ORIGINAL ARTICLE

DIRECT VS. INDIRECT TECHNIQUES IN CORONAL RESTORATIONS: AN OBSERVATIONAL STUDY

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Abstract: *Background*: In recent years, direct composite resin restorations have become the preferred choice for treating posterior cavities due to their favorable mechanical strength and aesthetic properties. Indirect restorations are generally recommended for managing larger dental defects. This study aims to analyze the therapeutic options employed in coronal restoration using direct and indirect techniques in a real clinical setting, highlighting their distribution according to the types of restorative materials used. *Methods*: An observational study was conducted on a sample of 31 clinical cases involving upper and lower teeth, consecutively selected from private dental practice and a dental laboratory between January and April 2025. *Results*: A correlation analysis was performed between the chosen treatment method and lesion diagnosis. Of the 21 patients diagnosed with carious lesions, the majority received direct restorations, demonstrating that carious lesions (particularly those of moderate size) can be effectively treated with direct restorations performed in the dental office without requiring complex procedures or additional interventions. *Conclusions*: Direct techniques were preferred when a conservative intervention was desired, maximizing preservation of dental hard tissues. Indirect techniques were chosen in cases requiring superior control over the restoration's aesthetics.

Keywords: direct restoration, indirect restoration, dental composites, ceramic materials

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1. Introduction

Since their introduction into clinical practice, both resin composite materials and adhesive techniques have undergone significant improvements [1,2]. When adhesive protocols are carefully followed and direct restorations are correctly placed, they can demonstrate long-term clinical success lasting several decades [3].

Despite these advancements, resin composite restorations remain prone to failures, most commonly due to secondary carious lesions and fractures [4]. The likelihood of failure tends to increase in older patients, in those wearing removable prostheses [5], and in restorations involving molars, endodontically treated teeth, or multiple surfaces [6].

In addition, direct restorations placed by less experienced clinicians or those working in large dental group practices are more susceptible to failure [5]. Gender does not appear to play a significant role in the success of direct restorations [3,5]. The specific type of resin composite material also does not seem to influence the long-term success of direct restorations [6]. However, "sandwich" restorations (combining resin composites with glass ionomer cements) have been associated with marginal defects due to the dissolution of the glass ionomer component [7].

The development of secondary carious lesions is generally attributed to polymerization shrinkage and stress at the tooth-material interface. Fractures are often related to the mechanical limitations of the materials and tooth or patient-specific factors, particularly in larger restorations involving cusp reconstruction [8].

Another important consideration is the effectiveness of polymerization in direct resin composite restorations, which can be compromised by inadequate maintenance of light-curing units and technique-sensitive variables during placement [9].

Indirect resin composite restorations help address several limitations associated with the direct technique and are theoretically expected to offer increased longevity. These restorations can be fabricated using prefabricated resin composite blocks through computer-aided design and manufacturing (CAD/CAM) technology or with laboratory-processed restorative composites fabricated by a dental technician. These materials benefit from prolonged polymerization under controlled conditions and from multiple directions, resulting in a higher degree of monomer conversion and, consequently, improved mechanical properties [10].

Additionally, some resin composites used for indirect restorations can undergo heat treatment, which further increases their degree of conversion and helps improve mechanical properties such as microhardness [11]. The superior monomer conversion achieved in indirect restorations contributes to better biocompatibility, as the release of monomers is significantly lower compared to direct resin composites. This is largely due to the fact that potential monomer elution is limited to the thin layer of resin cement used to bond the restoration to the tooth [12,13]. Another advantage of indirect restorations is the ability to achieve more precise and stable occlusion. This is facilitated by the dental technician’s capacity to accurately reproduce the missing tooth anatomy on gypsum models and to

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verify occlusal guidance using an articulator [14,15].

However, the indirect technique comes with some notable disadvantages. These include higher costs, the need for multiple dental visits-although this can be reduced with CAD/CAM workflows [14,15] as well as the removal of a greater amount of tooth structure during preparation compared to direct restorations [16,17].

Regardless of the material used, the main reasons for failure in indirect restorations are similar to those seen in direct ones, primarily involving fractures and secondary carious lesions. Fractures are more frequently associated with ceramic materials, while carious lesions are more commonly linked to cemented metal-based restorations [18].

In terms of performance, indirect gold restorations have demonstrated superior outcomes compared to indirect resin composite restorations over the medium and long term. Meanwhile, lithium disilicate and leucite-based indirect restorations have shown comparable survival rates to indirect resin composites over the short and medium term [19].

Interestingly, the clinical success of gold restorations does not appear to be influenced by tooth- or patient-related factors such as tooth type, restoration design, margin placement, pulp capping, use of liners, the presence of craniomandibular disorders, patient age, gender, or compliance with maintenance care [20]. Similarly, no consistent associations have been reported between the longevity of indirect resin composite restorations and specific tooth- or patient-related variables [19,21,22].

Furthermore, the method of fabrication and cementation whether using CAD/CAM, pressable, or layered techniques, or applying selective enamel etching before using self-adhesive resin cements does not seem to have a significant impact on the longevity of indirect restorations, including resin composites used in these treatments [23-25].

The novelty of this study lies in its comparative, clinically applied approach to real-world therapeutic choices made in coronal restorations, without experimental interventions or controlled laboratory conditions. The study provides relevant data on the frequency of use of direct and indirect techniques in a current clinical setting, including details related to the restorative materials preferred based on clinical indications.

Additionally, it may contribute to understanding current trends in coronal rehabilitation and to shaping a perspective grounded in direct clinical observation.

The aim of this study is to analyze the therapeutic options adopted in coronal restoration using direct and indirect techniques in a real clinical environment, and to highlight their distribution according to the types of restorative materials used.

2. Materials and method

This observational study was conducted on a sample of 31 clinical cases involving restorations of both upper and lower teeth, consecutively selected from a private dental practice and a dental laboratory between January and April 2025. The study aimed to analyze the use of direct and indirect techniques in partial coronal restorations and to assess the complexity of the clinical cases.

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All patients provided informed consent to participate in the study.

Inclusion criteria:

- Vital teeth diagnosed with simple carious lesions, dental fractures, or discoloration;
- Upper and lower, anterior and posterior teeth;
- Teeth restored using either direct or indirect techniques;
- Good patient cooperation and signed informed consent.

Exclusion criteria:

- Non-vital teeth;
- History of failed prior endodontic treatment;
- Patients with severe systemic conditions;
- Teeth that could not be effectively isolated with a rubber dam system.

For each case, the following parameters were evaluated:

- Patient gender and age;
- Reason for presentation and lesion diagnosis;
- Type of restorative technique used (direct or indirect);
- Restorative material applied.

All clinical procedures were performed by the same clinician, and all inlays/onlays or veneers were fabricated by the same dental technician, in order to minimize technical variability.

Statistical Analysis

For the 31 patients included in the study, a descriptive statistical analysis was conducted using Microsoft Excel, a spreadsheet software developed and distributed by Microsoft Corporation, headquartered in Redmond, Washington, United States. The analysis included pie charts, bar graphs, and line graphs to clearly visualize the distribution of patients based on various clinical criteria, such as the diagnosis of the dental lesion and the chosen treatment method (direct or indirect technique).

3. Results

A total of 31 patients were included in the present study, selected based on clinical criteria relevant to the evaluation of the type of dental lesion and the treatment method applied. Of the total participants, 18 were female, representing 58% of the analyzed sample. The remaining 13 patients, accounting for 42%, were male (Figure 1).

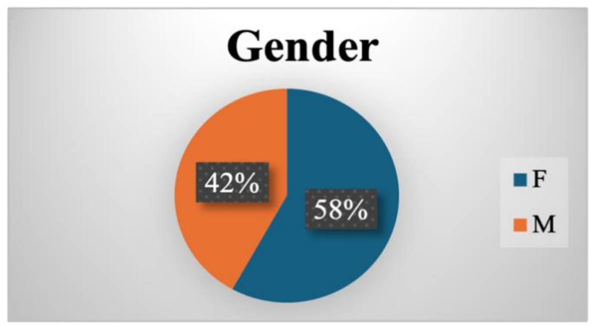

Figure 1. Patient distribution by gender.

The age of the patients included in the study ranged from 24 to 54 years, representing a socially and professionally active population in the adult stage of life. This age group is clinically relevant, as the incidence of dental conditions such as carious lesions, coronal fractures, and tooth discoloration is higher during this period (Figure 2).

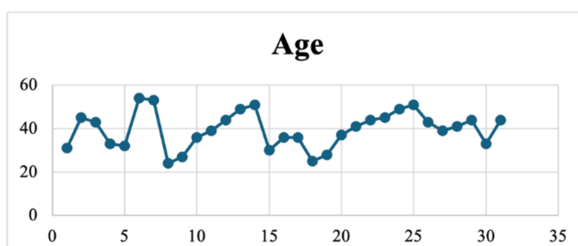

Figure 2. Distribution of patients by age.

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The age distribution between 24 and 54 years allowed for the application of a wide range of treatment methods, both direct and indirect, depending on the extent of dental damage and the individual aesthetic or functional needs of each patient. Moreover, since the study included young and middle-aged adults, the selection of restorative techniques also took into account patients' expectations regarding aesthetics, durability, and treatment time.

In addition to aesthetic concerns, some patients reported sensitivity to sweet foods, a common symptom associated with simple carious lesions, indicating enamel compromise and dentin exposure. Cases of sensitivity during toothbrushing and difficulties in mastication were also reported, generally caused by significant loss of tooth structure (Figure 3).

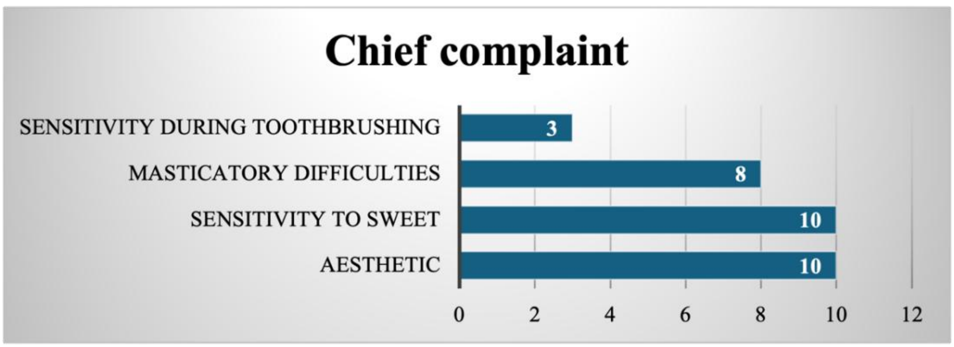

Figure 3. Medical reason for the clinic visit.

Regarding diagnosis, of the total 31 patients included in the study, the majority-21 patients (approximately 68%) were diagnosed with carious lesions, representing the primary dental issue investigated. A smaller number, 5 patients (approximately 16%), presented with dental fractures, which, although less frequent in this sample, often require complex interventions due to structural damage. Additionally, 5 patients (approximately 16%) were diagnosed with dental discolorations, aesthetic conditions that can significantly affect the smile's appearance and necessitated specific treatments (Figure 4).

Regarding the treatment method chosen for the 31 patients included in the study, an indirect technique was selected for 18 patients (approximately 58%), while a direct technique was applied in 13 patients (approximately 42%) (Figure 5).

In the case of the direct restoration technique, the majority of patients were treated with composite fillings. This method was selected for 10 patients, representing approximately 77% of the 13 patients who received direct restorations. Composite fillings are preferred due to their superior aesthetic properties, good adhesion to tooth structure, and long-term durability, making them especially suitable for both aesthetic and functional restorations of anterior and posterior teeth (Figure 6).

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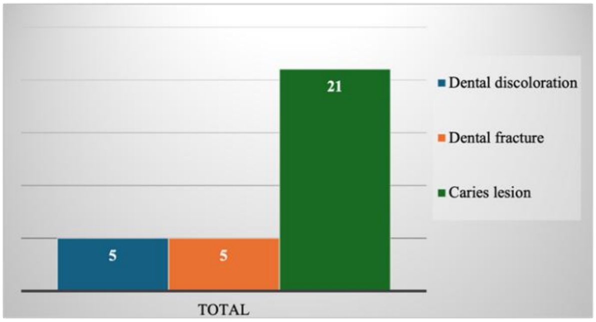

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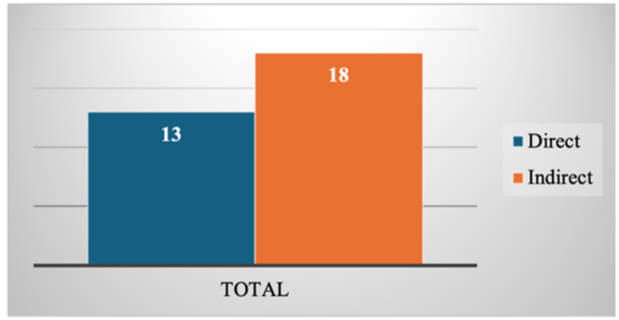

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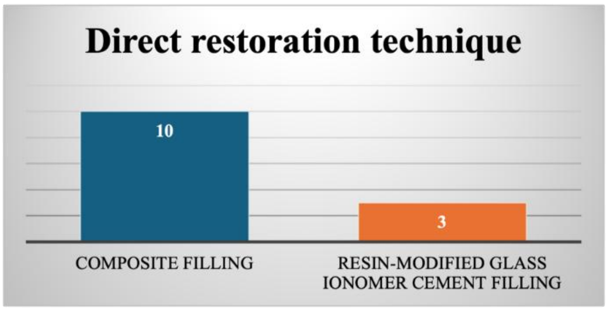

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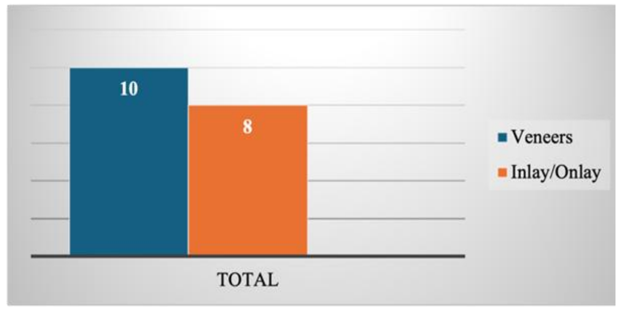

(Figure 7)

Figure 4. Distribution of patients by diagnosis. **Figure 5.** Distribution by chosen technique. **Figure 6.** Distribution for the direct restoration technique. **Figure 7.** Distribution for the indirect restoration technique.

In the case of indirect restoration techniques, applied to 18 patients, the majority received more complex aesthetic and functional restorations. Thus, 10 patients (approximately 56%) were treated with dental veneers, a method that provides significant aesthetic improvements (Figure 7).

Of the 10 patients who received dental veneers as part of the indirect technique, the majority were treated with ceramic veneers, which were used in 8 patients (80%). In contrast, only 2 patients (20%) received composite veneers, which, although a faster and less expensive option, have lower durability and mechanical strength compared to ceramic veneers (Figure 8). Composite veneers are preferred in cases where a minimally invasive treatment approach is desired.

Regarding inlays/onlays, out of a total of 8 patients who received this type of restoration within the indirect technique group, the majority-5 patients (62.5%) were treated with ceramic inlays/onlays. On the other hand, 3 patients (37.5%) received composite material inlays/onlays, a solution that offers advantages in terms of reduced fabrication time and lower costs, being indicated in cases with moderate lesions where a functional and aesthetically acceptable restoration is desired for the medium term (Figure 9).

An analysis of the correlation between the chosen treatment method and the lesion diagnosis was also performed for the 31 patients included in the study. Among the 21 patients diagnosed with carious lesions, the majority (13 patients) underwent direct restoration techniques, reflecting the fact that carious lesions, especially those of moderate

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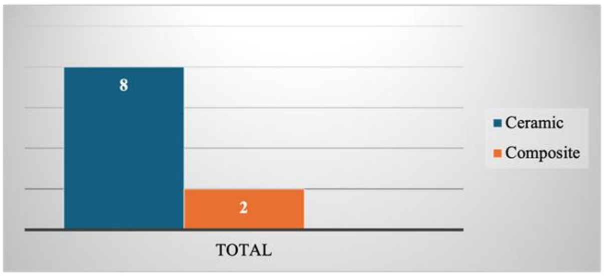
size, can be effectively treated with direct fillings performed in the dental office without requiring complex procedures or additional interventions (Figure 10). On the other hand, 8 patients in this group were treated using indirect techniques, indicating the need for more durable or aesthetic restorations in cases of extensive lesions or clinical situations where direct restorations did not provide an optimal long-term solution (Figure 10).



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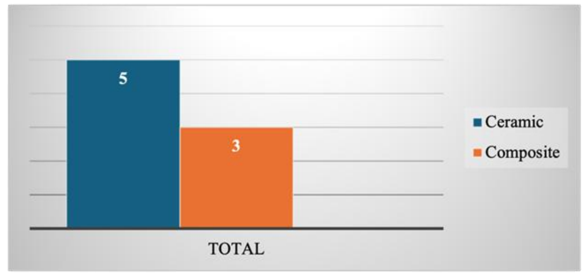

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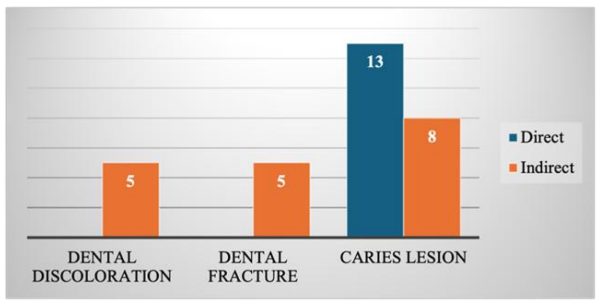

(Figure 10)

Figure 8. Distribution of veneers according to the material used. **Figure 9.** Distribution of inlays/onlays according to the material used. **Figure 10.** Correlation between the chosen treatment method and diagnosis.

The therapeutic approach for patients requiring dental veneers was developed with the main objective of restoring dental aesthetics and functionality through careful planning and minimally invasive clinical execution, tailored to the specific characteristics of each case. An example of this approach, in clinically healthy patients without significant medical history, known allergies, or previous major dental treatments in the anterior region, involves identifying a clear aesthetic motivation and establishing a durable, minimally invasive therapeutic solution aimed at improving the appearance of the smile by achieving a balanced, bright, and harmonious result. An example of clinical examination revealed that teeth 1.3-2.3 were vital and free of carious lesions; however, there was an unbalanced width-to-height ratio of the dental crowns, uneven enamel coloration, and an unaesthetic shape of the maxillary central and lateral incisors, with uneven dimensions (Figure 11).

Paraclinical examination included intraoral and extraoral photography for aesthetic analysis, digital scanning of the upper and lower arches, and the creation of a digital treatment plan using Digital Smile Design software. The diagnosis was dental discoloration accompanied by an incorrect proportion between the size and shape of the crowns.

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(Figure 11)

(Figure 12)

(Figure 13)

(Figure 14)

Figure 11. The initial appearance of the teeth. **Figure 12.** Representation of the 3D model. **Figure 13.** Representation of the ceramic veneers after glazing. **Figure 14.** Ceramic veneers applied on the printed model.

The therapeutic objective was to correct the esthetics of the shape, size, and color of the anterior teeth, achieve a natural, proportionate, and facially harmonious smile, conserve dental tissue through minimally invasive preparation, and use biocompatible, durable, and translucent materials. Ceramic veneers (E.max Press) were indicated due to maximal preservation of enamel, excellent mechanical resistance in the anterior region, superior aesthetics with translucency similar to natural enamel, and precise adaptation enabled by CAD/CAM technology and digitally controlled milling. Unlike traditional crowns, veneers cover only the facial surface of the tooth, preserving vitality and natural dental proportions.

The restorative treatment began with consultation and digital planning, including professional intraoral and extraoral photography, evaluation of facial parameters such as the smile line, symmetry, and proportions, and the creation of a digital mock-up and smile simulation (DSD). This was followed by a discussion with the patient to establish aesthetic expectations and approve the treatment plan. The digital mock-up was physically transferred into the oral cavity using a temporary composite material, verified both functionally and aesthetically, serving as a guide for subsequent conservative tooth preparation.

Tooth preparation involved limited enamel reduction (0.3-0.7 mm) without dentin exposure. Rounded contours were created to facilitate ceramic adaptation, monitored using reduction guides. Impressions were taken with precision using a double-mix, double-phase addition silicone technique, with careful isolation and recording of occlusion and

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antagonist arch. Shade selection was done according to the Vita guide. If necessary, provisional restorations were fabricated from flowable composites to maintain aesthetics until delivery of the final restoration.

In the dental laboratory, the restoration was modeled by 3D printing models based on scans or impressions (Figure 12), digitally designing veneers via CAD, followed by wax milling and pressing of E.max ceramic in the exact anatomical form according to the "press" technology. Finishing and glazing included sintering and glazing cycles (Figure 13), along with individualized staining to replicate the natural enamel effect.

The veneers were fitted on the printed model to verify proximal and occlusal contacts and marginal adaptation (Figure 14), then prepared for delivery to the clinic.

Definitive cementation began with a trial fit of each veneer in the oral cavity, verifying adaptation, shade, and aesthetics, obtaining the patient's approval before cementation. Restorations were prepared by sandblasting the internal surface with fine aluminum oxide, applying silane and allowing it to react according to the manufacturer's protocol. Tooth surfaces were prepared by selective etching of enamel with 37% phosphoric acid for 15 seconds, followed by application of a light-cured adhesive bonding agent. Cementation was performed using dual-cure resin cement applied on both veneer and tooth, with gradual light curing, removal of excess cement, and margin finishing.

Final adjustments included checking occlusal contacts in maximum intercuspation, lateral and protrusive movements, with occlusal refinements as needed. Margins were polished using fine abrasive systems and polishing brushes. Oral hygiene and maintenance instructions were provided to the patient. Postoperative follow-up involved an initial evaluation at 7 days and a subsequent check-up at 6 months to assess adaptation and maintain aesthetic integration.

The restorative treatment with ceramic veneers provided the patients with a natural and stable aesthetic result through a minimally invasive procedure. The choice of pressed ceramic allowed achieving high standards of translucency, gingival integration, and mechanical resistance, contributing significantly to clinical success and patient satisfaction.

The therapeutic approach for patients requiring onlay restorations was developed with the aim of preserving as much healthy dental structure as possible while restoring function, morphology, and aesthetics. Treatment planning was individualized based on the extent of hard tissue loss, occlusal requirements, and material selection to ensure long-term durability. Modern adhesive techniques were employed to achieve precise marginal adaptation and optimal integration within the existing dentition.

An example of clinical assessment and treatment planning in such cases involved patients presenting with occasional discomfort during mastication in the posterior mandibular region, typically caused by extensive coronal destruction or defective restorations. These patients reported no significant systemic conditions and had not undergone prior endodontic or prosthetic treatments in the affected area. Clinical examination revealed visible cavities or loss of dental structure in posterior teeth, often

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accompanied by mild pressure sensitivity during chewing, but without spontaneous or nocturnal pain. The main therapeutic objective was to restore masticatory function and aesthetics through a durable and conservative treatment option using onlay restorations. Clinical and radiographic examination revealed an extensive mesio-occluso-distal carious lesion involving a large portion of the occlusal surface of tooth 3.6, without communication with the pulp chamber. Vitality tests showed a positive response, and the periapical radiograph demonstrated no signs of periapical pathology. The final diagnosis was a mesio-occluso-distal carious lesion with partial loss of support of the buccal cusps, in a vital tooth.

The therapeutic objective was to achieve a durable, functional, and minimally invasive restoration that would protect the weakened cusps, preserve sound dental tissue, and restore anatomical integrity, aesthetics, and a stable occlusal relationship.

An indirect onlay restoration was selected as the treatment option. This prosthetic technique involves the fabrication of a restoration covering one or more cusps of the tooth without completely encasing the crown. The onlay represents an intermediate solution between an inlay (which does not cover the cusps) and a full crown (which covers the entire coronal surface), thus allowing a conservative yet effective approach.

The main advantages of an onlay include conservation of remaining tooth structure, restoration of masticatory function, precise marginal adaptation, superior aesthetics especially when using ceramic materials and protection of fragile cusps against fracture.

In this case, pressed ceramic (E.max Press) was chosen for its high mechanical strength and excellent esthetic properties.

Under local anesthesia and rubber dam isolation, all decayed dentin and fractured enamel margins were removed. The cavity was prepared according to the principles of indirect restorations, ensuring optimal adaptation of the future restoration. The parapulpal wall was preserved to maintain as much sound tooth structure as possible. After verifying the mechanical retention and stability of the margins, an impression was taken using an addition silicone material in two viscosities, accurately recording the cavity and adjacent teeth. An opposing arch impression and bite registration were also obtained.

A temporary restoration made of light-cured provisional composite material was placed to protect the cavity during the laboratory phase.

In the dental laboratory, a high-precision working model was poured using type IV dental gypsum and articulated with the opposing model. The dental technician analyzed the preparation and designed an onlay covering the affected cusps (Figure 15).

An anatomic wax-up was created to reproduce the original occlusal morphology while maintaining correct proximal and occlusal contacts. The restoration was then fabricated by the pressed ceramic technique (E.max Press), achieving an excellent fit on the working model (Figure 16). The onlay was subsequently glazed, its occlusal and marginal adaptation verified, and prepared for cementation.

During the clinical tryin, marginal adaptation, stability, color, and proximal

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contacts were checked. The internal surface of the restoration was sandblasted with fine aluminum oxide, silanized, and conditioned for bonding (Figure 17). The cavity was treated using selective enamel etching and a light-cured adhesive system.

(Figure 15)

(Figure 16)

(Figure 17)

Figure 15. Onlay restoration. **Figure 16.** Onlay adapted on the working model. **Figure 17.** Onlay adapted on the working model after sandblasting and silanization.

Cementation was performed using a dual-cure resin cement, applied both to the internal surface of the onlay and to the prepared cavity. The restoration was seated and maintained in position until complete polymerization was achieved.

After removing the excess cement, occlusal contacts were verified in maximum intercuspation, lateral and protrusive movements. Minor adjustments were performed, followed by final polishing of the restoration margins.

At the 7-day follow-up, the restoration showed excellent functional and esthetic integration. A routine control was scheduled at 6 months to evaluate the long-term stability of the restoration and the periodontal condition of the surrounding tissues.

The indirect ceramic onlay restoration on tooth 3.6 successfully restored the original morphology and function while preserving healthy dental tissue. The technique provided protection for the weakened cusps, precise marginal adaptation, and enhanced mechanical resistance in a highly loaded occlusal area, ensuring long-term clinical success.

Another therapeutic approach for onlay restorations focused on the management of posterior teeth affected by extensive structural loss but maintaining pulpal vitality. In these cases, the clinical objective was not only the replacement of lost tissue but also the reinforcement of the remaining tooth structure through a conservative and biomechanically sound design.

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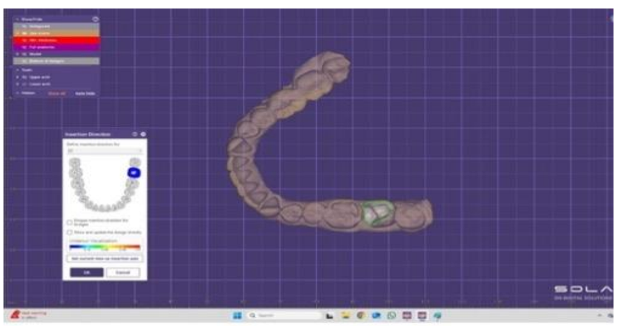
Patients typically presented with occasional masticatory discomfort in the posterior mandibular area, where clinical and radiographic examinations revealed occluso-mesial carious lesions involving cusp damage without pulpal communication or periapical pathology. Vitality tests confirmed positive responses, indicating a favorable prognosis for indirect adhesive rehabilitation.

The treatment strategy emphasized cusp coverage and structural reinforcement to restore occlusal integrity and prevent fracture risk. Pressed ceramic onlays (E.max Press) were selected for their optimal balance between mechanical strength, marginal precision, and aesthetic integration, offering a predictable long-term outcome and high patient satisfaction. The treatment followed the standard protocol for indirect restorations. After complete removal of carious tissue and verification of the cavity configuration, an impression was taken. A digital mock-up was designed, transferred, and tested intraorally to evaluate the esthetics and functionality of the proposed restoration (Figure 18).

This stage allowed a realistic three-dimensional visualization of the final outcome, providing both the clinician and the patient the opportunity to assess the restoration's adaptation in the clinical context (Figure 19). The position, shape, and volume of the planned onlay, as well as its integration into the existing occlusion, were carefully evaluated (Figure 20).



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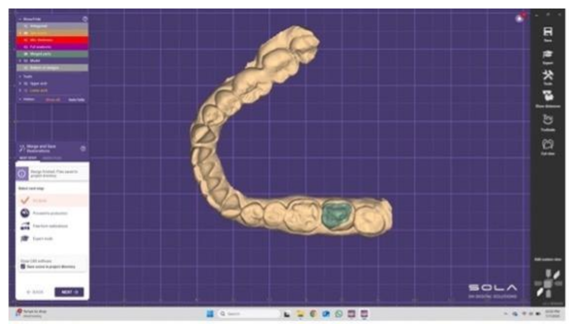

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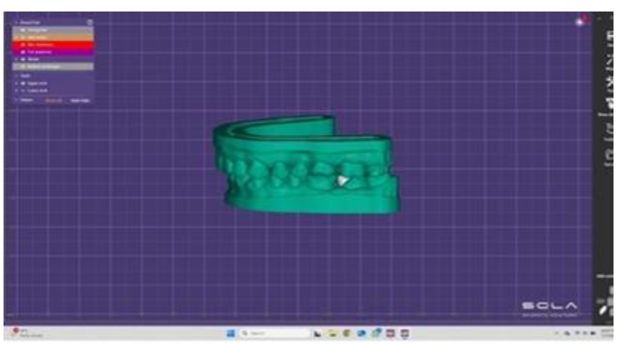

(Figure 20)

(Figure 21)

Figure 18. Digital mock-up representation. **Figure 19.** Three-dimensional view of the onlay. **Figure 20.** Viewing the integrated onlay in occlusion **Figure 21.** Ceramic veneers applied on the printed model.

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To protect the prepared cavity during the laboratory phase, a provisional restoration made of light-cured temporary composite was applied. It was shaped to ensure proper functional adaptation and an acceptable esthetic appearance, maintaining patient comfort and protecting the dental structure until final cementation.

After fabrication by the dental technician, the onlay was clinically tested to verify marginal adaptation, stability, shade match, and interproximal contacts. The internal surface of the onlay was treated by fine aluminum oxide sandblasting, followed by silanization to enhance adhesion with the resin cement. The tooth cavity was conditioned using selective etching and a light-cured adhesive. Cementation was performed with a dual-cure resin cement, applied both to the cavity and to the restoration. The onlay was precisely positioned and maintained in place until complete polymerization was achieved.

After removal of the excess cement, occlusal contacts were checked in maximum intercuspation, as well as in lateral and protrusive movements. Minor adjustments were made, followed by final polishing of the restoration margins to ensure a smooth transition between the restorative material and the natural tooth, optimizing both comfort and periodontal health.

At the 7-day postoperative control, functional and esthetic integration of the onlay was confirmed (Figure 21).

The patients were scheduled for periodic 6-month follow-up evaluations to assess the longevity of the restorations and monitor the periodontal health of the treated areas.

At follow-up examinations, the indirect ceramic onlay restorations demonstrated excellent functional integration and aesthetic harmony with the surrounding dentition. The restorations maintained stable occlusal relationships, ensured proper load distribution in the posterior region, and exhibited favorable periodontal responses. This therapeutic approach confirmed the reliability of adhesive ceramic onlays as a long-term solution for functional rehabilitation and aesthetic enhancement of posterior teeth.

4. Discussion

Contemporary dental medicine continues to advance in accordance with patients' growing expectations for high-quality aesthetic outcomes. Although materials such as amalgam and gold have a long history of clinical reliability, they are often rejected by patients due to their metallic appearance. Today, even restorations placed on posterior teeth are expected to closely mimic the natural appearance of enamel [26].

Minimally invasive restorative dentistry offers a wide range of techniques and materials for the conservative treatment of posterior teeth. Among these, resin composites-used either directly or indirectly-are widely accepted as effective aesthetic alternatives to metallic restorations [27].

Composite resins are composed of an organic polymer matrix combined with various types of inorganic filler particles. The clinical performance of composite resins is influenced by filler content, particle size, and the strength of the filler-matrix bond. In general, a higher filler load increases the mechanical strength of the restoration [27].

Dental composites have evolved significantly, progressing from traditional macrofilled and microfilled types to hybrid, microhybrid, and nanofilled composites. The

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latest generations feature smaller filler particles and higher total filler content, resulting in improved mechanical properties [28,29].

These fine particles reduce polymerization shrinkage and contribute to better color stability, flexural strength, and tensile strength. Various polymerization techniques are used to convert monomers into polymers, and a controlled degree of polymerization can further enhance properties such as strength, fracture resistance, and color stability [28,29].

Direct restorations involve placing light-cured resin composite directly into the prepared cavity. Their main advantage lies in the preservation of tooth structure, in accordance with the principles of minimally invasive dentistry. Typically, they can be completed in a single visit and are relatively inexpensive. However, they are prone to polymerization shrinkage and tend to have lower long-term durability [30].

In recent years, the use of glass ionomer cements has declined due to their limited durability in the oral cavity. They have been mainly recommended for restoring deciduous teeth or as intermediate restorative materials [31]. Nevertheless, glass ionomer-based materials have evolved significantly thanks to ongoing research and technological improvements. Resin-modified glass ionomer cements have been developed, combining the advantages of traditional ionomers with the properties of composites, providing greater mechanical strength, better stability in the oral environment, and superior esthetics [32].

In the current research, the analysis of direct restoration techniques showed that the majority of patients treated with this approach received composite fillings, with 10 out of 13 patients (approximately 77%) benefiting from this method. This preference reflects the advantages of composite materials, including superior aesthetics, strong adhesion to tooth structure, and long-term durability, making them suitable for both anterior and posterior restorations.

These materials have gained renewed interest and are increasingly used for Class I, II, and V restorations (according to Black's classification) in adult patients. Resin-modified glass ionomers offer chemical adhesion to tooth structure and long-term fluoride release, contributing to secondary caries prevention and favorable clinical performance in areas subject to moderate stress [33].

Additionally, because of their versatility and tolerance to moisture, these materials represent an attractive option for provisional or even definitive restorations, especially in cases where moisture control is difficult to achieve [33]. Amalgam has traditionally been used for posterior restorations due to its good marginal adaptation. However, its main advantage has always been the simplicity of application, which makes it a practical choice in many clinical situations [34].

In contrast, indirect restorations are fabricated outside the oral cavity using an impression of the prepared tooth. This technique minimizes shrinkage and allows for improved physical and mechanical performance through additional polymerization processes. Indirect restorations provide better occlusal anatomy, enhanced proximal contacts, and greater compatibility with antagonists. Despite these advantages, indirect techniques require more time, higher costs, and multiple appointments,

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which may not be suitable for all patients depending on their preferences or financial limitations [35].

Indirect restorations are generally recommended for larger dental defects. Before placement, the dentist must take an impression of the prepared tooth, which is then used to fabricate the restoration in a dental laboratory, requiring at least one additional visit for cementation. Alternatively, a digital 3D scan-either of a model or directly from the patient's mouth can be used to design the restoration virtually. The digital file is then sent to a milling device or a 3D printer to produce the final restoration [36].

Common materials used for indirect restorations include cast alloys, resin-based composites, and ceramics. Indirect restorations offer advantages such as increased wear resistance and mechanical strength. While softer metals like gold can adapt to oral conditions due to their malleability, ceramics are rigid and do not offer such flexibility [37,38].

Although several studies have shown that both direct and indirect restorations can achieve similar clinical outcomes, it remains important to determine which method should be considered the preferred first-line option for restoring lost tooth structure [37,38].

Direct restorations have demonstrated higher success rates in teeth with minimal to moderate structural loss compared to those with more extensive lesions. They are a viable option for vital posterior teeth with at least two remaining intact coronal walls. However, when the remaining tooth structure is significantly compromised, indirect restorations are generally preferred [30,34].

Indirect restorations have been shown to be more effective in patients diagnosed with amelogenesis imperfecta, as the altered enamel quality in these cases does not support strong adhesion to resin composites. Excluding cases with significant tissue loss or enamel defects, both direct and indirect restorations have demonstrated similar medium-term survival rates in posterior teeth. Moreover, for teeth with minimal to moderate structural loss, there is no significant difference in clinical performance between the two approaches [31].

In the present study, the treatment method applied to the 31 patients showed a predominance of indirect techniques, chosen in 58% of cases compared to 42% for direct techniques, thus reflecting a clinical tendency to prefer solutions with greater durability and superior aesthetics.

Veneers are custom-made restorative solutions fabricated from ceramic, porcelain, or resin composite, designed to cover the front surface of the teeth to improve their appearance. They are tailored to match the natural color and shape of the teeth and are used to mask imperfections such as discoloration, surface defects, or diastemas [39].

In the current study, regarding indirect restoration techniques applied to 18 patients, most cases involved more complex solutions aimed at achieving both aesthetic and functional improvements. Dental veneers were the most frequently chosen option, applied in 10 cases (approximately 56%), highlighting the importance of aesthetics in treatment planning for indirect restorations.

Different preparation methods exist depending on the type of veneer and the

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condition of the tooth. Traditional preparation involves removing a small amount of enamel from the front surface of the tooth, taking an impression, and sending it to a dental laboratory where the veneer is fabricated to match adjacent teeth. The veneer is then bonded to the tooth using resin cement [40].

For minor aesthetic concerns, such as small gaps, minimal or no-prep veneer techniques may be used. These approaches require little or no enamel removal, with the tooth surface being slightly roughened by acid etching to enhance adhesion [41].

Technological advances now allow digital scanning of the tooth and computer-aided design (CAD) of the veneer, ensuring a more precise fit. The veneer is then fabricated using a milling unit or 3D printer. Once produced, the veneer is bonded to the tooth using cementation techniques. Traditional cementation employs resin cements, while newer self-adhesive resin cements enable bonding without the need for separate enamel etching [42].

Composite veneers are frequently chosen because they offer a conservative and minimally invasive approach for treating discolorations, restoring fractures, and improving unattractive tooth shapes. However, they are prone to issues such as marginal fractures and staining, which can reduce their aesthetic appeal over time [43].

Recent advances in adhesive systems and the physical characteristics of resin composites have significantly improved the success and longevity of these restorations. Ceramic veneers are also widely used due to their durability and highly aesthetic outcomes. Nevertheless, they share some limitations with composites, including brittleness, potential postoperative sensitivity, marginal defects, and fracture risk [44,45].

Although ceramics are often preferred for their superior fracture resistance and long-term color stability, research has shown that composite veneers can also achieve excellent aesthetic and functional results [46]. Ceramic materials have long been the predominant choice for veneers, reflected by the broader body of research available on ceramic veneers compared to composite resin veneers. Numerous studies suggest that ceramic veneers provide better clinical outcomes than indirect composite laminate veneers [47,48].

Despite this, composite veneers have gained significant recognition for their ability to meet increasing aesthetic demands while offering the advantage of minimally invasive or even no-preparation treatment options for patients [43]. Bonding to enamel has been associated with reduced marginal discoloration and lower fracture rates [8]. Moreover, the more natural tooth structure is preserved, the less the tooth flexes, which may explain the low failure rates [44].

However, despite advances in materials and techniques, studies suggest that early veneer failures may be linked to other clinical factors. These early failures can result from inadequate treatment planning, technical errors during the procedure, or patient-related factors. These findings highlight that the success of a clinical treatment depends not only on materials and techniques but also on proper case selection, thorough planning, precise clinical and laboratory procedures, and patient habits [44].

In the present investigation, of the 10 patients who received dental veneers as part of the indirect technique, the majority were

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treated with ceramic veneers, applied in 8 cases (80%). This choice reflects the superior durability, mechanical strength, and aesthetic qualities of ceramic materials. In contrast, only 2 patients (20%) received composite veneers, which, although offering a faster and less expensive option, present lower longevity and mechanical performance. Composite veneers were chosen in cases where a minimally invasive treatment approach was prioritized.

For teeth with extensive carious lesions, inlays and onlays are often recommended as alternatives to full-coverage crowns. They tend to be more cost-effective and generally better accepted than complete crown restorations. Although ceramics are a popular aesthetic material for anterior crowns, their brittleness makes them less suitable for posterior restorations. The effectiveness of ceramic inlays and onlays in posterior teeth remains a subject of debate [49,50].

Several factors, including parafunctional habits, occlusal forces, and the presence of secondary caries, can influence the success of ceramic inlays and onlays [50,51]. Some studies have found that composite materials used for inlays and onlays show lower survival rates, with material type and follow-up duration significantly affecting restoration longevity. This may be due to greater material degradation over time [52].

Nevertheless, while hybrid materials and ceramics are generally preferred for indirect partial restorations in posterior teeth because of their superior clinical performance, composite materials can still be considered a valid option due to their cost-effectiveness, given that their survival rates remain relatively high despite slightly inferior performance compared to other materials [52].

Limitations of the study

The study presents several important limitations that require caution in interpreting the results. The small sample size and the fact that the research was conducted in a single center limit the generalizability of the conclusions, which reflect local clinical trends rather than universal findings. Additionally, the lack of a detailed evaluation of relevant clinical factors (periodontal status) and the absence of medium or long term follow-up do not allow for a comprehensive assessment of the clinical performance and durability of the restorations. Overall, these limitations highlight the need for future multicenter studies with larger samples and longitudinal monitoring.

Recommendations for future studies

To strengthen and expand the conclusions of the study, future research should be conducted on larger and more diverse samples from multiple dental centers, both public and private, to obtain more representative data; standardize therapeutic choice criteria through clear clinical protocols; implement longitudinal follow-up to assess durability, functionality, aesthetics, and patient satisfaction; investigate subjective and economic factors influencing restorative decisions; and integrate new technologies and digital materials, such as CAD/CAM, intraoral scanning, and 3D printing, to analyze their impact on decision-making and clinical outcomes.

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5. Conclusions

The current research highlights the varied application of direct and indirect dental restoration techniques in a real clinical context, where therapeutic decisions were adapted to the specifics of each case. The choice of each technique depended on factors such as the extent of tooth substance loss, aesthetic requirements, material availability, clinical time needed, and long-term prognosis. Direct techniques were preferred in situations requiring a conservative approach with maximum preservation of hard dental tissues, while indirect techniques were chosen in cases demanding superior control of shape, contour, and aesthetics, as well as greater long-term strength.

The study emphasizes the importance of an individualized approach in selecting restorative techniques, considering clinical needs and the functional and aesthetic objectives of the treatment. Appropriate integration of direct and indirect restorations, along with careful material selection, contributes to achieving stable, efficient, and clinically and aesthetically satisfactory results.

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The authors declare no conflicts of interest concerning this study.

Data availability statement

Will be provided on request.

Ethics statement

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