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Apical maladaptation in retrograde obturation depending on the obturator material

Desadaptação apical na obturação retrógrada em função do material obturador

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ABSTRACT

Objective: This study aims to evaluate the apical disadaptation of retrofilling materials in retrograde obturation. **Material and Methods:** Forty-eight palatal roots of maxillary molars were instrumented using the step-back technique and filled using the single cone technique. After preparation and filling, the roots were embedded in resin, leaving 2 mm of the apex exposed. A 2 mm apicoectomy was performed on the root apices, and retro-preparation was carried out using a diamond-coated ultrasonic tip (S12 900D). The groups were then divided based on the retrograde filling material: MTA Group - retrograde filling with MTA; S26 Group - retrograde filling with Sealer 26. After completing the retrograde fillings, the roots were immersed in deionized water for 72 hours at 37°C to allow the materials to set. The root blocks were dried, sputter-coated, and analyzed under a scanning electron microscope to obtain images at 50x magnification. The photomicrographs of each root were digitized, and the total area of apical disadaptation was measured using the Image Tools software. Data were analyzed using the Mann Whitney test with a significance level of 5%. **Results:** There was no significant difference in disadaptation between the different types of materials. **Conclusion:** The type of obturation material did not affect apical disadaptation in retrograde fillings.

KEYWORDS

Apicoectomy; Endodontics; Retrograde obturation; Root Canal Filling Materials; Tooth apex.

RESUMO

Objetivo: O objetivo deste estudo é avaliar a desadaptação apical dos materiais de retropreenchimento na obturação retrógrada. **Material e Métodos:** Quarenta e oito raízes palatinas de molares superiores foram instrumentadas usando a técnica step-back e preenchidas usando a técnica do cone único. Após o preparo e a obturação, as raízes foram embutidas em resina, deixando 2 mm do ápice exposto. Uma apicectomia de 2 mm foi realizada nos ápices das raízes e o retropreparo foi feito com uma ponta ultrassônica revestida de diamante (S12 900D). Os grupos foram então divididos com base no material de preenchimento retrógrado: Grupo MTA - obturação retrógrada com MTA; Grupo S26 - obturação retrógrada com Sealer 26. Após a conclusão das obturações retrógradas, as raízes foram imersas em água deionizada por 72 horas a 37°C para permitir que os materiais endurecessem. Os blocos de raiz foram secos, revestidos por pulverização catódica e analisados em um microscópio eletrônico de varredura para obter imagens com ampliação de 50x. As fotomicrografias de cada raiz foram digitalizadas, e a área total de desadaptação apical foi medida usando o software Image Tools. Os dados foram analisados usando o teste Mann Whitney com um nível de significância de 5%. **Resultados:** Não houve diferença significativa na desadaptação entre os diferentes tipos de materiais. **Conclusão:** O tipo de material de obturação não afetou a desadaptação apical em obturações retrógradas.

PALAVRAS-CHAVE

Apicectomia; Endodontia; Obturação retrógrada; Materiais Restauradores do Canal Radicular; Apice dentário.

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INTRODUCTION

Endodontic surgery seeks to treat patients presenting clinical and radiographic signs of endodontic disease [1]. Endodontic microsurgery is effective for treating teeth with refractory apical periodontitis [2]. The long-term success rate of periradicular surgery can exceed 90%, provided thorough curettage of infected periapical tissues, adequate resection of 3 mm of the root end, and complete sealing of the apex with root-end preparation and obturation. A success rate of 86.9% was observed after 1 to 4 years of follow-up, compared to 67.2% after 5 to 9 years [3]. Root-end retrofilling is crucial for ensuring apical sealing and reducing microbial reinfection [4].

Retrograde root-end preparation and filling after apicectomy are essential for achieving sealing, thus hindering microleakage and recurrence of lesions [5,6]. Ultrasonic preparation and the use of mineral trioxide aggregate (MTA) are key intraoperative prognostic factors for periapical healing [4].

Ultrasonics are employed in various endodontic procedures, such as removing post-retained devices, retreatments, and obturations [7]. The development of micro-tips enabled their use in preparing cavities for retrograde fillings, offering technical ease and the ability to create regular cavities along the canal's long axis [4].

Retrograde obturation must fit well against the dentinal walls, have low porosity, and be dimensionally stable [8] to ensure good sealing. In the past, materials like amalgams and zinc oxide eugenol-based cements were used for retrograde fillings, but recently, bioceramic materials have been preferred. Bioceramics offer advantages like superior biological properties, easier handling, radiopacity, dimensional stability, acceptable mechanical properties, and overall clinical performance [9].

Contemporary endodontics utilizes bioactive materials that can effectively create a biological seal in various applications, such as root perforations, root fillings, pulp capping, pulpotomy, apexification, and regenerative procedures, along with other clinical conditions [10].

Mineral trioxide aggregate (MTA), introduced in 1993, is highly valued in dentistry for its sealing properties, biocompatibility, and antimicrobial action, excelling in perforation repair, pulp capping, and retrograde obturation [11]. With components that include mineral oxides and ions such as calcium and phosphate, it assures compatibility with dental tissues [9]. Compared to other filling materials, MTA offers superior sealing and can be used in moist environments, though it has a setting time of 3.5 to 4 hours and complex handling [12]. Available in Brazil since 2001 (MTA-Angelus, Ângelus, Londrina, Brazil) as an alternative to ProRoot-MTA (Dentsply Tulsa OK), its initial pH of 10.2 rises to 12.5 upon contact with moisture, contributing to its antimicrobial action [11]. MTA is biocompatible, does not cause significant inflammation, and promotes tissue repair, including dental, cementum, and bone regeneration [13].

Sealer 26 is an endodontic sealer using epoxy-bisphenol resin in its formulation, containing bismuth oxide and calcium hydroxide. It exhibits antibacterial activity and good apical sealing capabilities. For retrograde obturations, a higher powder-to-resin ratio is used to achieve a thicker consistency. Additionally, Sealer 26 has high radiopacity, making it effective and suitable for such procedures.

By investigating the sealing ability and resistance to microbial leakage of MTA and Sealer 26, this study will provide crucial guidance for improving success rates in clinical practice, particularly in challenging cases such as endodontic retreatments, where bacterial persistence is frequently a factor in treatment failure.

Given the lack of studies analyzing the adaptation of retrofilling materials like MTA and Sealer 26, it is timely to conduct this study to inform clinicians performing periradicular surgery about which material will best adapt to cavity walls, ensuring greater success in these procedures. Understanding the cement that provides optimal sealing ability and resistance to microbial leakage can assist dentists in addressing clinical situations like endodontic retreatments, where failure is often linked to the persistence of bacteria in the endodontic canals [14].

The objective of this study was to analyze, in vitro using Scanning Electron Microscopy (SEM), the adaptation of retrograde fillings based on the retrofilling material used: MTA or Sealer 26. The null hypothesis was that there would be no differences between the retrofilling materials.

MATERIAL AND METHODS

The sample calculation used G * Power v. 31 for Mac by selecting Man-Whitney test. The data from a previous study [15] that evaluated root end filling material adaptation was used. The effect size utilized in the present study was established (=1.02). The alpha type error was 0.05, and the beta power was 0.95. A total of 23 specimens were necessary for the group. The group utilized twenty-four teeth due to the risk of losing any specimen.

This study was submitted to and approved by the local ethics committee. Forty-eight palatal roots of extracted maxillary molars, donated by patients with signed consent forms, were instrumented using the step-back technique, up to K-Files number 40 (Maillefer, Bailanges, Switzerland) and stepped back to K-Files number 60 (Maillefer, Bailanges, Switzerland). During the biomechanical preparation, 1% sodium hypochlorite (NaOCl) (Biodinâmica, Ibiporã, Paraná, Brazil) [16] and, at the end, EDTA (Biodinâmica, Ibiporã, Paraná, Brazil) for 3 minutes and physiological saline solution were used [17]. The roots were filled using the single cone technique with gutta-percha and Endofill cement (Dentsply Ind e Com. Ltda, Petrópolis, Rio de Janeiro) [18]. Subsequently, the roots were embedded in acrylic resin blocks, leaving 2 mm of the apical portion exposed.

After the resin polymerized, the exposed two millimeters of the root were resected with a Zecrya bur (KG Sorensen) at high speed and at a 90-degree angle. The retrograde cavities were prepared with a Jet-sonic Four Plus ultrasonic device (Gnatus, Ribeirão Preto, São Paulo, Brazil) and an S12 900 diamond tip using the Endodontics mode at frequency 5, ceasing the retro-preparation upon complete removal of the gutta-percha. During retro-preparation, irrigation was performed with physiological saline solution using a disposable syringe and needle. The roots were then divided into two groups: Group S26: roots retrofilled with Sealer 26 (Dentsply Ind e Com. Ltda, Petrópolis, Rio de Janeiro), and Group MTA: retrofilled with white MTA Ângelus (Ângelus Ind. E Comércio Ltda, Londrina, PR, Brazil). For the MTA, the manufacturer's instructions for the proportion and handling of the material were followed, while for Sealer 26, a proportion of 0.4 grams of powder to 0.1 gram of resin was used. During the retrograde obturation, the materials were placed into the cavity with the help of a Lucas curette, and then condensed with Bernabé-type plugger. After filling the cavity, the material was burnished against all the walls with a burnisher number 33.

Following the retrograde obturation, the roots were immersed in bottles containing deionized water for 72 hours at 37°C to allow the materials to set [19]. After this period, the teeth were kept at room temperature for drying for 24 hours.

After drying, the roots were sputter-coated with gold and subjected to analysis using a scanning electron microscope (SEM), where images of the apical portion were obtained at a magnification of 50x (Figures 1 and 2).

The microscope images were digitized, and then the Image Tools software (UTCSSA, San Antonio, Texas, USA) was used to measure the area of disadaptation. For each sample, calibration was conducted using the scale bar on the image

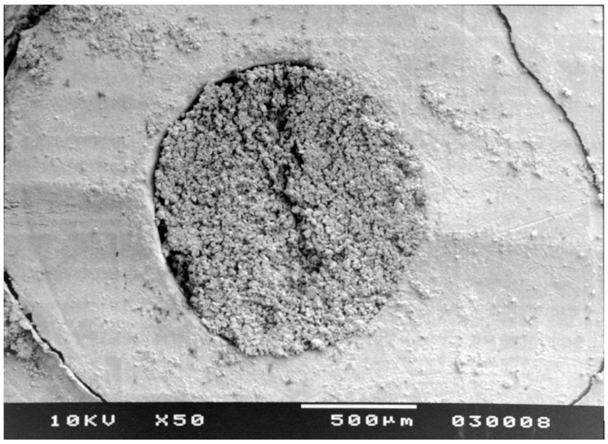

Figure 1 - Photomicrograph of the MTA group.

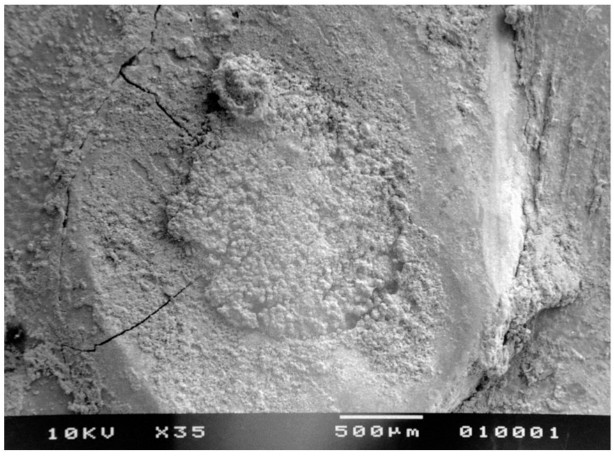

Figure 2 - Photomicrograph of the Sealer 26 group.

corresponding to 500 micrometers (0.5mm). The areas were measured in mm^2, measuring the total area of the retrograde filling and the area at each point where disadaptation was detected. Then, the areas from each point were summed, providing the total disadaptation area for that sample. Subsequently, the percentage of disadaptation area relative to the total filling area was calculated.

Statistical analysis

Data were analyzed using the Mann Whitney test, with a significance level of 5%.

RESULTS

Table I contains the median, minimum, and maximum values of the disadaptation percentage for MTA and Sealer 26 in retrograde fillings. No statistically significant difference ($p>0.05$) was found between the two materials tested.

DISCUSSION

This study aimed to evaluate the apical disadaptation in retrograde obturation using different retrofilling materials. No significant differences were found between MTA and Sealer 26, thus the null hypothesis could not be rejected.

The level of microleakage is also influenced by the sectioning plane; a 90° angle was chosen for root end sectioning as it is the most widely accepted based on previous studies [20,21]. Resecting the root end at angles of 30° or 45° may compromise healing due to exposed dentinal tubules, loss of dentin, cementum, and bone, increased mechanical stress, and potential for postoperative radiographic errors [21].

In this study, the root end cavity preparation was performed using ultrasonic tips to overcome the main disadvantages associated with bur-prepared retro-preparations [20]. The use of small ultrasonic tips allows for precise preparation of a class I cavity along the longitudinal axis of the root end while extending bucco-lingually through the isthmus, with minimal alteration to the canal morphology [4]. Previous studies have demonstrated that cavities prepared with small ultrasonic tips are more precise and conservative.

Various techniques have been used to evaluate the adaptation capacity of retrofilling cements. SEM was employed in this study, as this method is widely used for analyzing disadaptation [22,23]. However, SEM presents several limitations. Preparing biological samples requires high vacuum evaporation, which can introduce artifacts such as cracks in hard tissues and detachment of filling material from the surrounding dental structures. Marginal adaptation analysis through SEM can provide insights into the sealing potential of retrofilling materials in dentin. In this study, direct reading was used. Bidar et al. [24] compared direct reading in SEM using low and high vacuum and noted greater disadaptation with high vacuum, where sample metallization occurs.

To minimize artifacts like cracks, samples were embedded in resins, resulting in a low artifacts index. Embedding in resin is easier and more practical than molding samples in silicone and obtaining resin replicas, providing a more reliable and straightforward methodology [25].

The quality and stability of dental materials are crucial for the longevity of restorations under clinical conditions, with marginal adaptation and the intimate interface contact with surrounding tissues as key determinants. Various materials, such as MTA, Biodentine, Super EBA, IRM, and amalgam, have been used as retrofillers.

MTA is a widely recognized gold standard for retrofilling materials in endodontics due to its effectiveness and superior sealing capacity, which contribute to tissue healing after endodontic surgery [26]. While Soundappan et al. [27] highlighted MTA's superior marginal adaptation compared to Biodentine, Bolhari et al. [28] found their sealing abilities comparable as both are calcium silicate based. Jardine et al. [29] reported no differences between MTA Angelus, Biodentine, and Neo MTA Plus. Similarly, bacterial leakage tests showed no significant differences between biphasic calcium phosphate

Table I - Mean, standard deviation (SD), Median (Med), minimum (Min) and maximum (Max) values of the percentage of maladaptation between the two materials tested

	Mean	SD	Med	Min	Max
MTA	1.17	1.42	0.61	0	4.14
Sealer 26	1.10	1.46	0.57	0	5.30

cement (BCPC) and MTA, indicating BCPC-S as a viable root-end filling [30]. There's also a lack of evidence favoring tricalcium silicate over MTA for periapical surgeries [31,32]. MTA is biocompatible and does not cause significant inflammation, instead promoting the deposition of dentin, cementum, and bone, supported by its excellent sealing and moisture resistance [12,22]. Recent findings by Singh et al. [33] demonstrated that MTA Angelus had the best sealing capacity. Tanomaru-Filho et al. [5] found MTA's apical sealing was superior when using Methylene Blue, emphasizing the need to consider various factors in material selection for endodontic procedures. Also, MTA and IRM outperformed Biodentine in another comparative study [27].

Sealer 26 was significantly more effective than FujiX and IRM in preventing bacterial infiltration [34], however no difference in periapical tissue healing after retrograde filling with Sealer 26, Sealapex plus zinc oxide, or MTA [5]. In this study, no differences were found between Sealer 26 and MTA.

The clinical significance of this study is rooted in its potential to inform material selection, improve surgical outcomes, reduce the risk of reinfection, and enhance overall patient care in endodontics. While in vitro results can inform and guide clinical practice, practitioners must remain cognizant of the differences between controlled laboratory settings and the complexities of real clinical environments. This awareness allows for more informed decision-making and the adaptation of research findings to optimize patient care.

A limitation of this study is the potential for artifacts during metallization or reading due to the vacuum required for SEM [22,23] and its inability to represent the adaptation of two surfaces in three dimensions. The results of this in vitro study might differ from actual clinical situations due to various influencing factors, such as the presence of blood and tissue fluids during the placement of the retro-filling materials, the presence of a periapical lesion, and anatomical differences. Additionally, variations in experimental design, and operator techniques may also affect study outcomes. Despite these potential differences, the study was designed to assess the sealing ability of different materials, and the data showed no statistically significant differences between Sealer 26 and MTA. Consequently, any of these materials could be effectively used in endodontic microsurgery.

Utilizing advanced techniques such as micro-computed tomography (micro-CT) can significantly improve the evaluation of material adaptation and microleakage by providing detailed three-dimensional imaging. Longitudinal studies with extended follow-up periods are also essential to gain insights into the durability and long-term effects of various retrofilling materials on periapical healing, resulting in better clinical outcomes.

CONCLUSION

In conclusion, both materials exhibit similar behavior in terms of apical adaptation.

Data availability

Datasets related to this article will be available upon request to the corresponding author.

Author's Contributions

AGL, MAHD: Conceptualization, Investigation, Methodology. MAHD: Data Curation, Formal Analysis. GFS: Project Administration. RRV, MPA, GFS: Supervision, Validation, Visualization. All authors: Writing – Original Draft Preparation, Writing – Review & Editing.

Conflict of Interest

The authors have no conflicts of interest to declare.

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Regulatory Statement

This study was submitted to and approved by the local ethics committee.

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