Root Perforation Repair with MTA in Maxillary Incisor: Clinical Case Supported by a Systematic Scoping Review *

Reparación de perforación radicular con MTA en incisivo maxilar: Caso clínico apoyado en revisión sistemática de alcance

Reparo de perfuração radicular com MTA em incisivo superior: caso clínico apoiado por uma revisão sistemática do escopo

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ABSTRACT

Background: Treatment of a root perforation involves sealing the communication between the root canal and the periodontal tissues with a biocompatible restorative material. **Purpose**: To present a clinical case in which MTA was used as a restorative material for a lateral root perforation in a maxillary central incisor, supported by a scoping systematic review on the use of

the same material in similar cases. **Methods**: MeSH and DeCS standardized descriptors with Boolean operators were used in four databases (PubMed, LILACS, SciELO, and Google Scholar) to search for related research. Case reports, case series, clinical trials, systematic and narrative reviews, and retrospective studies on the use of MTA in lateral root perforations were identified. **Results**: Of 194 article titles found, 16 were selected that addressed similar treatments in single-rooted canals. **Case description**: The case involved a 23-year-old female patient with a lateral root perforation caused during the removal of a fiberglass post. The perforation was sealed with MTA via intracanal placement in a maxillary central incisor. Clinical follow-up extended for one year. **Conclusions**: This clinical case supports the evidence regarding the efficacy of MTA in the repair of lateral root perforations, with favorable results at one year. The scope of review supports its use as an effective and viable alternative, thanks to its biocompatibility and superior sealing capacity in the medium term.
Keywords: dentistry; endodontics; iatrogenic perforation repair; incisors; mineral trioxide aggregate; MTA; root canal treatment; root perforation; systematic scope review

RESUMEN

Antecedentes: El tratamiento de una perforación radicular consiste en sellar la comunicación entre el conducto radicular y los tejidos periodontales con un material reparador biocompatible. **Objetivo**: Presentar un caso clínico en el que se utilizó MTA como material reparador de una perforación radicular lateral en un incisivo central superior, el cual estuvo apoyado por una revisión sistemática de alcance sobre el uso del mismo material en casos similares. **Métodos**: Se emplearon descriptores normalizados MeSH y DeCS con conectores booleanos en cuatro bases de datos (PubMed, LILACS, SciELO y Google Académico) para buscar las investigaciones relacionadas. Se identificaron estudios de casos clínicos, series de casos, ensayos clínicos, revisiones sistemáticas y narrativas, y estudios retrospectivos sobre el uso de MTA en perforaciones radiculares laterales. **Resultados**: De 194 títulos de artículos encontrados, se seleccionaron 16 que abordaron tratamientos similares en conductos unirradiculares. **Descripción del caso**: El caso se trató de una paciente de sexo femenino de 23 años de edad con perforación radicular lateral provocada durante el retiro de un perno de fibra de vidrio. Se selló la perforación con MTA vía intraconducto en un incisivo central superior. El seguimiento clínico se extendió durante un año. **Conclusiones**: El caso clínico apoya la evidencia sobre la eficacia del MTA en la reparación de perforaciones radiculares laterales, con resultados favorables a un año. La revisión de alcance respalda su uso como una alternativa eficaz y viable, gracias a su biocompatibilidad y capacidad de sellado superior a mediano plazo.
Palabras Claves: agregado de trióxido mineral; endodoncia; incisivos; MTA; odontología; perforación radicular; reparación de perforación iatrogénica; revisión sistemática de alcance; tratamiento del conducto radicular

RESUMO

Antecedentes: O tratamento de uma perfuração radicular envolve o selamento da comunicação entre o canal radicular e os tecidos periodontais com um material restaurador biocompatível. **Objetivo**: Apresentar um caso clínico no qual o MTA foi utilizado como material restaurador para uma perfuração radicular lateral em um incisivo central superior, com base em uma revisão sistemática de escopo sobre o uso do mesmo material em casos semelhantes. **Métodos**: Descritores padronizados MeSH e DeCS com operadores booleanos foram utilizados em quatro bases de dados (PubMed, LILACS, SciELO e Google Scholar) para buscar pesquisas relacionadas. Foram identificados relatos de caso, séries de casos, ensaios clínicos, revisões sistemáticas e narrativas e estudos retrospectivos sobre o uso de MTA em perfurações radiculares laterais. **Resultados**: De 194 títulos de artigos encontrados, 16 foram selecionados por abordarem tratamentos semelhantes em canais radiculares únicos. **Descrição do caso**: O caso envolveu uma paciente de 23 anos com perfuração radicular lateral causada durante a remoção de um pino de fibra de vidro. A perfuração foi selada com MTA por meio de aplicação intracanal em um incisivo central superior. O acompanhamento clínico estendeu-se por um ano. **Conclusões**: Este caso clínico corrobora a evidência da eficácia do MTA no reparo de perfurações radiculares laterais, com resultados favoráveis após um ano. O escopo da revisão apoia seu uso como uma alternativa eficaz e viável, graças à sua biocompatibilidade e capacidade de selamento superior a médio prazo.
Palavras-chave: agregado de trióxido mineral; endodontia; incisivos; MTA; odontologia; perfuração radicular; reparo de perfuração iatrogênica; revisão sistemática do escopo; tratamento de canal radicular

INTRODUCTION

In the field of endodontics, one of the most frequent causes of failure is root perforation, which accounts for approximately 10% of failed cases (1). It is estimated that about 12% of these perforations are detected during non-surgical retreatment of previous endodontic procedures (2). Root perforation is defined as a connection between the root canal system and the periodontal tissues, which can cause

lesions in the latter. This condition can induce inflammatory processes, bacterial infections, bone resorption, and proliferation of epithelial tissue (3).

Root perforations can originate from pathological processes or iatrogenic accidents (4). The latter can occur during access to the cavity, endodontic instrumentation, or preparation for post placement (5). The treatment prognosis depends on multiple factors, such as early diagnosis, the size, location, and shape of the lesion, as well as the type of treatment (surgical or non-surgical), the material used, and, especially, the professional's experience (6,7). It is essential to identify these perforations promptly to avoid periodontal complications that could compromise tooth retention (3,5).

To achieve successful treatment, it is necessary to establish an accurate diagnosis based on a thorough medical history, as well as clinical and radiographic examinations (8,9). With the advancement of technology, the use of surgical microscopes and other visual magnification devices has facilitated diagnosis and improved the accuracy of procedures, resulting in a higher success rate in many cases (10).

Various materials have been used to treat root perforations (5,11). However, mineral trioxide aggregate (MTA) has been considered the material of choice for this type of repair, as it possesses excellent sealing and biocompatibility properties (12,13). It is a biocompatible calcium silicate-based compound introduced to the market in the early 1990s (5). This material has proven effective in various endodontic treatments, including perforation repair (14). Its main advantage is its ability to set in a moist environment, unlike other available materials (14,15). Long-term studies have found that the use of MTA in root perforations promotes healing in more than 80% of cases (6,12), making it a viable option for treating these lesions (6).

The literature, particularly systematic reviews, indicates the use of MTA for repairing root perforations, regardless of the affected area (5,13). One systematic review mentions that biodentin showed better performance than MTA in repairing furcation perforations (16). Although MTA has been widely used in clinical practice, variability persists in placement procedures, and there is debate about its effectiveness in different clinical contexts, especially in single-rooted teeth. Furthermore, the available literature focuses mainly on its use for repairing root perforations in molars or furcation areas, which hinders evidence-based clinical decision-making. This could be explained by the fact that most root perforations, approximately 87%, occur in the floor of the pulp chamber (17).

For these reasons, a scoping systematic review was proposed to explore the use of MTA in single-rooted teeth. This review was used to support a clinical case in which this restorative material was used to treat a lateral root perforation in a maxillary central incisor, with one year of follow-up. This scoping systematic review provides evidence on the MTA placement technique, as well as its effectiveness and feasibility for resolving this type of endodontic lesion.

MATERIALS AND METHODS

Type of Study and Design

The scoping systematic review was conducted following the protocols established by the PRISMA-ScR extension (18). The search for studies was carried out between April 5, 2024, and May 5, 2024. The strategy focused on the use of MTA for the repair of perforations in single-rooted teeth, with application techniques similar to those used in the clinical case. Once the studies were selected, the data were collected in an Excel® spreadsheet (Table 1).

Information Sources and Search Strategy

The electronic databases used for the search included PubMed, Google Scholar, LiLACS, and SciELO. The search strategy across all databases included MeSH and DeCS terms, as well as keywords, combined with Boolean operators in English, Spanish, and Portuguese. Relevant studies were imported

into EndNote X7 software to remove duplicates. Two authors (EA and LI) reviewed potentially eligible studies based on their titles and abstracts. This elimination process was supplemented by a manual evaluation, which involved a preliminary reading of the abstracts and full texts of the selected studies.

- PubMed: “MTA” AND “perforation repair”; “MTA for perforation” NOT “biodentina”; “perforation repair endodontics”
- Google Scholar: “MTA dentistry” AND “permanent teeth” NOT “immature teeth”; “central incisor perforation” AND “MTA”; “root perforation” AND “MTA”
- LiLACS: “MTA en endodoncia”; “root canal perforation”; “materiales regenerativos endodoncia”
- SciELO: “MTA para endodoncia”; “manejo de perforaciones endodoncia”; “MTA repair material”

Eligibility Criteria

The search strategy for the scoping systematic review included studies published in indexed scientific journals with evidence other than in vitro, in situ, and animal studies. These included, among others, randomized controlled trials, systematic reviews, narrative reviews, and case reports. Inclusion criteria were as follows:

- The selected year range was from 2013 to 2024.
- The languages of the selected studies were primarily English, Spanish, and Portuguese.
- Regarding publication status, it only included published studies.
- Studies on perforations in single-rooted teeth were selected.

Exclusion criterio were:

- Abstracts, incomplete text studies, unpublished theses/dissertations, letters to the editor, and animal studies.
- Studies describing surgical techniques for MTA placement.
- Studies on furcation perforation treatments in permanent molars.
- Studies on perforations in primary teeth.
- Studies describing treatments for pathological perforations.
- Studies that used other repair materials.

Data and Element Extraction of the Studies

The two independent reviewers mentioned above also extracted the necessary data from the selected studies. For each study, the following criteria were assessed: author, year, study design, number of patients, number of teeth treated, tooth type, reason for treatment, lesion size, material used to repair the perforation, additional procedures, final treatment, and follow-up. Any disagreements between the reviewers were resolved through discussion and re-evaluation of these variables.

Bias Risk Assessment

To assess the risk of bias in the included case studies, a critical appraisal was performed using the CARE guidelines (19). Retrospective studies were assessed using the STROBE guidelines (20). In randomized controlled trials, protocol quality was assessed using the CONSORT guidelines (21). Finally, systematic reviews and meta-analyses were assessed using the PRISMA 2020 statement (22). Narrative reviews were assessed based on the quality and validity of the information sources used, as

well as the presentation of the evidence. Assessments were performed in duplicate by two reviewers. In case of discrepancies, each criterion was discussed and reassessed to determine its inclusion or exclusion.

RESULTS

Searching for Literature

Table 1 lists the studies selected for systematic scoping. The initial search, using MeSH, DeCS, and other keywords, identified a total of 194 studies in the aforementioned electronic databases. Of these, 55 were eliminated due to duplication across databases. After reviewing titles and abstracts, 178 studies were excluded. Consequently, 16 studies were selected for full-text review and verification of their relevance and similarity of approach to the presented clinical case. The eligibility process is summarized in Figure 1. The selection process for each electronic database is described below:

PubMed: 38 titles were identified, of which 31 were excluded because they corresponded to other research topics in endodontics. In total, 7 studies met the inclusion criteria: 1 retrospective study, 1 clinical trial, 1 systematic review with meta-analysis, and 4 systematic reviews.

Google Scholar: 93 studies were identified, of which 88 were excluded for investigating other endodontic research problems. Five studies met the inclusion criteria: 2 case descriptions with the same treatment and 3 systematic reviews.

LiLACS: Forty titles were found, of which 37 were removed. Of these, 36 were excluded because they corresponded to other research topics in endodontics, and 1 could not be obtained. In total, 3 studies met the inclusion criteria and corresponded to case reports with the same treatment.

SciELO: 23 studies were found, of which 22 were excluded because they corresponded to other research topics in endodontics. In total, 1 study met the inclusion criteria and was a case description with the same treatment.

Characteristics of the Studies

The main characteristics of the included studies are summarized in Table 1. A review of each study allows for a clinical analysis of the presented case, based on the information provided by the different types of evidence identified. The search and review revealed a predominance of studies with a low level of evidence, such as literature reviews, case reports, and one retrospective study, all comparable to the presented clinical case. All literature reviews included up-to-date references from internationally indexed journals, consistent with their publication dates.

TABLE 1
Overview of the characteristics of each study included in the scoping review

Study design: Case Report

Author/ Year	No. patients	No. perforations	Type of tooth	Reason for treatment	Lesion size	Technique used	MTA used for the repair of the lesion	Final treatment	Period of follow-up	Treatment outcome
Braitt, et al., 2022 (23)	1	1	Upper premolar	Iatrogenic perforation	Does not mention	Non-surgical technique	MTA White (Angelus)	Restorative procedure	Does not mention	Successful
Kumar; 2022 (24)	1	1	Upper central incisor	Iatrogenic perforation	Does not mention	Non-surgical technique	MTA (Angelus)	Composite reinforced fiber post	1 year	Successful
Narang, et al., 2013 (25)	1	1	Lower central incisor	Iatrogenic perforation	Does not mention	Non-surgical technique	MTA (Dentsply)	Composite resin restoration	1 year, 6 months	Successful
Palomino, et al., 2021 (26)	1	1	Lower premolar	Iatrogenic perforation	2 to 3mm	Non-surgical technique	MTA White Angelus)	Metal post and metal-ceramic crown	2 years	Successful
Resende, et al., 2019 (27)	1	1	Upper central incisor	Iatrogenic perforation	Does not mention	Non-surgical technique	MTA Repair HP (Angelus)	Composite resin restoration	6 months	Successful
Soares et al., 2018 (28)	1	1	Upper central incisor	Iatrogenic perforation	Does not mention	Non-surgical technique	ProRoot MTA (Dentsply)	Crown-root restoration	6 years, 4 months	Successful

Study design: Retrospective study

Author/year	No. patients	No. perforations	Period of follow-up	Material used	Success rate (%)
Pontius, et al., 2013 (29)	69	70	Mean of 37 months	MTA (different brands)	90

Study design: Randomized clinical trial

Author/	Year	No. patients	No. tested teeth	No. control teeth	Type of teeth	Follow-up period	MTA Results
Tirone, et al., 2018 (30)	3	3	3	Upper central, lateral incisors	Upper canines	3 months	Bioactivity and biocompatibility

Study design: Systematic review with meta-analysis

Author/	Year	No. studies included	Success rate with MTA (%)	Presence of radiolucent areas	Location of perforation
Siew K, et al., 2015 (31)	17 (Systematic review)	12 (Meta-analysis)	Improvement to 80.9	Preexisting has a lower probability of success ($p<0.05$)	Teeth in the maxilla has greater success ($p<0.05$)

Table 1, continued…

Study design: Literature Review			
Author/year	**Included topics**		
Clauder, 2022 (5)	Background	Classification of perforations	Materials and techniques
Estrela et al., 2018 (4)	Diagnosis and prognosis	Materials used: Calcium hydroxide, MTA, bioceramic cements	Clinical overview
Haapasalo, et al., 2015 (32)	Use of bioceramic and hydric materials in endodontics	Scientific rationale for their selection	Application in various clinical situations
Makandar & Karobari, 2018 (33)	History	Properties and composition	Application in diverse clinical situations
Makkar, et al., 2016 (34)	Procedural accidents	Etiology, diagnosis, prevention	Application in diverse clinical situations
Tawil, et al., 2015 (14)	History	Composition	Clinical applications
Wang, et al., 2023 (35)	Backgrounds	Applications of bioceramic materials: MTA, Biodentine, Bioaggregate, iRoot BP Plus	Clinical guidelines for their applications

Source: the authors.

Three case reports (26,28) were of high quality according to the CARE scale. These provided detailed descriptions of the clinical case, the steps for using MTA, and its impact on the treatment outcome. In contrast, other studies (23–25) did not meet all the criteria established by the CARE guidelines. The retrospective study (29) presented high-quality information from the collected cases, according to the STROBE guidelines (20), and employed similar techniques for using MTA. Finally, only two studies (30,31) presented a high level of evidence: a randomized clinical trial and a systematic review with meta-analysis, both of high quality according to CONSORT and PRISMA. These analyzed the feasibility and effectiveness of MTA as a restorative material for perforations in single-rooted teeth, comparable to the clinical case presented.

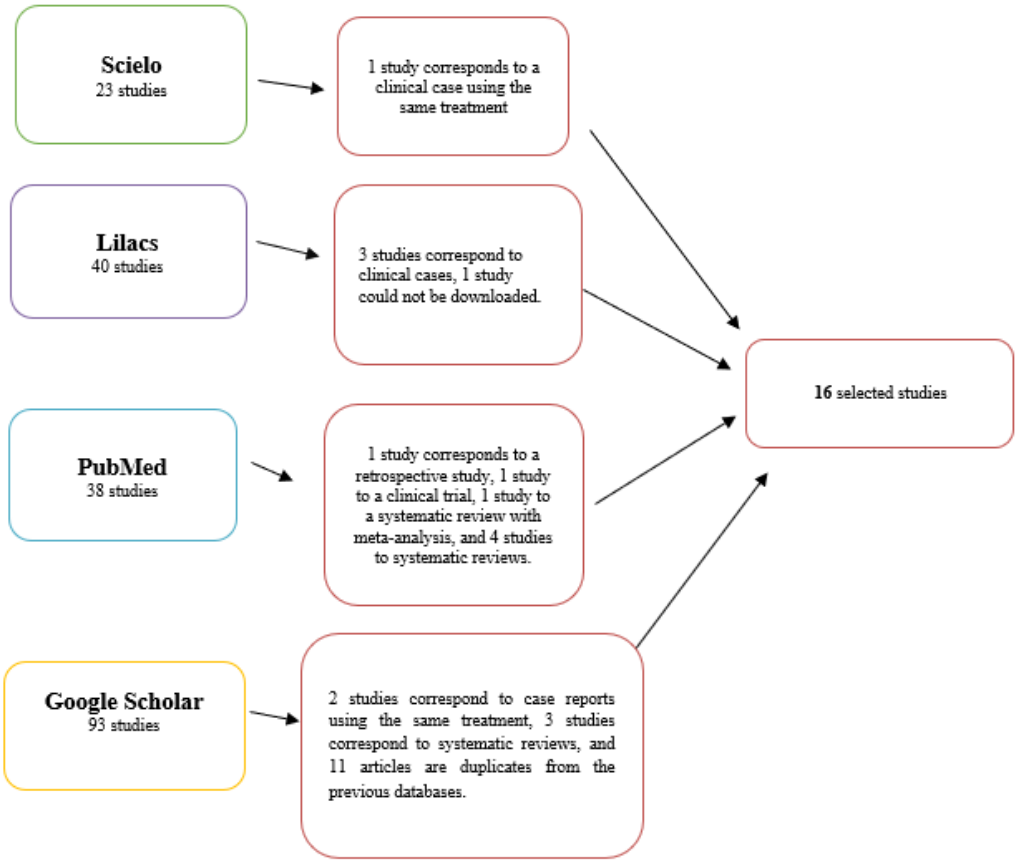

FIGURE 1
Flowchart for the selection of studies

CLINICAL CASE DESCRIPTION

A 23-year-old woman attended the Endodontic Specialty Clinic at the Dental School of the National University of Concepción, Paraguay. She reported pain in tooth 21 (FDI two-digit dental nomenclature). During the anamnesis, she stated that the pain began approximately two months after placement of a new post that replaced a fractured post. A complete clinical record was obtained. She reported no relevant personal or family medical history.

During the extraoral examination, no facial asymmetry, swelling, or lymphadenopathy was detected. The intraoral examination revealed an active fistula on the distal aspect, at the level of the attached

gingiva. Tooth 21 had a provisional acrylic crown with excess cement, which caused gingival inflammation (Figure 2A, B). A periapical radiograph showed a radiolucent area on the distal aspect of the tooth at the middle third of the alveolar bone. A radiopaque intrarradicular post was also observed, and the root canal appeared deviated toward the radiolucent area. This finding suggested a possible perforation in that region (Figure 2C).

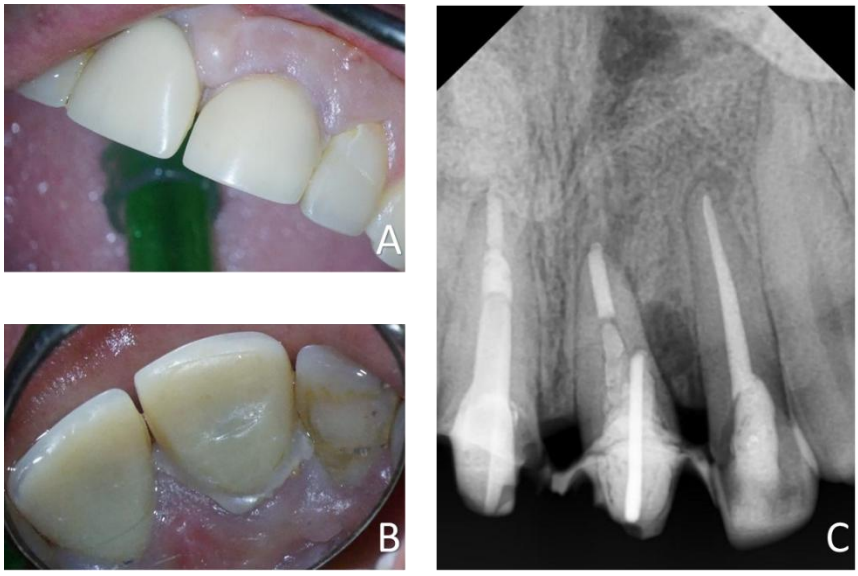

FIGURE 2
Clinical and Radiographic Findings
(A) Vestibular view of tooth 21, showing an active fistula at the level of the attached gingiva. (B) Palatal view of the tooth where an excess of cement material is observed. (C) Initial periapical radiograph showing a radiolucent area distally, with a post deviating from the root canal. Source: the authors.

Clinical Procedure

Based on the collected data, a presumptive diagnosis of iatrogenic lateral perforation of tooth 21 was established. The patient was informed of the diagnosis and the proposed treatment plan. This plan consisted of removing the acrylic crown and post. Subsequently, a sealing material would be placed to obturate the perforation using a non-surgical technique. To complete the rehabilitation, it was proposed to place a new preformed metal post, anatomically adapted with composite resin in the root canal. Finally, the fabrication of an esthetic acrylic crown was indicated. The patient authorized the procedure by signing an informed consent form.

Infiltration anesthesia was administered with 4% articaine and 1:100,000 epinephrine (Articaine®, DFL Indústria e Comércio Ltda., Rio de Janeiro, Brazil), and rubber dam isolation was applied. To improve visualization of the surgical field, a Newton Microscopía® MEC XXI dental operating microscope (Newton SRL, Buenos Aires, Argentina) was used. The acrylic crown, resin core, metal post, fiberglass post, and excess material were removed.

Immediately, a No. 0 CIHGI-FEK® retraction cord impregnated with Hemopare® liquid hemostatic agent (Maquira, Indústria de Produtos Odontológicos S/A, Maringá, Brazil) was placed to achieve hemostasis and gingival retraction. Next, the excess cement was removed, and the fiberglass post was removed using a No. 1012HL round bur (FAVA Industria, São Paulo, Brazil) at high speed and an explorer probe (Figure 2A). At this point, a perforation approximately 1.5 mm in diameter was detected, caused by the deviation of the post (Figure 2B), which confirmed the presumptive diagnosis. After

removing the excess material, the remaining fiberglass post was removed until the gutta-percha in the original root canal was reached. This was accomplished using an E3D ultrasonic tip (Helse Ultrasonic, São Paulo, Brazil) at 50% power, with the Jet Sonic® unit (Gnatus, São Paulo, Brazil) (Figure 2C).

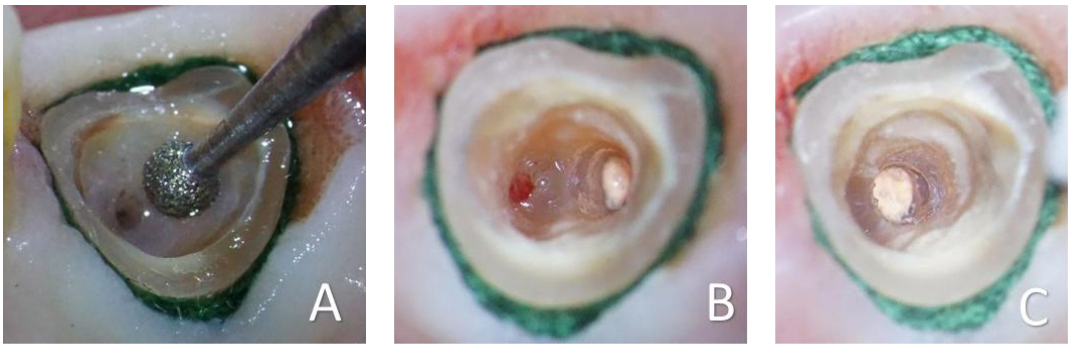

FIGURE 2
Preparation of the Root Canal
(A) Cement excess removal. (B) Localization of perforation. (C) Appearance of original canal filling. Source: the authors.

As a sealing material for the perforation, white MTA (Angelus®, Londrina, Brazil) was chosen and applied via the orthograde approach. Before inserting the sealing material, the original root canal was covered with Teflon tape to prevent the material from entering it. Once this area was covered, a Hemospon® hemostatic sponge (Maquira Indústria de Produtos Odontológicos S/A, Maringá, Brazil) was placed inside the lesion to prevent extrusion of the MTA into the periodontal tissues (Figure 3A). The MTA was handled according to the manufacturer's instructions. It was then placed incrementally using a cement applicator and compacted with a Paiva condenser. This allowed for a hermetic seal of the perforation (Figure 3B). Subsequently, it was covered with a layer of Riva Luting® glass ionomer cement (SDI-Southern Dental Industries, Bayswater, Australia) (Figure 3C). Finally, a layer of Opallis® flowable resin (FGM, Joinville, SC, Brazil) was applied using an adhesive technique (Figure 3D).

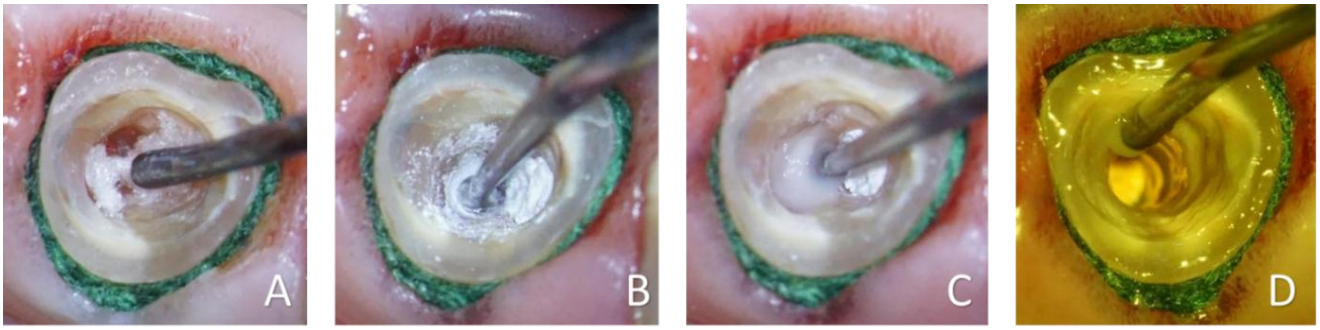

FIGURE 3
Obturation of the Root Canal
(A) Placement of Hemospon® hemostatic sponge in the perforation. (B) Insertion of MTA into the lesion. (C) Placement of glass ionomer. (D) Layer of flowable resin. Source: the authors.

After the perforation was treated, an anatomically shaped metal post was fabricated using Z350 XT dentin A2 composite resin (3M®, Saint Paul, Minnesota, USA). The post was cemented with AllCem Core A2® (FGM, Joinville, SC, Brazil). The same materials were used for the core buildup (Figure 4A). The core was prepared using a tapered bur with a rounded tip, No. 4138 (FAVA® Industria, São Paulo, Brazil). An esthetic acrylic crown was then fabricated and cemented with the same material (Figure 4B).

Once the clinical procedures were completed, a radiographic control was performed to verify the hermetic seal of the perforation (Figure 4C).

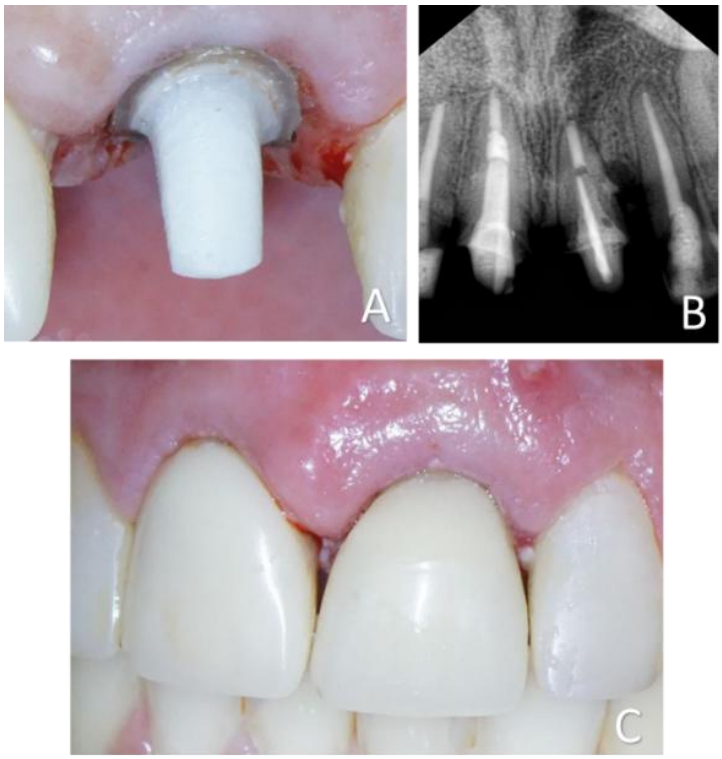

FIGURE 4
Preparation of the Stump and Provisional Restoration
(A) Reconstructed and shaped composite resin core. (B) Control periapical radiograph. (C) Acrylic crown cemented on tooth 21 in the immediate postoperative period. Source: the authors.

Clinical Control and Follow-up

The patient was instructed on the need for periodic clinical and radiographic follow-up examinations. These are essential to verify the long-term success of the treatment and to assess the healing of the bone lesion and the fistula. The patient attended follow-up appointments at 6 months and one year after treatment. Clinical and radiographic evaluations were performed at both visits. The patient reported no pain at either follow-up. Gingival recovery was observed, especially in the interdental papillae area. No active fistula was evident, and a scar was observed at the site of the previous fistula. Furthermore, a decrease in the size of the radiolucent lesion was observed, becoming almost imperceptible after one year, suggesting a trend toward healing (Figure 5).

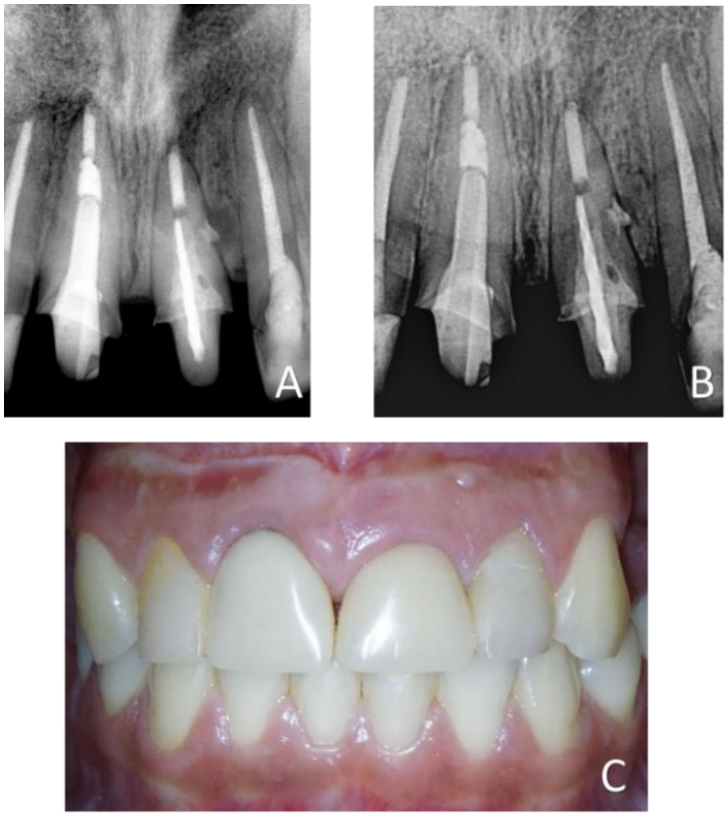

FIGURE 5
Clinical Control and Follow-up
(A) Radiographic follow-up at 6 months. (B) Radiographic follow-up at 1 year. (C) Clinical follow-up at 1 year after crown cementation. Note the recovery of the interdental papillae and the scar at the site of the previous fistula. Source: the authors.

DISCUSSION

This study presents a clinical case of lateral root perforation in a maxillary central incisor, in which MTA was used as a repair material. Despite its widespread use in clinical practice, more evidence is needed regarding its specific application in single-rooted teeth. To address this need, a comprehensive literature search was conducted through a scoping review. The objective was to critically examine the technique for applying MTA in the management of iatrogenic perforations in single-rooted teeth and to highlight its clinical feasibility and effectiveness.

The search of databases such as PubMed, LILACS, SciELO, and Google Scholar yielded a total of 194 studies. After applying the exclusion criteria and the eligibility process, 16 studies were selected (Figure 1, Table 1). These included case reports, retrospective studies, randomized controlled trials, systematic reviews, meta-analyses, and literature reviews. However, one of the main gaps identified was the predominance of studies with a low level of evidence, such as literature reviews and case reports. Only three case reports presented complete and high-quality information (26-28). Furthermore, only two studies provided a high level of evidence: a randomized controlled trial and a systematic review with meta-analysis (30,31). This reveals a significant gap in the availability of recent studies with a high level of evidence regarding the use of MTA.

The set of selected studies (Table 1) allowed us to analyze, first, the causes of iatrogenic root perforations. These are usually associated with the misalignment of burs or instruments during endodontic access or during prosthetic procedures (4,5,31). According to a systematic review with meta-analysis, 53% of perforations occur during restorative treatments, and 74.5% are located in the maxilla (31). As evidenced

in the presented clinical case, the root perforation of the upper central incisor 21, at the level of the middle third, occurred due to the misalignment of the bur with respect to the long axis of the tooth during post placement (5). This type of lesion in the maxilla has a higher probability of therapeutic success than mandibular perforations, due to its greater vascularization, which favors healing (31).

After diagnosis through clinical examination and periapical radiography, the treatment strategy was selected based on the Fuss and Trope classification system (36). This system considers the time elapsed until repair, the size, and the location of the perforation relative to the tooth as factors influencing the prognosis (36). In this case, despite the delayed repair (performed two months after the event, with bone loss and an active fistula), the treatment was successful up to one year of follow-up. The perforation, approximately 1.0 to 1.5 mm in size, was located in the middle third of the tooth and below the alveolar crest. It is worth noting that another gap identified in the literature review was the limited evidence on perforations with delayed repair, as most studies focused on repairs performed within the first month after the perforation (25-27). However, in this particular case, the location and small size reduced the risk of complications, such as epithelial migration (5,29).

In clinical practice, ensuring adequate visibility of the surgical field is essential. In this case study, performed at the Endodontics Specialization Clinic of the National University of Concepción in Paraguay, the magnification provided by the microscope increased the precision of the repair technique and prevented errors during the procedure (5). Secondly, the placement of a matrix to prevent extrusion of the repair material constitutes a critical preventive measure. Furthermore, according to the literature review, this aspect represents a promising emerging area that requires further research. In the described procedure, Hemospon® was used as a physical barrier. This hydrolyzed collagen material not only prevents the extrusion of the repair material into the periodontal space but also contributes to hemostasis and promotes a clear surgical field, free from obstruction by hyperplastic or granulation tissue, which sometimes protrudes into the defect (5). In other reviewed studies, materials were used for the same purpose, such as calcium sulfate and calcium hydroxide as part of a temporary obturation (25,26).

The current trend among patients toward preserving their teeth has benefited from technological advancements, which have increased the possibility of saving compromised teeth (31). Among these advancements, MTA stands out as one of the most studied endodontic materials in recent decades, leading to increased success rates and improved viability of repairs (14). Its hydrophilic nature, which allows it to set in the presence of moisture, such as water or blood, makes it suitable for scenarios where hemostasis may be challenging. However, the systematic scoping review highlighted the need for further research in the clinical setting to provide more robust information on its specific applications. Nevertheless, in the presented clinical case, the application of MTA after the placement of a collagen barrier optimized the marginal seal and leveraged its colloidal gel formation to create a highly alkaline environment with the release of calcium hydroxide. This inhibited bacterial leakage and promoted bioactive properties essential for the healing of injured periodontal tissues (14,28,37).

To ensure precise application during the drilling procedure, careful selection of cement carriers and condensers is required. This was demonstrated in the case presented through the use of the Paiva condenser (5), which allowed for a controlled technique with optimal visibility. White MTA, free of bismuth trioxide, was chosen because it reduces the risk of discoloration in esthetic areas, especially when excess material is removed before restoration (14). Even with the modifications associated with a lower content of iron, aluminum, and magnesium oxides, white MTA exhibits similar properties to gray MTA (14). This material is characterized by a greater release of calcium during the first 24 hours after activation (35) and a reduced setting time of approximately 15 minutes after preparation. This property was essential for completing the treatment in a single session and proceeding with the restorative procedures without interfering with the material (14). However, further clinical studies comparing gray and white MTA are needed, as the differences in their composition could influence the long-term outcomes of endodontic treatments.

The clinical follow-up at 6 months and one year showed satisfactory results in terms of lesion healing and bone crest regeneration, consistent with the clinical case reported by Resende et al. (27). The initial size of the perforation (1.5 mm) did not affect the success of the treatment during the 6-month follow-up, as reported in the retrospective study by Pontius et al. (29). A clinical-histological study in humans demonstrated the ability of MTA to release calcium ions and promote periodontal tissue repair, with periradicular cementum formation, even after 3 months (30,35). Furthermore, MTA does not induce alveolar bone resorption and allows for the growth of cementoblasts, which facilitates the regeneration of the periodontal apparatus (38).

These advantages explain why the literature reports a 90% success rate in non-surgical treatments of perforations repaired with MTA (29). Several clinical studies on perforation repair with MTA, some with larger sample sizes and long-term follow-up, confirm high success rates, ranging from 73.3% to 92%, with adequate sealing capacity over time (29,39-41). However, one retrospective study that analyzed 50 cases reported a 90% success rate after two years of follow-up, with failures in 20 cases (29). For this reason, among the gaps in the literature, there remains a lack of clinical studies with follow-up periods longer than two years after lateral perforation repair, to estimate its long-term success rate.

However, it is important to consider the limitations of this case report, such as the need for long-term follow-up to assess the survival of the treated tooth. Likewise, photographic records should be taken during follow-up to evaluate any root discoloration in the esthetic area, which may vary depending on the periodontal biotype (42,43). Another relevant limitation was the absence of a cone-beam computed tomography scan, so the analysis was limited to periapical radiographs. It is acknowledged that this examination is necessary to obtain an accurate three-dimensional diagnosis of the lesion, allowing for better treatment planning and a more reliable prognosis by visualizing the different planes and surfaces in the area of the affected tooth (4).

Finally, among the limitations of this scoping systematic review, which allowed for the analysis of the clinical case procedure, it is worth noting that the search focused exclusively on single-rooted teeth. This decision was due to the scarcity of studies on perforations in anterior teeth. Furthermore, the need for prospective studies with long-term follow-up was identified to better understand the use of MTA in this context (29). The review also revealed that there are few studies with a high level of evidence, such as randomized controlled trials and systematic reviews, that specifically address the use of MTA in root perforations of anterior and single-rooted teeth. This research topic is particularly complex, as root perforations are not frequent events and occur mainly due to iatrogenic causes (30). Likewise, the ethical difficulties related to obtaining samples and including patients without exacerbating their condition make this a controversial topic in current research (30).

CONCLUSIONS

The clinical case presented demonstrated the efficacy and applicability of MTA in the repair of a lateral perforation, with a one-year follow-up. Combined with the scientific evidence identified in the scoping review, this supports the use of MTA as an effective and viable alternative for the treatment of root perforations, due to its biocompatibility and its ability to provide a long-lasting seal.

RECOMMENDATIONS

Further high-level studies are needed to evaluate the use of MTA in perforations of anterior and single-rooted teeth, as well as to document its long-term clinical performance. In particular, the scoping review highlights the need to investigate the treatment outcomes in perforations with delayed repair and to compare the different types of MTA available on the market. Furthermore, more research is needed on the use of matrices, their impact on MTA placement, and the different types that could optimize

clinical results. These studies would allow for the establishment of clearer guidelines for clinical practice and improve the effectiveness of endodontic treatments.

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