0	0	0	0	1	0	0

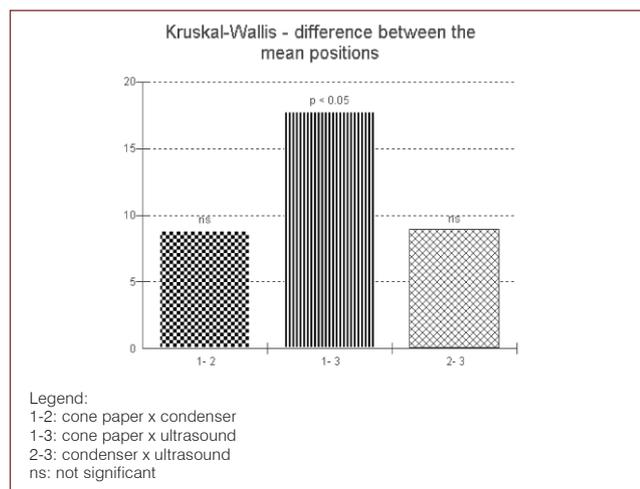
**Table 2.** Comparison of Average Posts of Insertion Techniques of Portland cement: paper cone, vertical condenser and ultrasound.

Comparison Average Posts	Posts Differences	Calculated Z	Critical Z	P
Paper cone (1) x Condenser (2)	8.0000	1.6681	2.394	n.s.
Paper cone (1) x Ultrasound (3)	18.1000	3.7741	2.394	< 0.05
Condenser (2) x Ultrasound (3)	10.1000	2.1060	2.394	n.s.

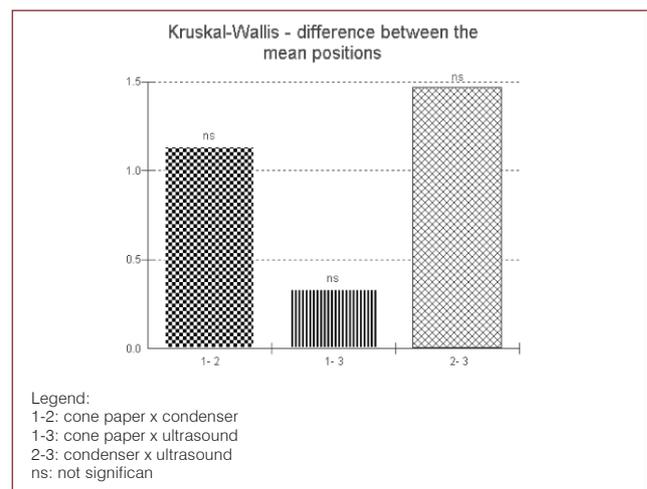
n.s.: not significant; < 0.05 significant at level of 5.0%.

**Table 3.** Value in scores of infiltration of insertion techniques of white MTA cement.

Insertion Techniques	Scores														
Paper Cone	2	0	0	1	3	3	2	4	2	3	0	4	0	4	3
Condenser	2	2	1	2	2	2	3	0	3	4	3	0	2	2	3
Ultrasound	3	4	2	3	0	2	3	3	4	1	2	3	2	0	0



**Figure 1.** Difference between the posts averages comparing the insertion techniques for the Portland cement.



**Figure 2.** Difference between the posts averages comparing the insertion techniques for the white MTA cement.

**Table 4.** Comparison of posts average of insertion techniques of white MTA (A) and Portland (P) cements: paper cone, vertical condenser and ultrasound.

Comparison Average Posts	Posts Differences	Calculated Z	Critical Z	P
Paper cone (A) x Condenser (A)	0.7333	0.0769	2.935	ns
Paper cone (A) x Ultrasound (A)	1.5333	0.1607	2.935	ns
Paper cone (A) x Paper cone (P)	4.5333	0.4752	2.935	ns
Paper cone (A) x Condenser (P)	16.6000	1.6353	2.935	ns
Paper cone (A) x Ultrasound (P)	33.2000	3.4803	2.935	< 0.05
Condenser (A) x Ultrasound (A)	0.8000	0.0839	2.935	ns
Condenser (A) x Paper cone (P)	3.8000	0.3983	2.935	ns
Condenser (A) x Condenser (P)	16.3333	1.7122	2.935	ns
Condenser (A) x Ultrasound (P)	33.9333	3.5572	2.935	< 0.05
Ultrasound (A) x Paper cone (P)	3.0000	0.3145	2.935	ns
Ultrasound (A) x Condenser (P)	17.1333	1.7961	2.935	ns
Ultrasound (A) x Ultrasound (P)	34.7333	3.6410	2.935	< 0.05
Paper cone (P) x Condenser (P)	20.1333	2.1105	2.935	ns
Paper cone (P) x Ultrasound (P)	37.7333	3.9555	2.935	< 0.05
Condenser (P) x Ultrasound (P)	17.6000	1.8450	2.935	ns

ns: not significant; < 0.05 significant at level of 5.0%.

## Discussion

Accidents and complications during the endodontic treatment may happen frequently. Among these accidents and complications, furcation perforation or trepanation deserves careful analysis of the endodontist, mainly in the planning phase to seal this undesirable communication, which exposes the regions inside and outside of a tooth [12,13]. Many dental materials and different techniques to promote the sealing ability of furcation perforations have already been proposed and tested. This way, the authors of this research proposed analyzing three different ways of inserting two sealers. The MTA and Portland cement are two materials that may be indicated for the sealing of furcation perforations, because they present similar physical, chemical and biological behaviors [2,4,14,15]. On the other hand, these two materials suffer marginal infiltration [11,12]. There is a consensus among researchers that there is not yet a material and/or efficient techniques to solve safely the furcation perforation, mainly due to the fact that the occurrence of marginal infiltration, after the sealing procedure [1,12]. For the authors of this research, the sealer analyzes with MTA and PC should continue, especially with respect to the integration of these materials into perforations using ultrasound.

In both groups and subgroups analyzed, the authors of this research noted that the dye solution of methylene blue at 2.0% presented different scores of infiltration. In subgroup IC, it was noted that the infiltration extended until  $\frac{1}{4}$  of sealant material. In other subgroups, infiltration covered all cotton accommodated in the pulp cavity. In positive and negative control groups were verified infiltration above  $\frac{3}{4}$  of sealant materials. Thus, the results obtained in this research are in agreement with other studies that have analyzed infiltrations in the furcation region [6,7,12,14]. On the other hand, researchers have reported that the MTA has excellent properties sealers, especially when applied in the perforations of floors of pulpal chamber [2,3,16].

One of the factors attributed to infiltration in marginal furcation suggests also be associated to the difficulties of insertion of the material in the perforation because of their small size, therefore, researchers have proposed the use of various instruments such as port amalgam and syringe Centrix® (New DFL, Rio de Janeiro, Brazil) to facilitate the insertion of the restorative material. In cases of limited access these instruments can be awkward to handle, endangering the adaptation of the material, because the mixture can be dehydrated, making it crumbly and impossible to handle [12]. Cervi et al. [10] proposed the accommodation of MTA and PC in furcation perforations using insert of ultrasound with the purpose to promote a more uniform marginal adaptation and, then, the placing of a little ball of cotton moistened with water to moisturize the cited sealers. When analyzing subgroup IC, the results obtained can be considered as satisfactory and suggestive so new researches using PC and MTA in furcation perforations with final accommodation

through ultrasound, since this technique seemed to be a viable option, especially in clinical application.

A study in dogs allowed us to conclude that after ninety days of perforations made in furcations of upper and lower premolars and sealed with MTA (ProRoot and Angelus) and white PC, the materials used allowed the sealing of the perforations with mineralized tissues [17]. Clinical studies have shown promising results using MTA and PC in cases of endodontic complications, especially those in which there are infections caused by micro-organisms [18-20]. Both sealers mentioned suffer setting expansions so, from a physical standpoint, this may prevent the marginal infiltration, when these sealers are used in furcation perforations [2]. The favorable clinical performance of MTA and PC have already been confirmed by other authors [18-20], however innovative “*in vitro*” researches as proposed by the authors of this research contribute to the improvement of techniques for inserts in dental critical regions, as is the case of the region of pulp chamber floor of molars and premolars.

## Conclusions

In this research it was possible to confirm that the use of MTA and PC entered by three different techniques prevented the occurrence of infiltration in furcations of extracted human molars. It is also clear that the PC accommodated in furcation perforations through ultrasound had better performance. The authors suggest that further researches should be performed in order to improve the performance of sealant materials for application in dental critical regions.

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