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Case Report
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Indirect restorations with digital workflow in hypomineralized permanent molars: A series of pediatric cases

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Highlights

Molar incisor hypomineralization (MIH) compromises dental enamel, causing sensitivity and difficulties in chewing, which impacts children's quality of life.

This study documented the use of the computer-aided design and manufacturing (CAD/CAM) digital workflow to treat permanent molars affected by severe MIH.

CAD/CAM indirect restorations demonstrated good marginal adaptation, fracture resistance, aesthetics, and reduced dental sensitivity.

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Abstract

Molar incisor hypomineralization (MIH) is an enamel defect that presents significant challenges in clinical management due to its complexity and functional impact. This study evaluated the efficacy of indirect restorations in severely MIH-affected first permanent molars using digital technology and advanced restorative materials, including polymethyl methacrylate (PMMA), three-dimensional (3D) printed resin (Prizma Bio Crown, Makertech Labs, Tatuí, SP, Brazil), hybrid ceramic (Vita Enamic®, VITA Zahnfabrik, Bad Säckingen, Germany), and hybrid resin (Shofu Block HC, Shofu Inc., Kyoto, Japan). Molars from four pediatric patients were treated between August 2022 and August 2023 using a minimally invasive preparation approach, computer-aided design and manufacturing (CAD/CAM), and resin cementation techniques. The results demonstrated excellent marginal adaptation, high fracture resistance, improved aesthetics, reduced dental sensitivity, enhanced chewing function, and better oral hygiene maintenance over a follow-up period of 6 to 24 months. These findings suggest that indirect restorations are a suitable treatment option for severe MIH cases, with digital technology facilitating behavioral management and ensuring durable, high-quality restorations. Further studies comparing the performance of different restorative materials and evaluating cost-effectiveness are recommended to optimize clinical outcomes and practice.

Keywords: Computer-Aided Design; Molar Hypomineralization; Onlays; Pediatric Dentistry

INTRODUCTION

Molar Incisor Hypomineralization (MIH) is a defect that compromises the quality of enamel in the first permanent molars and, in some cases, the incisors. This defect is characterized by opacities ranging from mild to severe, sometimes resulting in significant enamel loss, especially on occlusal surfaces[1]. It is prevalent in children and can impact quality of life, as affected teeth often exhibit sensitivity[2]. Sensitivity, associated with the severity of hypomineralization, correlates with increased difficulty in maintaining oral hygiene and limitations in food intake[3].

When considering the treatment of MIH in children, clinical factors such as the stage of dental development, the severity of the enamel defect, and the patient's level of cooperation become essential. The porosity associated with this defect compromises the adhesion of restorative materials, increasing susceptibility to fractures and the need for replacements[4]. Furthermore, cooperation in children may be hindered by fear and anxiety, often exacerbated by previous negative experiences[5]. Thus, different intervention options are described in the literature according to defect severity, including fissure sealants, preformed metal crowns, direct and indirect restorations, and, in more severe cases, tooth extractions[6].

Given the challenges MIH poses to treatment, particularly in severe cases, digital technologies have emerged as a viable alternative, especially in Pediatric Dentistry. With the development of the CAD/CAM (Computer-Aided Design and Computer-Aided Manufacturing) digital workflow, it is possible to create customized restorations tailored to each patient's needs[7,8]. Studies indicate that CAD/CAM indirect restorations offer greater durability, resistance, better marginal adaptation, and aesthetics. Additionally, they reduce treatment time[9]. However, this approach has limitations, including high cost, the need for specific technical skills, and additional laboratory procedures[10].

In this case series, four patients aged nine to ten years with extensive crown destruction in the first permanent molars due to severe MIH were included. Most reported difficulties with chewing and toothbrushing due to sensitivity. The evolution of restorative materials, from polymers such as polymethyl methacrylate (PMMA) to ceramics, printed resins, and hybrids, was reflected in the treatments performed. The caregivers were informed about the treatment options and opted for indirect restorations using the CAD/CAM digital workflow.

CASE REPORT

The cases were conducted as part of the Department of Dentistry, São Leopoldo Mandic College, Campinas, Brazil from August 2022 to August 2023. Under the supervision of experienced faculty, all procedures were performed by graduate students following standardized clinical protocols to ensure consistency in treatment approaches. A digital workflow was employed, from intraoral scanning to the fabrication and cementation of indirect restorations, aiming for greater precision and control in the procedures. Each case was documented through clinical and imaging examinations, allowing for a detailed analysis of treatment outcomes over time. Informed consent was obtained from all patients and their guardians, and the ethical approval for each case included in this series was obtained from the Institutional Review Board (IRB) of the respective institution.

CASE 1

A 10-year-old male patient presented with complaints of sensitivity during eating and tooth brushing. During the anamnesis, the guardian denied current medical treatment but mentioned a history of respiratory illness. The clinical examination revealed extensive loss of dental structure in the lower left first permanent molar due to severe Molar Incisor Hypomineralization (MIH) (Figure 1a). The legal guardian signed the informed consent form, authorizing both the treatment and case report, while the minor assented to the treatment.

For tooth preparation and the fabrication of an indirect restoration, anesthesia of the inferior alveolar nerve was administered using 2% lidocaine with 1:100,000 epinephrine (Aphacaine®, DFL®, Brazil). The hypomineralized enamel, which would contact the margins of the restoration, was removed using a high-speed bur (DC18090J, KG, Sorensen, Brazil) to improve adhesion of the future PMMA crown (Figures 1b, 1c). After preparation, an intraoral scan of the lower dental arch was performed with a Trios® scanner (3Shape, Denmark) (Figure 1d).

Prior to crown cementation, the tooth surface was conditioned with 37% phosphoric acid (Condac 37%, FGM®, Brazil), followed by the application of Single Bond Universal® adhesive (3M ESPE, United States) with frictional movements on the tooth surface (Figure 2e), and then light-cured for 20 seconds (Valo Cordless Grand 3200, Ultradent, United States). The crown was cemented with Dual Allcem resin cement (FGM®, Brazil) (Figure 2f). The procedure was completed in two sessions on the same day.

At the 12-month follow-up, the PMMA crown remained intact and functional (Figure 2a). The patient reported a reduction in pain during chewing and consuming cold liquids, along with improved oral hygiene. Periapical radiography showed preserved enamel, proper root development, intact periodontal ligament, and normal bone appearance (Figure 2b). At the 24-month follow-up, slight mesial wear was observed in the central groove of the crown (Figure 2c), without affecting comfort or masticatory function. The periapical radiograph confirmed dental and periodontal integrity (Figure 2d).

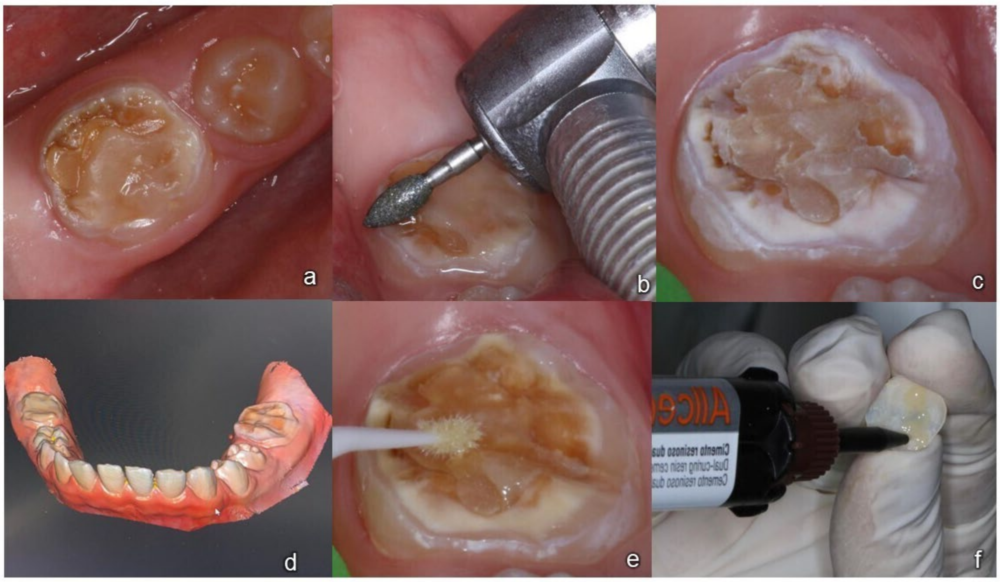

Figure 1. Clinical sequence of Case 1. (a) Initial image of the first permanent molar with extensive coronal destruction; (b) Removal of hypomineralized enamel for improved adhesion of the PMMA crown; (c) Tooth preparation showing margins on intact enamel; (d) Intraoral scanning after tooth preparation; (e) Application of adhesive to the tooth surface; (f) Insertion of resin cement into the PMMA crown

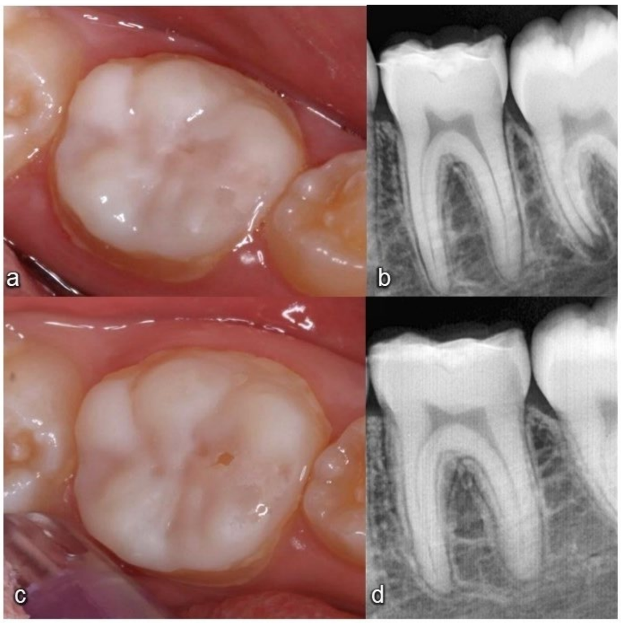

Figure 2. Clinical and radiographic follow-up of Case 1. (a) Intact and functional crown at 12 months; (b) Periapical radiograph at 12 months; (c) Crown with slight mesial wear at 24 months, without functional impact; (d) Periapical radiograph at 24 months

CASE 2

An 11-year-old male patient presented with no complaints of pain or dental sensitivity. During anamnesis, the guardian reported a history of high fever, antibiotic use, and hospitalization due to respiratory diseases in early childhood. Clinical examination revealed a loss of dental structure in the upper left first permanent molar, which had undergone endodontic treatment and was restored with composite resin. A demarcated opacity was also observed on the right upper permanent central incisor, with a diagnosis consistent with MIH. Figures 3 and 4 show the initial photographs and intraoral scanning with a Trios® scanner (3Shape, Denmark) of the upper dental arch performed at the first appointment, respectively. The legal guardian signed the informed consent form, authorizing both the treatment and case report, while the minor assented to the proposed treatment.

Figure 3. Initial photographs of Case 2. (a) Frontal view; (b) Right lateral view showing a demarcated opacity on the right upper permanent central incisor; (c) Left lateral view showing a demarcated opacity on the right upper permanent central incisor

Figure 4. Initial intraoral scan of Case 2, showing structural loss in the upper left first molar with an existing direct restoration

At the follow-up appointment, the patient arrived with fixed orthodontic braces, which did not interfere with the treatment sequence. Tooth preparation was performed using a multi-bladed bur, aiming to keep the boundaries on sound dental structure (Figure 5a). Subsequently, a new scan (Trios®, 3Shape, Denmark) and a 3D model print were performed to fabricate a 3D-printed composite resin crown (PrisZma 3D Bio Crown, Makertech Labs, India). For crown cementation, the tooth surface was conditioned with 37% phosphoric acid (Condac 37%, FGM®, Brazil) for 30 seconds, followed by the application of Single Bond Universal® adhesive (3M ESPE, United States) with friction on the surface and light-curing (Valo Cordless Grand 3200, Ultradent, United States) for 20 seconds. Finally, the crown was cemented with Dual Allcem resin cement (FGM®, Brazil).

Figure 5b illustrates the clinical outcome immediately after cementation. At the six-month follow-up, minimal wear of the crown was observed (Figure 5c), with aesthetics and masticatory function preserved. The follow-up periapical radiograph (Figure 5d) showed adequate restoration material filling, satisfactory endodontic treatment, and periodontal structures in normal condition.

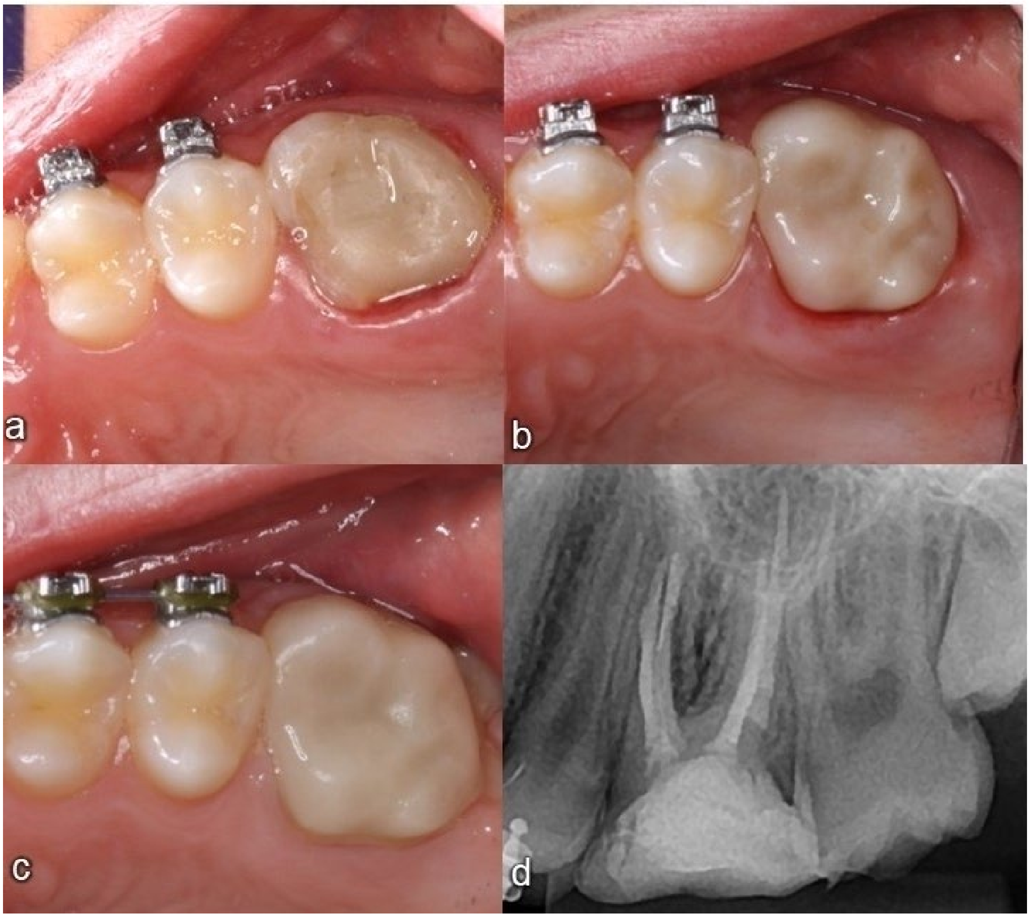

Figure 5. Clinical and radiographic follow-up of Case 2. (a) Tooth preparation on the upper first permanent molar; (b) Immediate clinical outcome after crown cementation; (c) Clinical follow-up at six months; (d) Periapical radiograph at six months

CASE 3

A 9-year-old male patient sought care due to complaints of dental sensitivity during eating and tooth brushing. During anamnesis, the guardian reported that the child was born preterm and stayed 21 days in the neonatal intensive care unit for weight gain. Dental history revealed prior treatment with applications of fluoride varnish (Duraphat®, Colgate, Brazil) without successful desensitization.

Clinical examination revealed extensive coronal destruction in the lower right first permanent molar, characteristic of MIH. The tooth had a restoration with glass ionomer cement (Riva Self Cure®, SDI, Australia), which showed structural defects (Figure 6a). The legal guardian signed the informed consent form, authorizing both the treatment and case report, while the minor assented to the treatment. Subsequently, the dental arch was scanned using a Trios® scanner (3Shape, Denmark), highlighting the extent of restorations in the lower permanent first molars (Figure 6b).

For the fabrication of an indirect restoration, anesthesia of the inferior alveolar nerve was administered with 2% lidocaine and 1:100,000 epinephrine (Aphacaine®, DFL, Brazil), followed by tooth preparation with a diamond bur (3168 FF, KG Sorensen, Brazil) (Figure 7a). The arch was rescanned with the Trios® scanner (3Shape, Denmark), and a provisional PMMA restoration was placed and fixed with calcium hydroxide cement (Hydcal, Maquira®, Brazil). In the following session, the provisional restoration was replaced with a definitive restoration in hybrid ceramic (Vita Enamic®, VITA Zahnfabrik, Germany).

For definitive cementation, the internal surface of the restoration was conditioned with silane (Prosil®, FGM, Brazil), applied with a microbrush and followed by air drying for 5 seconds. After tooth isolation, conditioning with 37% phosphoric acid (Condac 37, FGM®, Brazil) was performed for 30 seconds on enamel and 15 seconds on dentin, followed by rinsing and drying. Then, Single Bond Universal® adhesive (3M ESPE, United States) was applied with friction to the surface and light-cured for 20 seconds (Valo Cordless Grand 3200, Ultradent, United States).

For cementation of the definitive restoration, resin cement (Dual Allcem, FGM®, Brazil) was applied and light-cured. Figure 7b shows the immediate result after cementation. At the six-month follow-up (Figure 7c), the patient reported no dental sensitivity. The six-month follow-up periapical radiograph (Figure 7d) revealed slight radiolucency on the distal surface near the enamel preparation margin, without compromising the marginal adaptation of the restoration, showing adequate root development, unchanged periodontal ligament, and normal bone appearance.

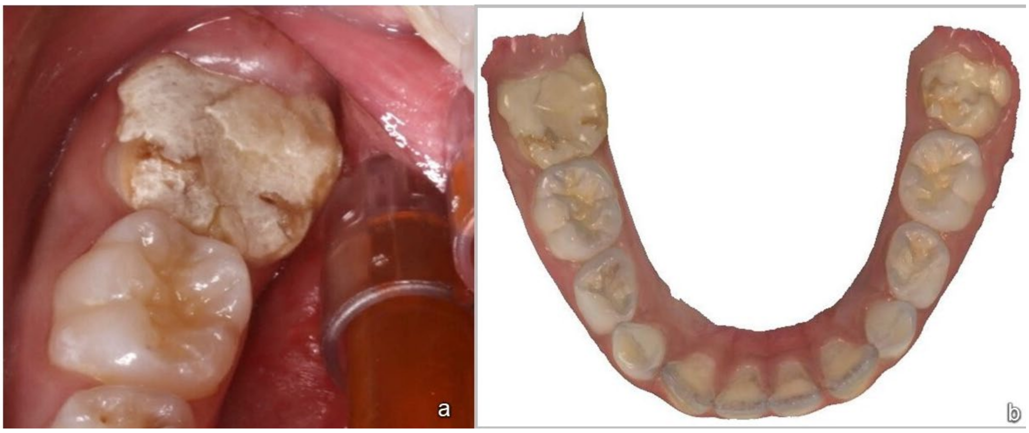

Figure 6. Initial clinical assessment of Case 3. (a) Lower right first molar with a restoration showing defects; (b) Initial scan of the lower dental arch

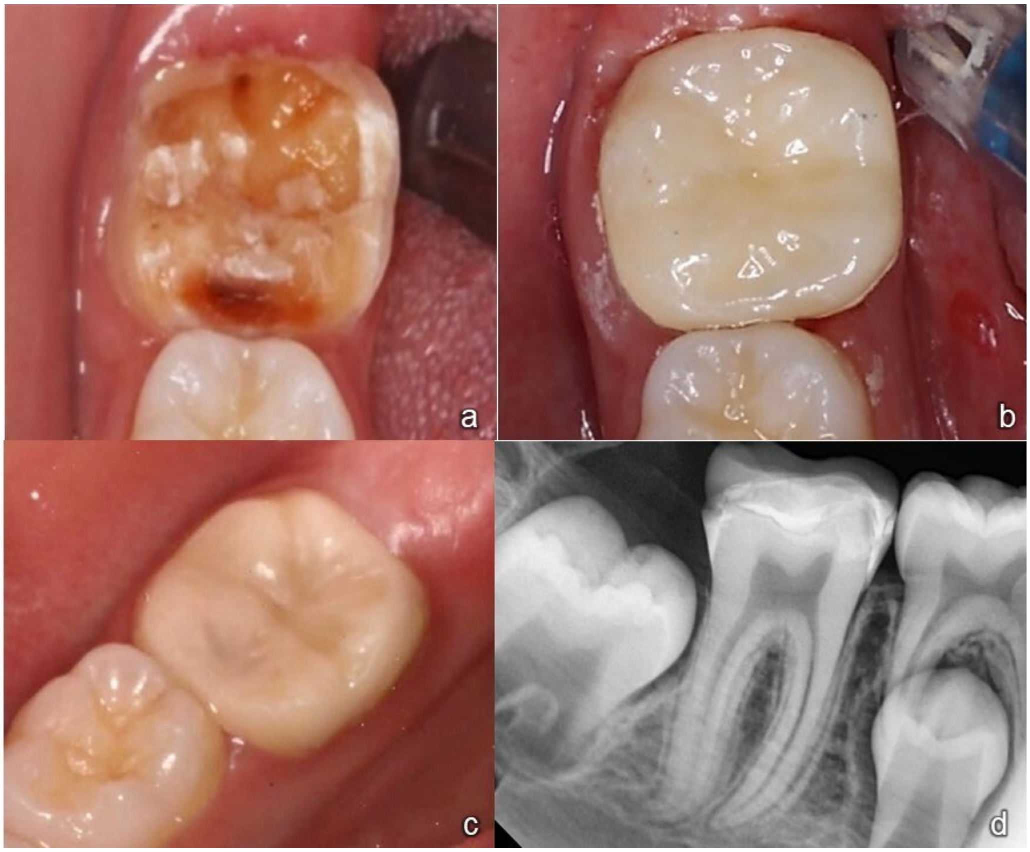

Figure 7. Clinical and radiographic follow-up of Case 3. (a) Tooth preparation for the indirect restoration; (b) Immediate outcome after cementation of the hybrid ceramic restoration; (c) Clinical follow-up at six months; (d) Control periapical radiograph at six months

CASE 4

A 10-year-old male patient sought care with complaints of dental sensitivity during eating. Clinical examination revealed yellow-brown opacities and loss of dental structure in the first permanent molars due to extensive coronal destruction caused by MIH. The procedure then began on the lower left first permanent molar (Figure 8a), which presented significant structural loss. Anesthesia of the inferior alveolar nerve was administered with 2% lidocaine hydrochloride and 1:100,000 epinephrine (Aphacaine®, DFL, Brazil), followed by tooth preparation with a 3168 FF diamond bur (KG, Sorensen, Brazil). After preparation, a digital scan was performed with a Straumann Virtuo® scanner (Straumann Group, Switzerland), and the data were sent to the laboratory for the fabrication of an indirect hybrid ceramic restoration (Shofu Block HC, Shofu®, Japan) (Figures 8b, 8c). For cementation, the tooth surface was conditioned with 37% phosphoric acid (Condac 37%, FGM®, Brazil) for 30 seconds (Figure 9a), followed by rinsing and drying (Figure 9b). Next, Single Bond Universal® adhesive (3M ESPE, United States) was applied with friction on the surface for 20 seconds (Figure 9c), followed by light curing for 20 seconds (Valo Cordless Grand 3200, Ultradent, United States). After placing the indirect restoration, excess Dual Allcem resin cement (FGM®, Brazil) was removed, followed by light curing. Figure 9d shows the restoration immediately after cementation, completed in a single session. The 15-month clinical follow-up showed preservation of the aesthetic and functional properties of the restoration, with no signs of wear, fractures, or marginal disadaptation (Figure 9e).

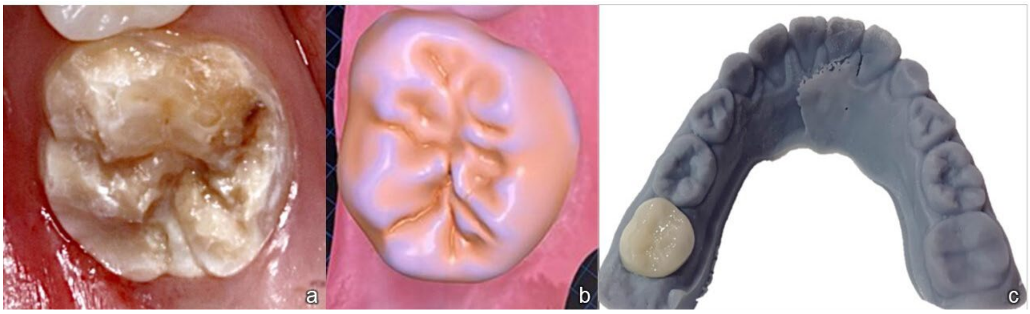

Figure 8. Treatment stages of Case 4. (a) Initial image of the lower first permanent molar with extensive coronal destruction; (b) Digital model of the occlusal surface of the tooth after preparation, viewed in scanning software; (c) 3D model with indirect hybrid ceramic restoration prior to cementation

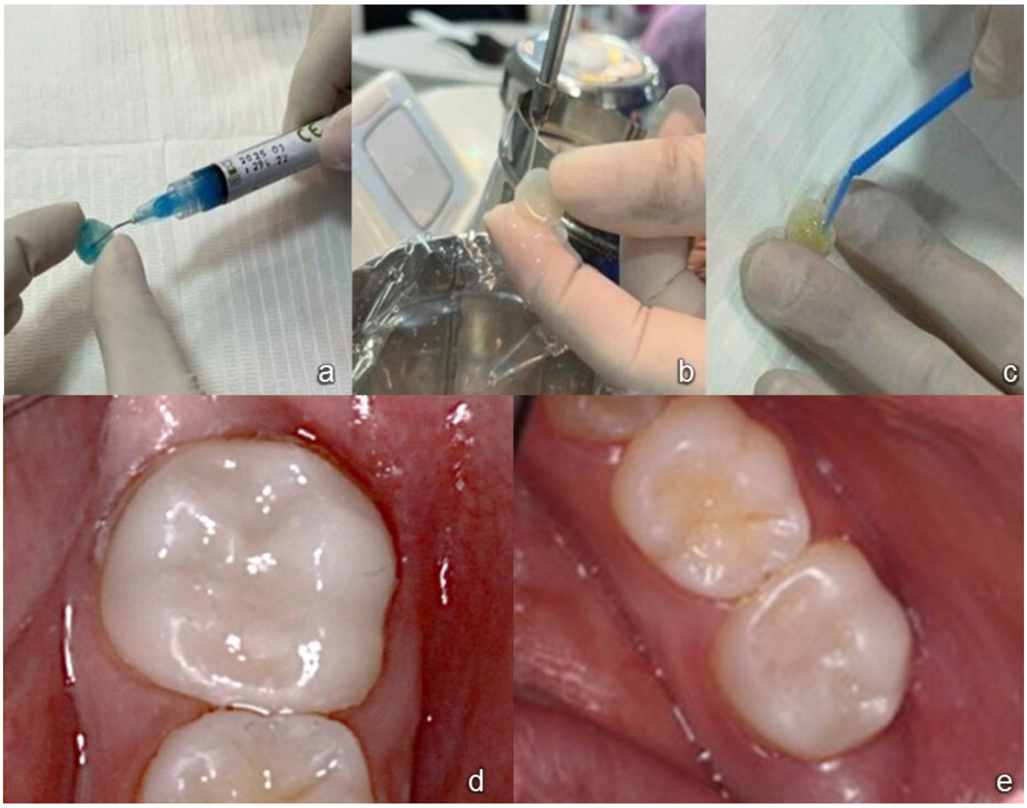

Figure 9. Stages of indirect restoration cementation and clinical follow-up. (a) Conditioning of the restoration's internal surface with 37% phosphoric acid; (b) Rinsing and drying; (c) Application of adhesive with friction; (d) Immediate outcome after cementation on the tooth; (e) Clinical follow-up at 15 months

DISCUSSION

To address the challenges in treating children with permanent first molars compromised by severe MIH, we adopted a CAD/CAM workflow and indirect restorations. This approach aimed to restore the function and aesthetics of the teeth, as well as reduce dental sensitivity. Follow-ups at six and 24 months showed a reduction in dental sensitivity in all cases, contributing to improved chewing function and oral hygiene.

The management of permanent molars affected by MIH lacks robust evidence. In more severe cases, treatment may include composite resin restorations, preformed metal crowns, indirect restorations, pulp therapy, and extractions [6,11]. Among these options, indirect restoration has emerged as an effective approach, positioned between direct restoration and full crowns[12]. While they exhibit similar clinical performance to direct restorations, they generally provide greater patient aderence due to fewer appointments[9]. Compared to full crowns, they are considered a more conservative approach, offering greater control and precision in laboratory procedures[13]. Additionally, they are recommended for cases of significant crown destruction due to their greater strength and durability, especially in areas of high occlusal load[14].

The choice of PMMA in Case 1 was based on its characteristics, such as low cost, high polishability, color stability, and good marginal fit.[15] Moreover, the choice of provisional material was necessary because the patient, who exhibited significant hypersensitivity, could not undergo orthodontic intervention prior to rehabilitation. It is important to note that the mechanical performance of the material is not ideal, being susceptible to cracking and fractures. Additionally, its vulnerability to degradation in contact with water and its low thermal conductivity may influence taste perception[16]. Satisfactory retention of the restoration was observed, with preservation of aesthetics and function over the 24-month period. However, due to the temporary nature of this material, periodic follow-up is essential, and long-term replacement of the restoration should be planned.

In Case 2, a 3D-printed resin crown was fabricated, which stood out for offering rapid and personalized adaptation, as well as providing fracture resistance, essential for endodontically treated teeth with extensive restorations. Hybrid ceramic, such as Vita Enamic, used in Case 3, was selected for its superior mechanical properties, especially due to crown destruction and the failure of the glass ionomer cement-based restorative material, aiming to provide greater durability, fracture resistance, marginal adaptation, and aesthetics[17]. Studies indicate that these materials are particularly effective in restoration of posterior teeth, where strength and structural integrity are essential[18]. In Case 4, resin-based composite materials, such as Shofu Block HC, were selected for their lower modulus of elasticity and hardness, characteristics that facilitate milling and intraoral adjustment, as well as minimizing wear on opposing teeth[19]. The follow-up of the cases demonstrated that the restorations-maintained aesthetics and function, with minimal surface degradation and no need for additional interventions.

Therapeutic decisions were based on the severity of the enamel defect, child cooperation, function, and aesthetics. This study is distinguished by its use of a digital workflow, which not only facilitated patient cooperation through shorter treatment sessions but also enabled cost-effective interventions using materials such as PMMA. The 3D-printed resin crown and hybrid ceramics were selected for their balance of mechanical strength, marginal adaptation, and aesthetics. Additionally, resin-based composite materials were chosen to minimize wear on opposing teeth and facilitate intraoral adjustments. However, the study has some limitations, including the small number of cases, which may limit the generalizability of the results. The follow-up period, ranging from six to 24 months, provided an initial observation of the durability of the restorations, without offering a view of their long-term longevity. Furthermore, the variability in materials used also hinders the comparability of the results. Since we are reporting a case series, we recommend further research with longer follow-up periods to validate the findings related to the durability of the restorations.

Studies could compare the effectiveness of different restorative materials and digital technologies. Additionally, cost-benefit analysis is essential to improve clinical practices and outcomes, especially for pediatric patients.

CONCLUSIONS

This case series demonstrated the efficiency of indirect restorations in treating severe MIH in the permanent first molars of children using CAD/CAM technology. The restorations, fabricated with materials such as PMMA, 3D-printed resin, hybrid ceramic, and resin-based composites, showed adequate marginal adaptation, fracture resistance, and aesthetics. Additionally, they effectively reduced dental sensitivity, improving chewing function and oral hygiene over the follow-up period of six to 24 months.

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Declarations

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