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Approaches and clinical outcomes of indirect onlay, overlay, and inlay restorations in dental aesthetics: a systematic review

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Abstract

Introduction: In the dental aesthetics scenario, there has been an increase in the indication of indirect restorations such as inlays, onlays, and overlays in ceramics and resins. **Objective:** This study aimed to examine the clinical outcomes of indirect onlay, overlay, and inlay restorations in dental aesthetic through a systematic review. **Methods:** The systematic review rules of the PRISMA Platform were followed. The search was carried out from March to April 2025 in the Scopus, Embase, PubMed, Science Direct, Scielo, and Google Scholar databases. The quality of the studies was based on the GRADE instrument and the risk of bias was analyzed according to the Cochrane instrument. **Results and Conclusion:** A total of 125 articles were found. A total of 37 articles were evaluated in full and 28 were included and developed in the present systematic review study. Considering the Cochrane tool for risk of bias, the overall assessment resulted in 18 studies with a high risk of bias and 20 studies that did not meet GRADE. It was concluded that there was an increase in the indication of indirect restorations inlays, onlays, and overlays in ceramics and resins. The restoration of posterior teeth, with loss of a large amount of tooth structure, using indirect restorations, aimed to overcome some problems associated with direct restorations, such as low mechanical and wear resistance, and difficulty in reestablishing proximal or occlusal morphology. Indirect Restorations are most indicated when there is loss of cusps, the need to reinforce the remaining teeth, and difficulty in reconstructing the anatomy directly in the mouth. Zirconia is a crystalline ceramic that has minimal or practically no glass phase and is available in powder (layered or sintered) or block (CAD/CAM). Another material option is laboratory composite resins, which have also been used to create indirect restorations, being an alternative to ceramics. Failures can be considered as events occurring after final cementation requiring some intervention or complete replacement of the restoration.

Keywords: Crowns. Resin. Ceramics. Dental prosthesis. Dental aesthetics.

Introduction

In the dental aesthetics scenario, there has been an increase in the indication of indirect restorations such as inlays, onlays, and overlays in ceramics and resins. When opting for an indirect restoration, it is often discussed which restorative material will be used: composite resin-based, ceramic-based, or hybrid materials that combine the properties of both. Today, there is a wide availability of materials for both partial and total reconstructions [1,2].

The restoration of posterior teeth, with loss of a large amount of tooth structure, using indirect restorations aims to overcome some problems associated with direct restorations, such as low mechanical and wear resistance, and difficulty in reestablishing proximal or occlusal morphology. Indirect restorations are more indicated when there is loss of cusps, need to reinforce the remaining tooth, and difficulty in reconstructing the anatomy directly in the mouth [3]. Indirect partial restorations of posterior teeth can be classified as inlays (without cusp coverage), onlays (with coverage of at least one cusp), and overlays (coverage of all cusps). These partial restorations allow the preservation of the

remaining dental structure, promoting the reinforcement of the compromised tooth [4-6].

With the advancement of technology, a variety of ceramic and resin materials have emerged for the manufacture of aesthetic restorations [7-9]. The first all-ceramic inlay was performed in 1837 by John Murphy, in England. The term "ceramic" derives from the Greek "keranos", which means fired material. Porcelain is considered a specific type of ceramic, however, the two terms are generally used interchangeably. With the help of Nicholas Dubois de Chemant, the art of ceramics was introduced into Dentistry. Feldspathic porcelains were developed in England, incorporating 40 to 50% alumina crystals, to improve the resistance of crowns without compromising aesthetics. In 1976, a new technique was introduced to further increase the resistance of dental crowns [10].

In light of this development, at the end of the 20th century, several innovative systems were introduced to the market, to enable the production of metal-free ceramic restorations. Since then, several ceramic systems have been developed, always to improve the physical and mechanical properties of the material. In this context, it is necessary to know each ceramic system currently available on the market, from its main characteristics to its limitations, to know how to correctly indicate it in each specific clinical situation [1,2,10].

The ceramics indicated for inlays, onlays, and overlays can be grouped into: feldspathic porcelains, ceramicized glasses, or lithium disilicate crystalline ceramics. Ceramicized glass porcelains have a combination of vitreous and crystalline phases, which allows them to be conditioned and provide excellent aesthetic results. Feldspathic porcelains were the first type of ceramic to be used in Dentistry, and are available in powder (layered) or block (CAD/CAM). Ceramicized glasses (fluorapatite, leucite, or lithium disilicate) are commercially available in the form of ingots (pressed), powder, or blocks, and are excellent choices since they present excellent aesthetics and high mechanical resistance, compared to porcelains. Alumina or Zirconia, are crystalline ceramics that have minimal or practically no glass phase and are available in powder (layered or sinderized) or block (CAD/CAM). Another material option is laboratory composite resins, which have also been used to make indirect restorations, being an alternative to ceramics [1,11].

In 1937, acrylic resins for dental use were introduced. Initially, they were used on metal, then called "veneer crowns". At the time, these materials were considered to have good aesthetic quality. However, they suffered color changes and wear in a short period. Thus, the need to use materials with more suitable mechanical and aesthetic properties was realized. After several studies, epoxy resin was combined with acrylic resin, obtaining Bis-GMA (bisphenol glycidyl methacrylate), an inorganic filler bonded to the matrix by an added bonding agent (silane), aiming to improve the material. The association of this material with acid etching began a new phase in aesthetic dentistry, thanks to the possibilities that emerged [10].

The final strength of resin restorations depends on the degree of conversion of the monomers (organic phase) and an adequate amount of inorganic phase, and are manufactured through chemical polymerization, photopolymerization, heat polymerization, or prefabricated block (CAD/CAM). Failures can be considered as events occurring after final cementation, requiring some intervention or complete replacement of the restoration. The main complications are fracture/chipping, endodontic problems, secondary caries, detachment, and severe marginal staining. Indirect partial ceramic and resin restorations still present many possibilities regarding the types of preparations, materials, and techniques used in their manufacture, which need to be further studied to provide scientific evidence [10,11].

Based on this, the present study aimed to address the clinical outcomes of indirect onlay, overlay, and inlay restorations in dental aesthetics through a systematic review study.

Methods

Study Design

This study followed the international systematic review model, following the PRISMA (preferred reporting items for systematic reviews and meta-analysis) rules. Available at: http://www.prisma-statement.org/?AspxAutoDetectCookieSupport=1. Accessed on: 04/17/2025. The AMSTAR-2 (Assessing the methodological quality of systematic reviews) methodological quality standards were also followed. Available at: https://amstar.ca/. Accessed on: 04/17/2025.

Data Sources and Search Strategy

The literature search process was carried out from March to April 2025 and developed based on Scopus, Embase, PubMed, Lilacs, Ebsco, Scielo, and Google Scholar, covering scientific articles from various periods to the present day. The following descriptors (DeCS /MeSH Terms) were used *"Crowns. Resin. Ceramics. Dental prosthesis. Dental aesthetics"*, and the Boolean expression "and" was used between the MeSH terms and "or" between the historical findings.

Study Quality and Risk of Bias

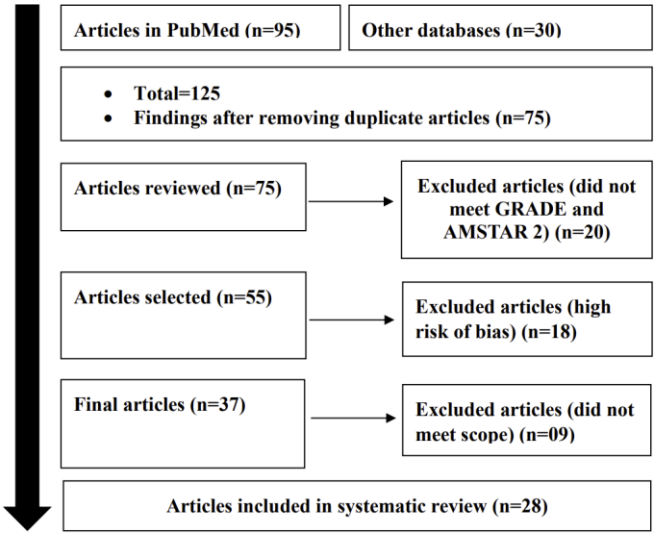
The quality was classified as high, moderate, low, or very low regarding the risk of bias, clarity of comparisons, precision, and consistency of analyses. The most evident emphasis was on systematic review articles or meta-analyses of randomized clinical trials, followed by randomized clinical trials. The low quality of evidence was attributed to case reports, editorials, and brief communications, according to the GRADE instrument. The risk of bias was analyzed according to the Cochrane instrument by analyzing the Funnel Plot graph (Sample size versus Effect size), using Cohen's d test.

Results and Discussion

Summary of Findings

A total of 125 articles were found and submitted to eligibility analysis, with 28 final studies being selected to compose the results of this systematic review. The studies listed were of medium to high quality (Figure 1), considering the level of scientific evidence of studies such as meta-analysis, consensus, randomized clinical, prospective, and observational. Biases did not compromise the scientific basis of the studies. According to the GRADE instrument, most studies presented homogeneity in their results, with X^2=83.7%>50%. Considering the Cochrane tool for risk of bias, the overall assessment resulted in 18 studies with a high risk of bias and 20 studies that did not meet GRADE and AMSTAR-2.

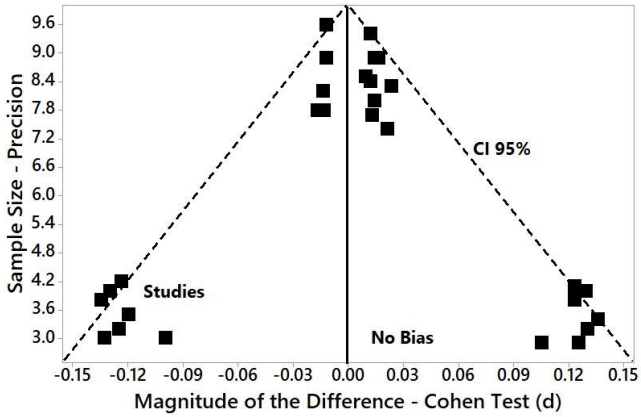
Figure 1. Screening and selection of the article.



Source: Own authorship.

Figure 2 presents the results of the risk of bias of the studies through the Funnel Plot, showing the calculation of the Effect Size (Magnitude of the difference) using Cohen's Test (d). The precision (sample size) was determined indirectly by the inverse of the standard error (1/Standard Error). This graph had a symmetrical behavior, not suggesting a significant risk of bias, either among studies with small sample sizes (lower precision) that are shown at the base of the graph or in studies with large sample sizes that are presented at the top.

Figure 2. The symmetric funnel plot suggests no risk of bias among the small sample size studies shown at the bottom of the graph. High confidence and high recommendation studies are shown above the graph (n=28 studies).



Source: Own authorship.

Major Clinical Outcomes

Important changes have occurred in recent decades in the clinical application of strategies for posterior restorations, from amalgam to composites in direct restorations and from traditional resistance crowns to adhesive partial restorations, such as onlays. Despite the extensive evidence available for these advances, there are still very few established guidelines for common clinical questions such as "When does an indirect restoration have a clinical advantage over a direct restoration? When should adhesive coverage of the cusps, such as an onlay, be performed? When should resistant form designs be implemented in adhesive restorations? What conditions create limitations to adhesion so that a resistant form preparation with a stiffer material, such as a traditional crown, may be more appropriate?" The focus is on clinical decisions for partial adhesive restorations regarding the indications for direct versus indirect materials, as well as the need for cuspal coverage and/or resistant form preparations based on the remaining tooth structure and esthetics [1,7].

A prospective, multicenter, clinical cohort study analyzed factors associated with the success of all-ceramic inlays, onlays, and crowns. Data were evaluated from 12,468 patients with CAD/CAM-fabricated restorations. At a mean (SD) follow-up of 3.3 years and 8.6 years, 940 restorations failed (annual failure rate: 5 years, 2.7%). The main types of failure were ceramic

fracture (n = 151), endodontic complications (n = 87), and tooth fracture (n = 77). In both scenarios, endodontic treatment, positive papillary bleeding index, and use of an EVA instrument significantly increased the failure rate compared to non-presence/non-use. Furthermore, ZrO2 significantly increased the time to any failure. For all ceramic restorations fabricated by CAD/CAM, high success rates could be found up to 25 years. Furthermore, after 8 years, tooth-, technique- and material-related factors were significantly associated with failure [12].

In this sense, the treatment of young first permanent molars with extensive carious tissue loss may often require restoration with preformed crowns. A recent randomized clinical trial designed by authors Geduk et al. (2023) [13] compared the clinical and radiographic performance of stainless steel crowns (SSCs) and preformed zirconia crowns (ZCs). A total of forty-eight affected incisor molars (IOMs) or permanent molars in 20 healthy patients between 6 and 13 years of age were randomly divided into ZCs and SSC groups (n=24 teeth/group) in a split group. The oral hygiene levels of the patients were assessed using the Greene and Vermillion Oral Hygiene Index-Simplified (OHI-S). Plaque accumulation and gingival health were assessed using the Silness&Löe Plaque Index (PI) and the Löe&Silness Gingival Index (GI), respectively. Clinical retention, marginal extension level, marginal adaptation of crowns, and wear of opposing teeth were assessed at baseline, 1, 6, 12, and 18 months. Radiological evaluations to assess the marginal adaptation of crowns and periapical pathology of the teeth were performed. Crown restorations were performed at 6 and 12 months. Forty teeth of 17 children were evaluated during 18 months. ZCs had significantly lower gingival index and plaque values than teeth restored with SSCs during all evaluation periods ($p<0.05$). Neither crown type resulted in clinically detectable wear in the opposing dentition or periapical pathology. One ZC was lost at 13 months, whereas all SSCs survived clinically in function. The cumulative survival rates of ZCs and SSCs were 95.2% and 100%, respectively.

Aesthetic restorations have been increasingly used in posterior teeth, due to the growing search by patients for treatments that combine clinical longevity and aesthetic excellence [9,14,15]. However, the choice of the technique used is associated with the condition of the remaining teeth [15]. With advances in studies of adhesive dentistry and the degree of aesthetic demand, there has been an increase in the indication of indirect restoration inlays, onlays, and overlays in ceramics and resins [15,16]. The restoration of posterior teeth, with loss of a large amount of tooth structure, using indirect restorations aims to overcome some problems associated with direct restorations, such as low mechanical and wear resistance, and difficulty in reestablishing proximal or occlusal morphology [9,16,17].

Indirect restorations are more indicated when there is loss of cusps, need to reinforce the remaining teeth, and difficulty in reconstructing the anatomy directly in the mouth. Indirect partial restorations of posterior teeth can be classified as inlays (without cusp coverage), onlays (with coverage of at least one cusp), and overlays (coverage of all cusps). These partial restorations allow the preservation of the remaining dental structure, promoting the reinforcement of the compromised tooth [15].

The use of indirect inlay/onlay restorations in posterior teeth using aesthetic materials is increasing, which results in an increase in the use of dental ceramics, which was previously restricted to treatment in anterior regions only. The search for aesthetic restorations has increased significantly, not only in the anterior region but also in the posterior region. New techniques and materials that are not only aesthetic but also resistant are being sought. Porcelains are still widely used in onlay and inlay restorations, however, new materials are arriving on the dental market, such as the nanoceramic resin Lava Ultimate ™ (3M™ ESPE™) [16,18-20].

Adequate understanding of the techniques and their indications has contributed to the widespread use of this restorative approach. Recent industrial development has brought new technologies to dentistry, including the introduction of nanoparticles for restorative procedures [17]. Indirect restorations are expected to have greater longevity than direct restorations [15,16,19].

Dental ceramics are recognized for their excellence in artificially reproducing natural teeth. They were first used in dentistry in the 18th century as an artificial tooth solution for complete dentures, and from the 20th century onwards they began to be used for the manufacture of metal-ceramic restorations. Currently, with the advent of improvements in ceramic technology, metal-free restorations have emerged. Ceramics have undergone rapid scientific evolution to improve their physical and mechanical properties to meet the required aesthetic needs [1,9].

Composite resins for indirect use and ceramics are the most suitable materials for reproducing a harmonious smile through indirect metal-free restorations [9]. Adhesive composite resin restorations are being widely used. An adequate understanding of the technique and its indications has contributed to the widespread use of this restorative approach [1,2,9,17,21].

The ceramics indicated for inlays, onlays, and overlays can be grouped into feldspathic porcelains, ceramicized glasses, or lithium disilicate crystalline ceramics. Ceramicized glass porcelains have a combination of vitreous and crystalline phases, which allows them to be conditioned and provide excellent aesthetic results. Feldspathic porcelains were the first type of ceramic to be used in Dentistry, and are available in powder (layered) or block (CAD/CAM). Ceramicized glasses (fluorapatite, leucite, or lithium disilicate) are commercially available in the form of ingots (pressed), powder, or blocks, and are excellent choices since they present excellent aesthetics and high mechanical resistance, compared to porcelains. Alumina or Zirconia are crystalline ceramics that have minimal or virtually no glass phase and are available in powder (stratified or sinderized) or block (CAD/CAM) [16,21-23].

The use of indirect inlay/onlay restorations in posterior teeth using aesthetic materials is increasing [16,24-27], which results in an increase in the use of dental ceramics, which was previously restricted to treatment in anterior regions only. Nanoceramic resins are a new restorative option, called Lava Ultimate™, a product developed by 3M™ ESPE™ (Irvine, California, USA).

Unsuccessful restorations can be considered as events occurring after final cementation requiring some intervention or complete replacement of the restoration. The main complications are fracture/chipping, endodontic problems, secondary caries, detachment, and severe marginal staining [28,29]. Indirect partial ceramic and resin restorations still present many possibilities regarding the types of preparations, materials, and techniques used in their manufacture, which need to be further studied to provide scientific evidence [30-33].

Conclusion

It was concluded that in the field of dentistry, there was an increase in the indication of indirect restoration inlays, onlays, and overlays in ceramics and resins. All ceramic restorations manufactured by CAD/CAM have high success rates up to 25 years. After 8 years, factors related to the tooth, technique, and material were significantly associated with failure. The restoration of posterior teeth, with loss of a large amount of tooth structure, using indirect restorations was intended to overcome some problems associated with direct restorations, such as low mechanical and wear resistance, and difficulty in reestablishing proximal or occlusal morphology. Indirect restorations are most indicated when there is loss of cusps, need to reinforce the remaining tooth, and difficulty in reconstructing the anatomy directly in the mouth. Zirconia is a crystalline ceramic that has minimal or practically no glass phase and is available in powder (layered or sinderized) or block (CAD/CAM). Another material option is laboratory composite resins, which have also been used to make indirect restorations, as an alternative to ceramics. Failures can be considered as events occurring after final cementation, requiring some intervention or complete replacement of the restoration.

CRediT

Author contributions **Conceptualization-** Thaís Maciel Pereira, Sabrina Pereira de Lima, Gabrielly Camolezi Cavariani, Ana Paula Bernardes da Rosa; **Formal Analysis-** Thaís Maciel Pereira, Sabrina Pereira de Lima, Gabrielly Camolezi Cavariani; **Investigation-** Thaís Maciel Pereira, Sabrina Pereira de Lima, Gabrielly Camolezi Cavariani**; Methodology-** Thaís Maciel Pereira, Sabrina Pereira de Lima, Gabrielly Camolezi Cavariani; **Project administration-** Thaís Maciel Pereira, Sabrina Pereira de Lima, Gabrielly Camolezi Cavariani, Ana Paula Bernardes da Rosa; **Supervision-** Ana Paula Bernardes da Rosa; **Writing - original draft-** Thaís Maciel Pereira, Sabrina Pereira de Lima, Gabrielly Camolezi Cavariani, Ana Paula Bernardes da Rosa; **Writing-review & editing-** Thaís Maciel Pereira, Sabrina Pereira de Lima, Gabrielly Camolezi Cavariani, Ana Paula Bernardes da Rosa.

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Informed Consent

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Conflict of Interest

The authors declare no conflict of interest.

Similarity Check

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Application of Artificial Intelligence (AI)

Not applicable.

Peer Review Process

It was performed.

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