Republic of Iraq Ministry of Higher Education and Scientific Research Al_Mustaqbal University College of Dentistry

Posterior Indirect Adhesive Restoration

2025-2026

A Research Project

Submitted to the College of Dentistry, AL-Mustaqbal University in Partial Fulfillment of the Requirements for the B.D.S. Degree in Dentistry

Salman Haider
Mohammad Ali Mahdi
Mohammad Safa'a
Karar Haider
Haider Nasser
Redaa Ghalib

Supervised by

Asst. Lect. Alaa Hashim Abbas

Supervisor's Declaration

certify that this research, entitled " Posterior Indirect Adhesive Restoration" was prepared by Salman Haider, Mohammad Safa'a, Haider Nasser, Mohammad Ali Mahdi , Karar Haider, and Redaa Ghalib under my supervision at the Faculty of Dentistry, Al Mustaqbal University.

as an incomplete fulfillment of the requirements for the bachelor's degree in Dentistry.

Supervisor:

Asst. Lect. Alaa Hashim Abbas

M.S.C Conservative Dentistry

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

﴿يُؤْتِي الْحِكْمَةَ مَنْ يَشَاءُ وَمَنْ يُؤْتَ الْحِكْمَةَ فَقَدْ أُوتِيَ خَيْرًا كَثِيرًا وَمَا

يَذَّكَّرُ إِلَّا أُولُوا الْأَلْبَابِ﴾

سورة البقرة - الآية (٢٦٩)

صدق الله العلي العظيم

List of Contents

Abstract

Posterior indirect adhesive restorations have become a fundamental component of modern restorative dentistry, offering a conservative and predictable approach for the management of structurally compromised posterior teeth. This review aims to provide an updated overview of the indications, cavity analysis, preparation designs, materials, and clinical protocols associated with these restorations. The selection of indirect techniques is primarily influenced by the extent of tooth structure loss, functional requirements, and patient-related factors. Advances in adhesive dentistry and restorative materials, including ceramics, composite resins, and hybrid materials, have significantly improved the biomechanical and esthetic outcomes of these restorations. Key concepts such as cavity factor analysis, immediate dentin sealing (IDS), and morphology-driven preparation design play a critical role in enhancing bond strength, reducing polymerization stress, and preserving remaining tooth structure. Furthermore, the integration of digital impression techniques and CAD/CAM technology has streamlined clinical workflows and improved precision. Although no single material demonstrates absolute superiority, evidence supports a case-specific approach to material selection based on clinical conditions. In conclusion, posterior indirect adhesive restorations represent a reliable and minimally invasive treatment modality, provided that proper diagnosis, material selection, and adherence to clinical protocols are achieved.

Chapter 1

Introduction

Introduction

Adhesively cemented indirect restorations are now a suitable option, particularly in the posterior sector, for numerous reasons which will be extensively illustrated in this chapter.[1]The indications for indirect techniques are highly varied and cannot be clearly classified. The factors that determine this choice are numerous, and not all are dependent on purely clinical factors; they include the operator's aptitude, the availability of instruments and expertise, and not least the patient's time and financial resources.[2] As can be seen, clinical factors are one of the various components that contribute to the choice, without prejudice to the absolute indications resulting from the analysis of the carious, traumatic, or wear processes that have affected the tooth. The more they have caused loss of dentin and enamel, the more compelling the choice of indirect restoration will be; if the dental pulp is undermined by an irreversible process and the tooth requires endodontic treatment, the option of indirect restoration would be the solution of choice.[3] In addition to those listed, another significant factor is the choice of materials, as indirect restorations consist of ceramics and composites of a very different quality than those available for direct restorations. Microhybrid and nanoparticle composites are the materials most often suggested for all kinds of cavities in posterior teeth.[4]However, the technical problems of composites that are not yet solved are curing shrinkage and dentin adhesion, and the clinical problems relate to the clinician's ability to manage the tooth isolation and adhesion, as well as reestablish the original morphology. These issues are particularly challenging when the restorations are wide, and the coverage of one or more cusps is necessary. This has led to the development of indirect techniques, which achieve full polymerization and good morphology.[5,6] loss of hard tissue presents a number of clinical issues: mandibular wear resistance; control of shrinkage stresses; possible postoperative hypersensitivity; predictability of dentin adhesion; difficulty of morphological restoration, with particular attention to occlusal surface, contact points, and emergence profile.[6,7]Consequently, in large cavities with cusp coverage, it is clinically more favorable to use an adhesively cemented restoration as the first treatment choice. Decision criteria that guide clinicians in the choice of materials and techniques can be divided into general and local parameters. General parameters include the patient's age, oral hygiene, motivation, caries risk assessment, dietary habits, functional activity, ergonomics, and financial resources; local parameters include cavity shape, thickness of remaining walls, position of cervical margins, presence of cervical lesions, presence of cracks, position of the tooth, evaluation of the element in preprosthetic function, and presence of pulp disease or periodontal lesions.[8] The new cavity design, published by Veneziani in the International Journal of Esthetic Dentistry in 2017, is called Morphology Driven.[8] The new preparation principles can be effectively applied to all types of traditional adhesively cemented restorations (inlays, single-unit restorations, overlays) and to a whole series of newly developed restorations (additional overlays, overlay-veneers, long-wrap overlays, adhesive crowns). The different restoration typologies thus defined allow us to shift the dividing line between the traditional and conservative prosthetic approaches in favor of the latter.

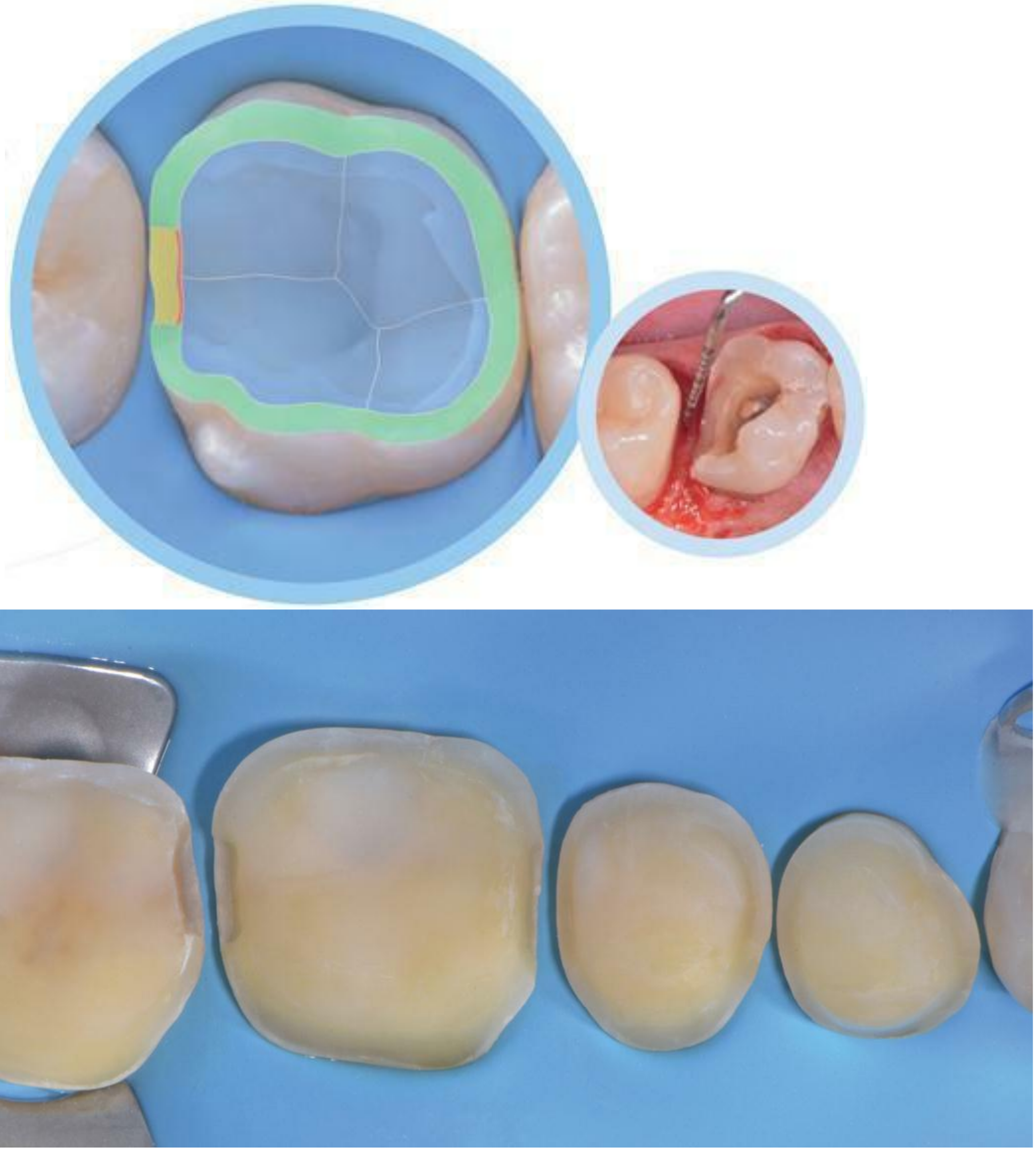


Figure1: new preparation principles

Aim of study

The aim of this study is to review and critically analyze the current evidence on posterior indirect adhesive restorations, focusing on their types, clinical performance, material selection, preparation and bonding protocols, indications, and long-term outcomes

Chapter2

Literature of review

Indications and contraindication

Figure2: some clinical situation that indicated for Onlay, Overlay, Overlay-Veneer, Long-Wrap Overlay, Additional-Overlay, Adhesive Crown and Endocrown.

The first-choice treatment option for large-scale restorations, as previously explained, is adhesively cemented restorations (ACR) [6]. An inlay, or adhesively cemented restoration, is defined as a rigid partial coronal restoration, made of composite (layered or CAD/CAM milled) or all-ceramic (layered, cast, or CAD/CAM) that must be passively inserted and adhesively cemented into a cavity with specific characteristics. Significant loss of substance, which is an indication for the use of cemented restorations, may be attributable to large carious lesions and/or coronal fractures with or without involvement of the attachment complex, wear of the tooth surfaces from mechanical abrasion (bruxism, night clenching) and/or chemical tissue loss (consumption of acidic beverages, gastroesophageal reflux, bulimia, etc.).[9] The classic indications provided by the literature of the mid-1990s (Geneva School 1994)[9]included:

- Class I and II cavities.
- Cuspal-covered restorations.
- Reduced cervical enamel (<1 mm height (H) and 0.5 mm thickness (L)) or absent.
- Cervical concavities (for example, mesial surfaces of the upper first premolars).
- Quadrant restorations (multiple restorations).

It is clear that the above indications are questionable in light of the clear clinical evidence and the development of materials. Some considerations[17]

- Class I defects are generally resolvable with direct techniques.

- Cusp coverage can also be performed using direct technique, but clearly beyond a certain limit it becomes clinically unsuitable.
- The absence of enamel at the cervical level cannot in itself constitute an indication for an inlay but should at least be evaluated in conjunction with the dimensions of the cavity.
- Cervical concavity is easily manageable with some direct restorative measures that allow adaptation of the matrix without resorting to an inlay.
- Multiple restorations should not lead to the use of indirect techniques, but each individual element must be treated based on the loss of substance, regardless of considerations related to the number of restorations or considerations of clinical convenience or pseudo-ergonomics of work.

In light of the above considerations, the current indications for adhesively cemented restorations, as per the Veneziani in the International Journal of Esthetic Dentistry in 2017 [8], can be summarized as:

- Large Class II cavities with cuspal coverage (of one or more cusps).
- Restoration of large occlusal surfaces lost due to wear and/or biocorrosion (erosion).

The presence of reduced or absent cervical enamel (<1 mm H and 0.5 mm L), cervical concavities, the need for quadrant rehabilitations (multiple restorations) with the need to verify occlusion in an articulator, and the need to restore or increase the vertical dimension are important co-factors that strengthen the indications. [13] For example, a medium-sized occlusal-distal cavity with absent cervical enamel can be filled with a direct restoration; if the cavity is medium-large and in addition, there is an absence of enamel, this increases the indication for an inlay restoration. It should also be emphasized that, even in the context of quadrant rehabilitations, it is reasonable to select the first-choice technique for each individual tooth regardless of considerations relating to the number of teeth to be treated and clinical ergonomics. This means that in the context of a quadrant requiring rehabilitation with indirect techniques, if one of the affected elements presents a cavity suitable for the direct technique, this must be selected and performed simultaneously with the build-up of the remaining elements, without involving it in an inlay design.

The advantages of these types of restorations (hereinafter referred to as ACR) are the following:

- They allow ideal anatomical modeling of the occlusion with optimal management of contact points and emergence profiles and verification of the occlusion in the articulator.[5]
- Maximum reduction of stress from polymerization shrinkage of the composite materials, which occur outside the cavity, with a consequent benefit on marginal adaptation; the only residual polymerization shrinkage, which is otherwise of little influence, will be borne by the thin layer of resin cement used for cementation[10]. Furthermore, the photothermal treatment (in a special oven at 130°C for 7 minutes) to which the restoration is subjected improves the degree of conversion of the composite and therefore the physical-mechanical properties of the restoration (wear resistance[11] and dimensional stability).[12]

Other advantages of these techniques include the possibility of using certain materials Traditional materials such as feldspar ceramics (layered or better yet, monolithic) or, more frequently, lithium disilicate-reinforced glass ceramics and a whole series of ceramic-reinforced CAD/CAM polymers. Ceramics can be made by die-casting or CAD/CAM milling, while composites can be made by layering or CAD/CAM milling; finally, new materials such as polymer-infiltrated ceramics can only be used with CAD/CAM methods.[13]

Type of indirect posterior restoration

inlay | Overlay-veneer | Long-wrap overlay | Adhesive crown

Additional overlay | Occlusal veneer | onlay | overlay

1. Inlay

Restorations without cuspal coverage. They are indicated for medium- to large-sized teeth in Class II cavities with two surfaces (MO/OD in living or endodontically treated teeth) or three surfaces (MOD in living teeth only) with well-preserved lateral walls and no cracks. The first-choice material is composite. Currently, this type of restoration can be performed using a direct technique with equal predictability but is more conservative and economical. [13]

FigureA: Amalgam restorations (#36) and composite restorations (#35) showed inadequate morphology and marginal fit, and evidence of recurrent caries.

Figure3: The inlays are tried before and after the placement of the dam and then adhesively cemented with heated light-curing composite**.**

2. Onlay

Partial cuspal coverage restorations. In living teeth, they are indicated in large Class II cavities with only partially supported lateral walls (>2-2.5 mm) and one or even two absent marginal ridges. In the case of an endodontically treated tooth (DTE), the presence of at least one intact marginal ridge and two partially well-supported cusps (>3-3.5 mm), presumably attached to the marginal ridge itself, is required. In both cases, the absence of cracks is required. They can be made with either composite or ceramic, taking into account the decision-making parameters and material characteristics previously described.[13]

Figure4: Totally inadequate preexisting restoration at the level of molar #36

Figure 5: The inlay is tried-in before and after placement of the dam and then cemented with heated light-curing composite .

3. Overlay

Full cuspal coverage restorations. In living teeth, they are indicated in large Class II cavities with inadequately supported lateral walls (≤2 mm) and the absence of both marginal ridges (MOD cavities) or in the case of enamel-dentin cracks (in living teeth) even with adequately supported walls. The material of choice for the overlays may be composite or ceramic, following the criteria outlined above and a series of sometimes complex evaluations (described in each individual case). In endodontically treated teeth, the absence of marginal ridges (MOD cavities) – generally associated with inadequately supported walls (<3-3.5 mm) – requires full cuspal coverage, especially if cracks are present. If cracks are present, the author generally recommends the use of ceramic materials to increase cusp stabilization, significantly increasing crown rigidity, although there is no clear evidence of this in the literature.[13]

Figure 6: Lower arch of a 22-year-old male patient with high caries susceptibility. Clinically, a large carious lesion is evident on tooth 37, which is best appreciated in its true extent and proximity to the pulp

Figure 7: Image of the quadrant immediately after removal of the dam. The image clearly highlights the depth of the lesion and the correct fit of the restorative material.

4. Additional overlay

These restorations provide partial, but more frequently, full, cuspal coverage without any tooth preparation. They are indicated for the anatomical restoration of teeth with loss of substance due to erosion/abrasion, for impacted teeth, for example, retained deciduous teeth in cases of agenesis of permanent teeth or for increases in the vertical dimension. The material of choice (composite predominantly CAD-CAM or cast ceramic or CAD-CAM) must be considered in each individual clinical case based on thickness, functional stresses, restoration design, and the possibility of reoperation and repair.

Figure 8: The tooth is "trapped" between the two permanent teeth #36 and #34, which are mesially and distally inclined, respectively.

Figure 9: The higher magnification detail shows the fully additive restoration.

Figure 10: The left lateral image shows how the element is perfectly in occlusion with restoration of function and occlusal stability.

5. Overlay-veneer

Full-cuspal coverage restorations, extending to the entire vestibular surface, restore the aesthetic and functional surface. They are indicated for teeth with significant loss of substance (including the vestibular walls) and/or severely discolored teeth resistant to bleaching, located in areas of Aesthetic importance (typically upper premolars). The restorative material of choice is ceramic: lithium disilicate cast or CAD-CAM. [13]

Figure 11: Lower arch of a 22-year-old male patient with high caries susceptibility. Clinically, a large carious lesion is evident on tooth 37, which is best appreciated in its true extent and proximity to the pulp

Figure 12: Image of the quadrant immediately after removal of the dam. The image clearly highlights the depth of the lesion and the correct fit of the restorative material.

6. Occlusal veneer

They are thin (1 mm-1.2 mm) and super-thin (0.6-0.8 mm) posterior adhesive indirect restorations with occlusal coverage and a non-retentive design. They are primarily indicated in cases of advanced attritional wear/biocorrosion of the occlusal surface or in restorative clinical cases requiring an increase in the vertical dimension. In vitro fatigue studies concluded that CAD-CAM composite resin occlusal veneers had a significantly higher fatigue resistance than ceramic occlusal veneers. At standard thicknesses of 1-1.2 mm, the fatigue resistance is comparable. Adhesive luting (over as large a portion of enamel as possible) is essential to provide this type of restoration with fracture resistance. [14]

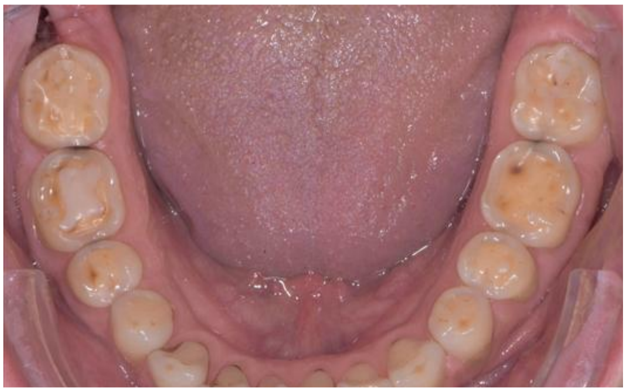


Figure 13: The patient presented with evident asymmetry of the occlusal plane with moderate to high wear and a disharmonious smile. Occlusal images of the arches clearly show attritional wear and biocorrosion of all occlusal surfaces (more evident in the lower teeth) and of the incisal edges (more evident in the upper teeth).

Figure 14: The clinical image, in the oral cavity, of the quadrant 3 and 4 restorations show excellent morphological and esthetic integration with adequate interproximal contact points and excellent marginal adaptation.

Figure15: The extreme thinness of the occlusal veneer is appreciated

7. Long-wrap overlay

Full cuspal coverage restoration extending to the buccal and palatal/lingual axial walls, depending on the degree of substance loss and regardless of the soft tissue profile. It is indicated in cavities requiring extended cuspal coverage to the axial walls due to large carious lesions, abrasions, biocorrosion, or fractures involving the external surfaces of the walls themselves. The material of choice is ceramic (lithium disilicate). Composite may be indicated as an economical compromise or when a possible reoperation is anticipated, for example, for endodontic reasons. In the case of reoperation on a preexisting full crown, once removed, where enamel is still present on the axial surfaces, it is possible to rehabilitate the tooth with an adhesively cemented partial restoration: this is called a Reverse Crown-to-Veneer Restoration.[13]

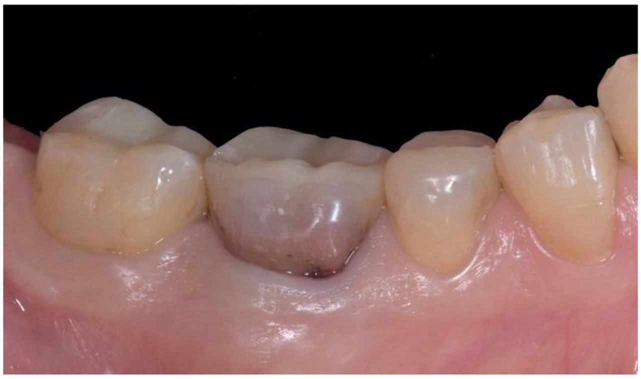


Figure 16: cervical carious lesion in the mesio-vestibular region. In this situation, the restoration of choice is an adhesive indirect restoration covering the vestibular surface – for the reasons – and the entire lingual wall lost to caries. Preparation is performed for a newly developed adhesive indirect restoration called a long-wrap overlay

Figure 17: The final oral image confirms the adequacy of the treatment in terms of morphofunctional and aesthetic integration with particular attention to the long-wrap overlay restoration of teeth #46, both radiographically and clinically, adequately rehabilitated with a new and less invasive approach than a traditional full crown.

8. Adhesive crown

A fully covered restoration with supragingival margins that follow the contour of the marginal soft tissues and adhesively cemented in an isolated field with a rubber dam. It is indicated in cases of significant tooth loss that require complete tooth preparation and in which the adhesive procedure allows for more conservative treatment of the already scarce residual dental tissue and periodontal tissue, avoiding crown lengthening procedures that would be necessary to provide strength and retention to conventional prosthetic restorations. The material of choice is etchable ceramic (lithium disilicate), but it is also possible to use cubic zirconia, which is stronger, higher-quality, non-etchable but can still be cemented with "simplified adhesive" procedures.[15]

Figure 18: It shows a metal-ceramic crown at level 47 and a composite filling at level 46 that are completely inadequate in terms of morphology, function, aesthetics, and marginal fit. Caries can be seen under the restorations

Figure 19: The image of the quadrant at the end of rehabilitation shows good morphological integration, which corresponds to correct function and good aesthetics.

9. Endocrown

This is a monolithic restoration made of composite or ceramic (lithium disilicate or feldspar ceramic), usually CAD/CAM but also occasionally cast, completely covering the cusps, which features a central extension inside the pulp chamber (on average 3.5 mm) to increase the surface adhesion area. It is clear that this type of restoration has a significantly greater thickness (7.5 mm on average) than a traditional overlay, and therefore the problem of conversion of the composite with which it is cemented arises. We recommend a dual-cured resin cement irradiated with a high-power lamp for 90 seconds on each of the three surfaces (at least 80% of the Vickers microhardness of the control side is achieved)[16], but several studies show that it is also possible to use a composite that is exclusively light-cured and achieve adequate conversion. Although further studies would be desirable, endocrown demonstrates behavior – in endodontically treated molars with extensive substance loss – similar or better than conventional treatments with root canal posts and indirect restorations[17,18]. Use in premolars would require further clinical studies to corroborate the in vitro study[19]. Regarding the choice of material, nano-ceramic resins and lithium disilicate glass-ceramics are the most suitable materials for creating restorations. In vitro 3D finite element studies[20] show that endocrowns made from CAD-CAM composite (Lava Ultimate, 3M and Grandio blocs, Voco) demonstrated more uniform stress distribution and higher fracture resistance than polymer-infiltrated ceramics (Enamic, Vita) and lithium disilicate (IPS e.max CAD). Further long-term clinical studies are needed to verify this effect. Nanoceramic resins also appear to have a better marginal fit[21].

Figure 20: A 40-year-old female patient presents with tooth 26 that has already been inadequately treated with a resulting endodontic lesion that is radiographically evident, particularly at the distobuccal root level – with an improper direct composite restoration without cuspal coverage. The tooth requires endodontic-restorative retreatment.

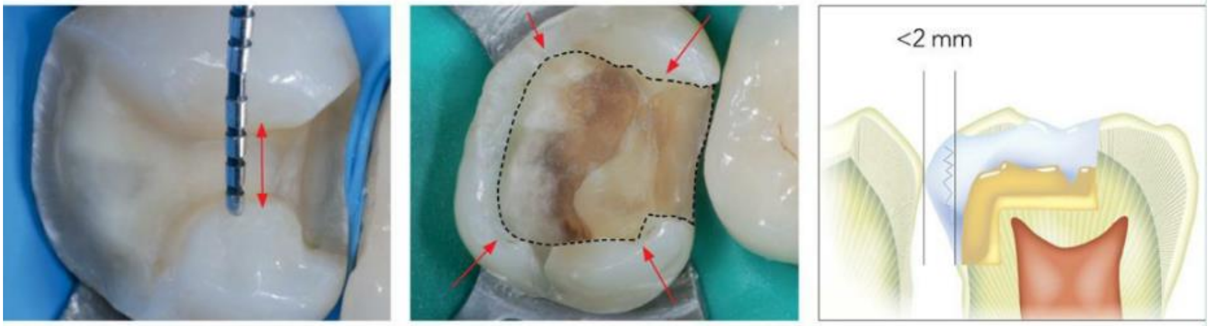
Figure 21: Once the filling material was removed and the cavity was cleaned, the expected clinical situation regarding the difficult-to-isolate interproximal margins was confirmed. Tissue inflammation, attributable to the patient's suboptimal plaque control, certainly complicated the situation..

Figure 22: Three months after cementation, the restoration is well integrated morphologically, functionally, and aesthetically in the oral cavity, with a good response from the marginal gingival tissues in the absence of inflammatory processes.

Cavity Factor Analysis

Residual tooth wall thickness: ≥2.0-2.5 mm (some authors 1-1.5 mm), >3.0-3.5 mm endodontically treated elements.

Limiting thickness of the material for cusp covering: ≥1.5 mm for layered composite, <1.0 mm (up to 0.6-0.8 mm) for CAD-CAM composite, ≥1.0 mm for cast lithium disilicate or CAD-CAM, ≥2.0 mm for feldspar ceramic.



Occlusal isthmus width ≥2.0 mm for composite and lithium disilicate (≥3.0 mm for feldspar ceramic).

Restoration margins not coinciding with occlusal contacts.

Interproximal over-jet of material possibly <2 mm.

Indirect restorations, indicated in large cavities with significant coronal tissue loss due to caries or fractures, present residual walls of a critical thickness that must be evaluated in order to maintain or not to maintain the wall itself. Furthermore, the cavities are always undercut and require adequate internal reconstruction (build-up or block-out) with specific characteristics and a precise rationale.3

After clinical and radiographic diagnosis and analysis, then remove the dental caries or previous dental restoration under rubber dam, the next step (with the exception of the considerations mentioned in the Indications chapter), we have to codify the practical procedures for clinicians to follow. Therefore, given that some factors (such as an occlusal overload and the presence of obvious hard tissue cracks) emphasize the risk of fracture, the adhesthetics protocol needs to be analyzed in terms of the diagnosis of cavity factors and the choice of the type of restoration.[22]The cavity analysis involves evaluating the residual thickness and is performed by measuring the base of the cusps according to parameters to be respected in cavity design which is :

- Dentin-enamel thickness of the residual tooth walls (in order to maintain them) >2-2.5 mm in vital teeth (recent articles report values of 1 mm that are usable but clinically questionable).[23]
- And >3-3.5 mm in endodontically treated teeth.[24]
- An element to evaluate, in addition to thickness, is the cavity depth factor, which reflects the extent of interaxial dentin loss and leads to an even more significant structural weakening than the width factor[25]. The loss of the pulp chamber roof leads to a further loss of resistance with greater deflection of the cusps under functional load and reduced elastic recovery with a greater risk of fracture, which is typical of endodontically treated teeth. [26]
- Width of the occlusal isthmus (ensuring the strength of the restoration): ≥2 mm for composite and lithium disilicate and >3 mm for feldspar ceramic.[27]
- Presence or absence of marginal ridges with consequent presence of an interproximal box to be assessed in the three spatial planes: occlusal-cervical depth, mesio-distal, and vestibulolingual. The marginal ridge plays a fundamental role in determining the resistance of the compromised tooth, constituting the structural factor connecting the vestibular and lingual-palatal walls.[28]
- Thickness of the cuspal coverage material: ≥1.5 mm for layered composite (a distinction can be made between 1.5 mm for the non-working cusp and at least 2 mm to cover a working cusp), ≥1 mm for lithium disilicate and ≥2 mm for feldspar ceramic (non-working cusps), and at least 2.5 mm to cover working cusps.[29]
- Interproximal overcast material should be ≤2 mm if possible. Excessive overcast creates a high risk of fracture of the marginal ridge of the restoration.
- Another important element to evaluate is the possible presence of cracks that can lead to cuspal coverage.

Figure 23: Measurement of Dentin-enamel thickness of the residual tooth

Remaining Tooth Structure

The reduction phase of the residual tissue , considered inadequately supported, follows the thickness evaluation phase, but must necessarily precede the adhesive build-up phase, in order to better evaluate the wall thickness and avoid exposing non-hybridized dentin after preparation.

However, it should be taken into account that the extent of occlusal reduction of the cuspal residue depends on five parameters:

- Minimum resistance thickness of the restorative material (composite or ceramic, layered or CAD-CAM).
- Amount of enamel not adequately supported by dentin; the wall will be reduced until a minimum amount of dentin is found to support the enamel.
- Enamel thickness: it is clear that the millimetric measurement of the cuspal residue is not sufficient to define its resistance and must necessarily take into account the relative extent in the context of the wall, the thicknesses of enamel and dentin.
- Extent of functional stresses relating to the occlusal component receiving the element (possible presence of parafunctions).
- “Convenience” cavity design: that is, there are situations in which the maintenance of residual tissues is not clinically relevant, while it is strategically useful to incorporate and protect them by involving them conservatively in the cavity design.

Immediate Dentin Sealing (IDS)

Comply with the fundamental principle of “Immediate Dentine Sealing” (IDS). Tooth preparation for indirect restorations can generate significant dentin exposure. Study results indicate that to improve the bond strength with dentin, these freshly cut surfaces should be sealed with DBA (Dentin Bonding Agent) immediately after tooth preparation, before taking impressions. For this specific purpose, the use of a 3-step etchand rinse-type filled adhesive is suggested, but other adhesive systems can also be used. The creation of IDS improves the strength of the microtensile bond compared to delayed dentin sealing (DDS). At the same time, if necessary, coronal relocation of the cervical margins (Deep Margin Elevation) is also performed, a clinical procedure aimed at simplifying subsequent restorative procedures. This involves coronally relocating a deep cervical margin, likely in dentin, with an increment of 1-1.5 mm of highly loaded flowable composite or heated composite. A more fluid flow material is then applied to the rest of the cavity, ideally 0.5 mm thick. Fill the undercuts that inevitably arise during the removal of the carious lesion. It is important to emphasize that during the build-up phase, it is contraindicated to completely remove the unsupported occlusal enamel from the walls to be maintained: the portion of unsupported tissue will partly remain (supported by the build-up) and partly will be removed only during the cavity preparation and margin definition phase. Establish the correct cavity geometry.[30]

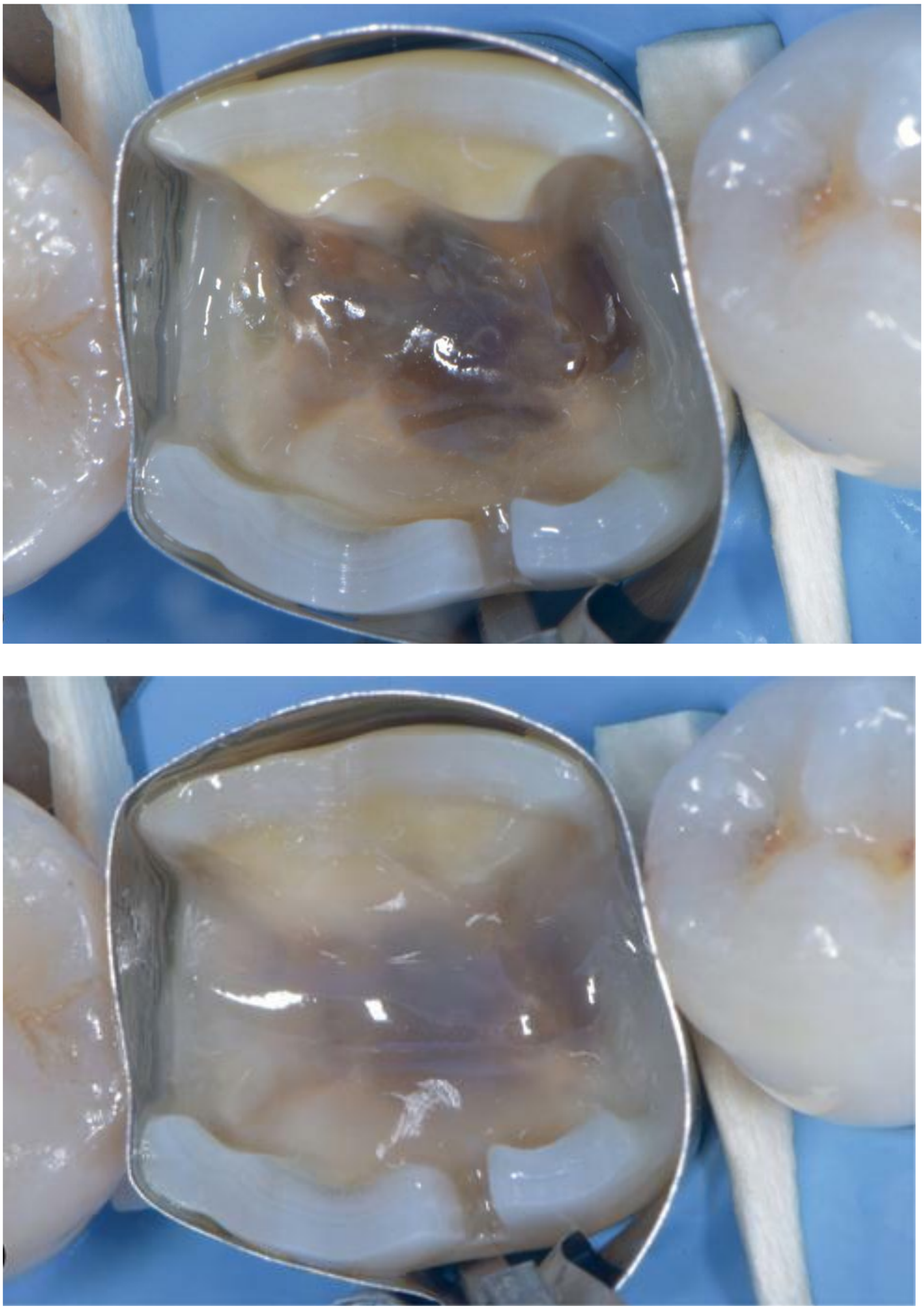


Figure 24: freshly cut surfaces should be sealed with DBA, apply flowable composite

Build-up

There are various advantages to the basic preventive reconstruction (the build-up or block out), which is carried out before proceeding with the definitive preparation:

•The block out of the undercuts, filling the areas in which the indirect restoration would not find a favorable morphology to the substrate. This allows for a conservative preparation, given that some areas that determine the undercut do not need to be physically removed as they are filled with the restorative material of the build-up.

• Immediate hybridization of the den-tin,[31]known as immediate dentin sealing (IDS),[32] especially when the exposed dentinal area is wide, [31]and by the consequent coverage with a material that has a variable thickness, which isolates the dentinal substrate from bacterial, environmental, and thermal situations that can occur, from the impression taking to the adhesive cementation.

• Being able to determine the thickness of the future restoration, an approach that has already been introduced under the names of dentin sealing[33] or dual bonding.[34]

The disadvantages are that the clinician has to perform an additional clinical step with the field isolation, adhesion, and reconstruction. Moreover, shrinkage stress of the build-up can occur if it is not managed properly, which is why resin-based materials with low-shrinkage properties are recommended, in addition to a stratification with controlled volumes.

A controversial question is raised by the presence of an adhesive post (eg. fiberglass) inside non-vital teeth. According to Dietschi et al.[35] the clinical indication for a post is in full-crown restorations where there is little residual hard tissue for the abutment. We assert that the indication for the presence of a post for the purpose of anchorage does not exist in the PIAR protocol, as this type of restoration mainly exploits the adhesive bond resulting from the low-retention de-sign of the preparation. We believe it to be realistic that the risk of fracture of the reconstruction and of the tooth is not increased, as can occur with customized metal posts, because the fiberglass post causes more debonding failures.[36,37]

Teeth restored with fiber-glass posts and composite resin cores showed a homogeneous stress distribution within the root dentin.[38]From a clinical point of view, it is advisable to adapt the post to the canal and not the other way round, so as not to remove healthy dentin and so weaken the residual root. In conclusion, a simple build-up without post is often suggested (Fig 25) for the PIAR. However, according to the aesthetics protocol, adhesive fiber posts are not contraindicated, for instance, in the case of a vast lack of some dental walls, or when it is thought that in future a prosthetic crown could be made on the capable of giving a favorable biomechanical distribution in the radicular dentin.

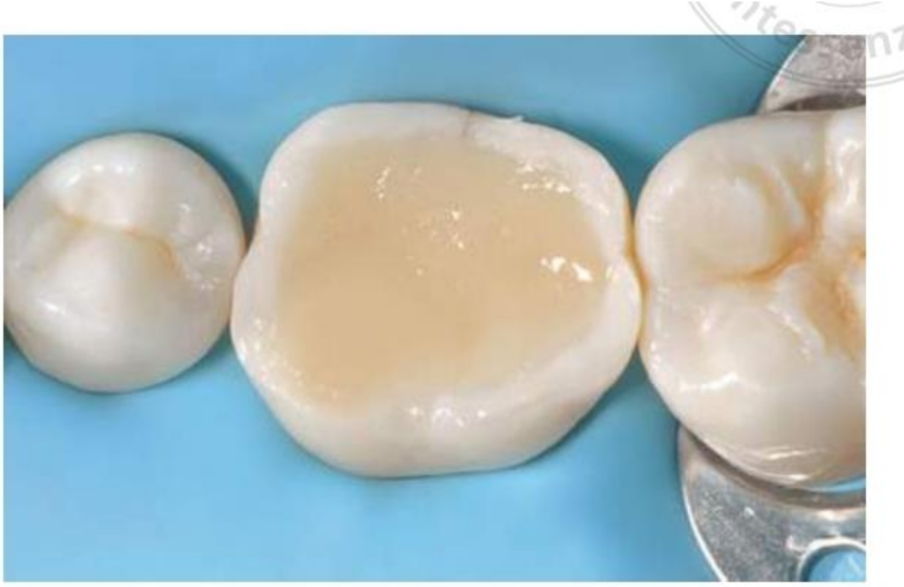


Figure 25: Build-up made with a resin-based compos-ite material. Low-shrinkage materials are useful for this purpose. The enamel margin should remain free in order to have a favorable adhesive substrate at the cementation step.

Preparation designs

Figure 26: Occlusal grooves represent the first step of preparation. They are useful to determine the vertical reduction.

Figure 27: Overlay preparation is done with a palatal butt joint, a buccal bevel (to include some enamel cracks in the preparation), and interproximal slots (the residual enamel was very thin). The central groove is not mandatory; it is done on the build-up to gain a better reference during the positioning phases at cementation, and to give more space in the area of the sulcus.

The morphologies of preparation can be different, depending on the clinical situation, but there are some general rules that apply (Figs 26, 27).

Types of preparations The PIAR can be applied to various needs and different clinical goals. There is no clear classification in the literature for the different types of preparation; therefore, a classification is presented here on the basis of clinical experience. In the case of posterior Onlay/overlay three types of preparation can be ap-plied to the main forms according to the adhesthetics protocol:

1- Axial Preparation Crown preparation is a fundamental procedure in fixed prosthodontics aimed at restoring the function, esthetics, and structural integrity of damaged teeth. Among the various components of tooth preparation, axial preparation plays a crucial role in determining the success of the final restoration. Axial surfaces include the facial, lingual, mesial, and distal walls of the prepared tooth, and their proper design ensures optimal retention, resistance, and marginal adaptation. The concept of axial preparation has evolved with advancements in dental materials and techniques. However, the fundamental biomechanical principles remain consistent, emphasizing conservation of tooth structure while providing sufficient space for restorative materials and this type including:

1.1 The butt joint preparation : requires minimal preparation and is therefore suit-able for adhesive techniques (Fig 28). It is represented by an occlusal reduction that follows the evolution of the cusps and the main sulcus, so is generally flat but with an inclined surface. At the level of the finishing line, the butt joint should have an inclined trend toward and follow the occlusal surface, which is then made more horizontal. The occlusal reduction is generally calibrated by burs with the presence of depth marks.

Indications for a butt joint preparation:

1-Cuspal reduction to protect the teeth from the occlusal load.

2-Cuspal fracture in the area of the occlusal third (or middle third, in some cases).

3-Presence of strong abrasions/erosions of the occlusal surface (with the possibility of increasing the vertical dimension).

Figure 28: Butt joint preparation, which is not flat but mainly follows the inclination of the occlusal plane. The more peripheral margins (buccal and lingual) have a more horizontal design.

1.2 The bevel preparation :(Fig 29) is similar to the butt joint but with the substantial difference of the presence of an inclined bevel, generally of 45 degrees or more, for an average length of 1 to 1.5 mm. which can be more extended in exceptional cases. This beveling is generally present on the buccal side but can also be on the palatal side (eg, in cases where the cracking of the enamel within the preparation should be included [see Figs 27] or when more thickness and support is required for a restoration on a working cusp). Where there is a bevel on the whole circumference, the variant of a full bevel can be considered.

Indications for a bevel preparation:

1-Esthetic need for a more gradual integration of the restoration-tooth transition.

2-Wider surface of external enamel, which enhances adhesive cementation procedures.

3-To create more space for the restoration in the peripheral zone (see Fig 35)

1.3The shoulder preparation: (Fig 30) is a preparation characterized precisely by a rounded shoulder, which develops on the peripheral part of the design. The central part is generally represented by the build-up for block out), usually made of a resin-based material. The thickness of the shoulder is about 1 mm, thus allowing for the largest possible enamel thicknesses that enhance adhesive cementation procedures. The management of the finishing line must be realized with a geometrically determined bur, with a slightly tapered shape and a rounded inner corner. If the bur head diameter is 1 mm, it should be sunk to the entire thickness of the substrates to be prepared, but if it is larger, it should not be completely sunk

Indications for shoulder preparation:

1-Previous cuspal fracture to the cervical third (or medium third in some cases), and then, by effect, the central build-up automatically defines the peripheral shoulder design .

2-Where greater structural protection is required for a cusp coverage with a cervical grasp

2. Proximal preparation designs There are three types of approaches for the interproximal areas according to the adhesthetics protocol: slot, bevel, and ridge up.

Figure 29: Bevel preparation. This kind of design is a variant of the butt joint, where it is possible to create a bevel (usually between 1 and 1.5 mm in length) on one or more surfaces. In this case, it is evident on the buccal side.

Figure 30: Shoulder preparation. A rounded shoulder characterizes this preparation design. The depth of the shoulder is usually around 1mm.absence of inflammatory processes.

2.1 Slot: a frequent interproximal preparation is represented by this design, which has a rounded shoulder (coherent with the shoulder preparation). generally, of about 1 mm (Fig 31). One reason for this preparation being so widespread is because this type of shoulder is naturally determined after the excavation of an interproximal carious lesion, allowing for the creation of a central reconstruction to the dental crown

2.2 Bevel: a less invasive preparation compared with the slot for restoring the interproximal area without going in too deeply at the cervical level. This configuration offers some advantages for a bevel preparation (Fig 32), such as a good surface of enamel, which enhances the adhesive cementation procedure. This preparation is indicated when an extensive restoration needs to be made to the interproximal area without a previous carious lesion, and localized cervically compared to the contact area.

2.3 Ridge up: the ridge preservation variant of this approach allows for the maintenance of the integrity of the marginal ridge (Fig 33), whereas the ridge coverage variant allows for minimal surface preparation (Fig 34), preserving the contact area that has not obviously suffered from carious lesions. Given that the ridge is one of the most important structural elements with regard to the integrity of the non-vital tooth,[39]in cases of reduced thickness of the adjacent cusps one can opt for a cuspal coverage with the preservation of the ridge. The indication for this type of preparation is a cuspal coverage with the purpose of structural protection, but with a good integrity of the ridge and the absence of cavitated carious lesions (Figs 35). **Preparation and finishing: clinical protocol First preparation:** Analysis and choice of preparation Cavity diagnosis plays a fundamental role in the choice of a preparation. The preparation should be made with clean cavities, without residual decay or previous restorations

Occlusal preparation: One of the first steps is the creation of occlusal grooves to determine the height of the preparation (see Fig 26) This cart be done using different types of burs such as rounded diamond burs (which are sunk to half their diameter and which produce a groove of a certain thickness) or tapered burs with depth marks (drawn with the laser) that allow for the use of rotary instruments such as a probe .The regularization of the occlusal sur face can be performed with the same conical tapered diamond burs, either medium grit (107 µm) or coarse grit (151 µm). The thicknesses to maintain vary, depending mainly on the restorative material being used: 2 mm is a se cure thickness in the case of layered composite, although it may be slightly lower. A thickness of 1 mm is suitable for monolithic restorations, ceramic materials such as lithium disilicate, and resin-based materials reinforced with ceramic, which in conditions of normal masticatory loads could be used up to a thickness of 0.5 mm a thickness of between 1.0 and 1.5 mm is considered safer in order to avoid clinical complications, even for a high-resistance glass ceramic such as monolithic lithium disilicate.[40]

Peripheral preparation: This can vary depending on the chosen design (butt joint, bevel or shoulder) and interproximal access, if required, which can be made with a pointed bur (ie, 858-314-010) especially to create the bevel to create a shoulder slot, a tapered bur with a reduced diameter can be used (847-314-012)

Finishing of the preparation: Once the first preparation has been done and the shape of the cavity is thus defined, surface finishing coherent with the preparation can be performed. For this purpose, for the adhesthetics protocol a fine grit bur (46 µm) with a reduced number of speeds can be used This should preferably be assembled on the speed-increasing handpiece (ie, red ring). The shape and dimension should be coherent with the burs used for the first preparation. The last step is the definitive finishing of the edges and, if desired, the flat surfaces. This phase in the adhetsthetics protocol can be done with manual instruments such as a chisel, or with diamond instruments. Preferably, extra-fine grit burs (25 µm) should be used, which have been introduced into the kit of adhesthetics burs so as to always have points with a coherent shape and dimension that can give an accurate definition of the finishing line, both in the shoulder and the interproximal slot as well as for the finishing of the occlusal inclined surface . When these types of burs are used, the goal should be to polish off the edges and surfaces using reduced pressure so as not to create undesired microgrooves. If a revision (also minimal) of the preparatory design is necessary, it is advisable to go back one or more steps

and use burs with a larger grit size. It is optional to use polishers to polish some of the preparation surfaces.

Figure 31: Slot interproximal preparation. This kind of design is very common, especially when a previous carious lesion has affected the area.

Figure 32: Bevel interproximal preparation. This approach is more conservative compared with slot interproximal preparation. It is suitable for when the contact area must be restored without managing a cavity from a previous carious lesion process.

Figure 33: Ridge up interproximal preparation. The most conservative approach for the ridge when a cuspal coverage is performed. In the variant known as ridge preservation, the aim is to maintain the structure intact.

Figure 34: Ridge up interproximal preparation. In the variant known as ridge coverage, the ridge is slightly prepared.

Figure 35: Non-vital overlay preparation. Ridge up (ridge coverage variant) on the mesial surface, slot on the distal surface, and bevel on the buccal surface. Processes.

Materials used in indirect posterior restoration

Fundamentally, solid materials in nature are classified based on their atomic bonding and microstructural network into three main classes: metals, ceramics, and polymers[41]. In the context of modern indirect posterior adhesive restorations, metallic materials are generally excluded. This is primarily because metals rely on traditional macromechanical retention rather than true micromechanical adhesion, as they cannot be conventionally acid-etched. Furthermore, they do not fulfill the current high esthetic demands. Consequently, the contemporary approach strictly focuses on tooth-colored materials that are capable of establishing a reliable adhesive bond with the tooth structure. These adhesive materials are broadly classified into: -

1. Composite materials

1.1 Clinical or laboratory composites layered in a traditional manner on a plaster model obtained from a traditional impression with elastomers.

1.2 Ceramic-reinforced polymers manufactured using CAD/CAM with the development of a stereolithographic or model-free model.

- resins nano-ceramic RNC (many companies produce composite ingots, such as Lava™ Ultimate, 3M; Cerasmart, GC; Grandio blocs, VOCO; BRILLIANT Crios, Coltene, etc.).
- Ceramics infiltrated with polymers PICN, such as VITA ENAMIC® (Vita Zahnfabrik).
- Resin matrix reinforced by ultrafine zirconium-silica particles (e.g., ParadigmTM, 3M ESPE).[42]

2. Ceramic materials

1. Etchable glass-ceramics (silica-based):

    - feldspar ceramics.
    - synthetic ceramics (vetroleucite, lithium disilicate, zirconia-reinforced lithium silicate).
    - glass-infiltrated ceramics (alumina, alumina-magnesium, alumina-zirconia).

2. Non-etchable polycrystalline ceramics:

   - alumina.
   - stabilized zirconia.
   - zirconia-reinforced alumina.
   - alumina-reinforced zirconia.

The above materials can be used to create CAD/CAM milled or cast restorations. [43] Simply put, the following are generally used:

- layered paste composites or milled CAD/CAM block composites, cemented after sandblasting or silicatization and the application of silane.
- Cast or CAD/CAM milled lithium disilicate cemented after etching and silane application.

Alternatives include etchable polymer-infiltrated ceramic (PICN VITA ENAMIC®, Vita Zahnfabrik) and zirconia-reinforced lithium silicate (Celtra Duo, Dentsply Sirona).[44]

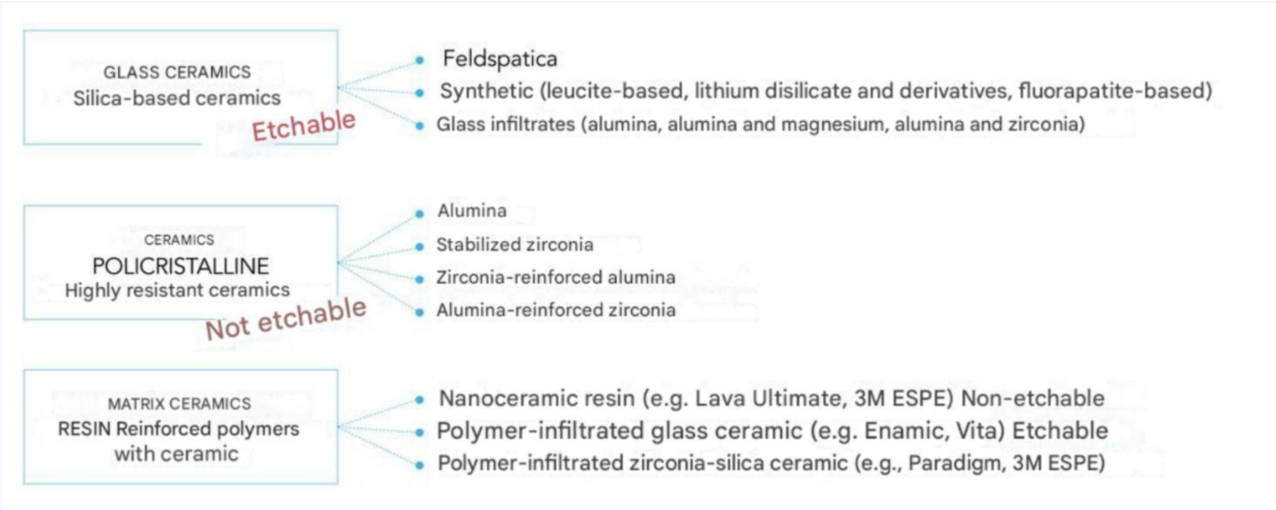
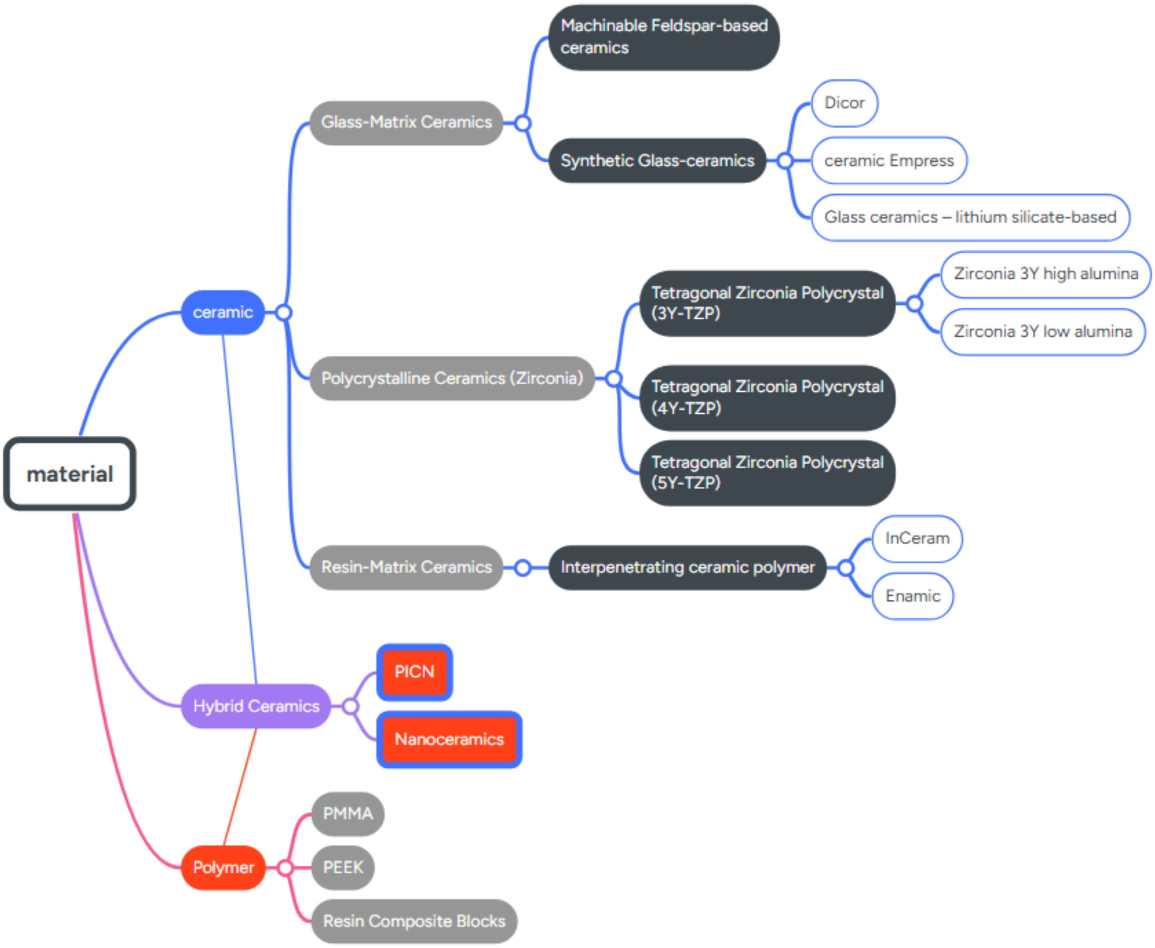


Figure 36: Posterior Indirect Adhesive Restorationcaries.



Clinical Considerations and Material Selection Strategy

The selection of restorative materials for indirect posterior adhesive restorations remains a subject of ongoing debate within the contemporary literature. Current evidence derived from systematic reviews suggests that there is no statistically significant difference in the overall clinical performance between ceramic inlays and resin composite restorations. Consequently, the concept of a universally superior material is not supported by robust scientific data[45,46].

In light of this, material selection should be guided by a case-specific, evidence-based approach rather than a generalized preference. Clinicians are encouraged to evaluate the unique clinical parameters of each case, including occlusal load, cavity design, esthetic demands, remaining tooth structure, and patient-related factors. This individualized strategy enables the practitioner to optimize treatment outcomes by leveraging the distinct mechanical and biological advantages inherent to each material category[47,48].

Ultimately, a rational selection protocol that integrates current evidence with clinical judgment is essential to achieving long-term success in indirect posterior adhesive restorations.

From a biomechanical standpoint, resin composite materials exhibit behavior closely resembling that of human dentin, particularly due to their comparable modulus of elasticity (10–16 GPa versus approximately 18.6 GPa for dentin). This similarity contributes to a stress-absorbing effect under functional loading, which may reduce the risk of catastrophic failure in restored teeth. In addition, resin composites are associated with reduced technical sensitivity during fabrication and placement, as well as lower overall treatment costs. Their wear characteristics are generally compatible with opposing enamel, and they offer a distinct clinical advantage in terms of reparability, as intraoral repair or rebasing can be performed with relative ease. Moreover, the use of composite materials throughout the restorative complex—including the build-up, luting agent, and indirect restoration—facilitates the formation of a more homogeneous adhesive interface.However, these favorable properties must be balanced against certain material limitations. Resin composites demonstrate higher coefficients of thermal expansion (20–50 × 10^{-6}/°C) compared to dental ceramics, as well as increased water sorption, both of which may compromise marginal integrity over time. Additionally, their long-term surface and color stability are generally inferior to those of ceramic materials, potentially affecting esthetic outcomes in the long term.Clinically, indirect resin composites are particularly indicated for single onlay restorations involving partial cuspal coverage, especially in cases where preservation of tooth structure and stress modulation are prioritized. They are also advantageous in situations where future endodontic or prosthetic re-intervention is anticipated, given their reparability, as well as in patients with financial constraints where cost-effective treatment options are required[49,50,51,52].

Glass-ceramic materials, particularly lithium disilicate, exhibit physical and mechanical properties that closely resemble those of natural enamel, thereby providing a rigid and durable restorative option for indirect posterior applications. Their favorable optical properties contribute to superior esthetic outcomes, while their excellent dimensional and color stability over time enhance long-term clinical predictability. In addition, glass-ceramics demonstrate extremely low water solubility and a coefficient of thermal expansion (11–17 × 10^{-6}/°C) that is highly compatible with dental hard tissues, supporting the maintenance of marginal integrity.

Despite these advantages, the clinical use of glass-ceramics is associated with increased technical sensitivity, particularly in relation to adhesive protocols and laboratory procedures, which may influence the overall complexity of treatment. Furthermore, these materials are generally more costly than resin-based alternatives. Certain ceramic systems, especially layered feldspathic ceramics, may also present an increased susceptibility to fracture and may exhibit less favorable wear characteristics against opposing dentition under specific conditions[53,54,55,56,57].

From a clinical perspective, monolithic lithium disilicate is widely regarded as a material of choice for extensive restorations involving complete cuspal coverage, including overlays, overlay-veneers, and adhesive crowns. Its high modulus of elasticity allows for effective splinting and stabilization of structurally compromised cusps, making it particularly suitable for teeth affected by Cracked Tooth Syndrome[58].

A final, crucial parameter in the decision-making process is the nature of the opposing tooth. If the antagonist tooth is already restored with a ceramic material, it is highly advisable to select a ceramic restoration for the prepared tooth to maintain tribological compatibility and prevent uneven wear rates.

Impression techniques

Precision impressions can be performed in two main ways:

- Traditional impression using elastomers (polyethers or polyvinyl siloxanes, PVS).
- Digital optical impression using a 3D intraoral scanner.

Traditional impression using elastomers (polyethers or polyvinyl siloxanes, PVS)

The materials of choice are polyethers and PVS. Polyethers (Fig. 41a-e) are very precise but also very rigid materials and require filling of any undercuts present in unprepared teeth; the author recommends a single-impression technique with two different consistencies: PermadyneTM Light (3M, ESPE), to be injected with a special syringe, and ImpregumTM Soft (3M, ESPE) in the impression tray. Polyvinyl siloxanes always used with a single-impression technique (for example, Flexitime®, Kulzer Light Flow+Monophase (Fig. 37) or Aquasil (Dentsply Sirona) Light + Regular (Fig. 38) are the real alternative to PE; they are equally precise and, thanks to their greater elasticity, removal is easier but above all laceration of the impression material in the interdental spaces of the preparations is less likely. Individual impression trays or commercial impression trays can be used – as long as they are not perforated – after applying the appropriate adhesive to detect both agonist and antagonist (the latter can also be detected in alginate). The occlusion (generally maximum intercuspation or, for complex cases, centric relation or better "reference position") is detected with special rigid waxes (Beauty Pink extra hard, Miltex ex Moyco) heated in a thermostatic pot or with self-mixing occlusion silicones (such as Flexitime® Bite, Kulzer; Occlufast, Zhermack etc.). In some cases it is also possible to use a dual arch half-impression tray of the check-bite type in metal (COE, USA n. 72) which allows the registration of the prepared element, the antagonist teeth and the habitual occlusal relationship (Fig. 39). This technique is however mainly indicated for single teeth and requires a stable class I occlusion; it has the advantage of reducing operating times and of recording both half-arches in precision material. The impressions are cast at least twice, obtaining a plaster model with removable dies (see for example

Fig.37) and a second non-separated model which will allow a more precise evaluation of interproximal contact points (see for example Fig. 37).[59,17,60]

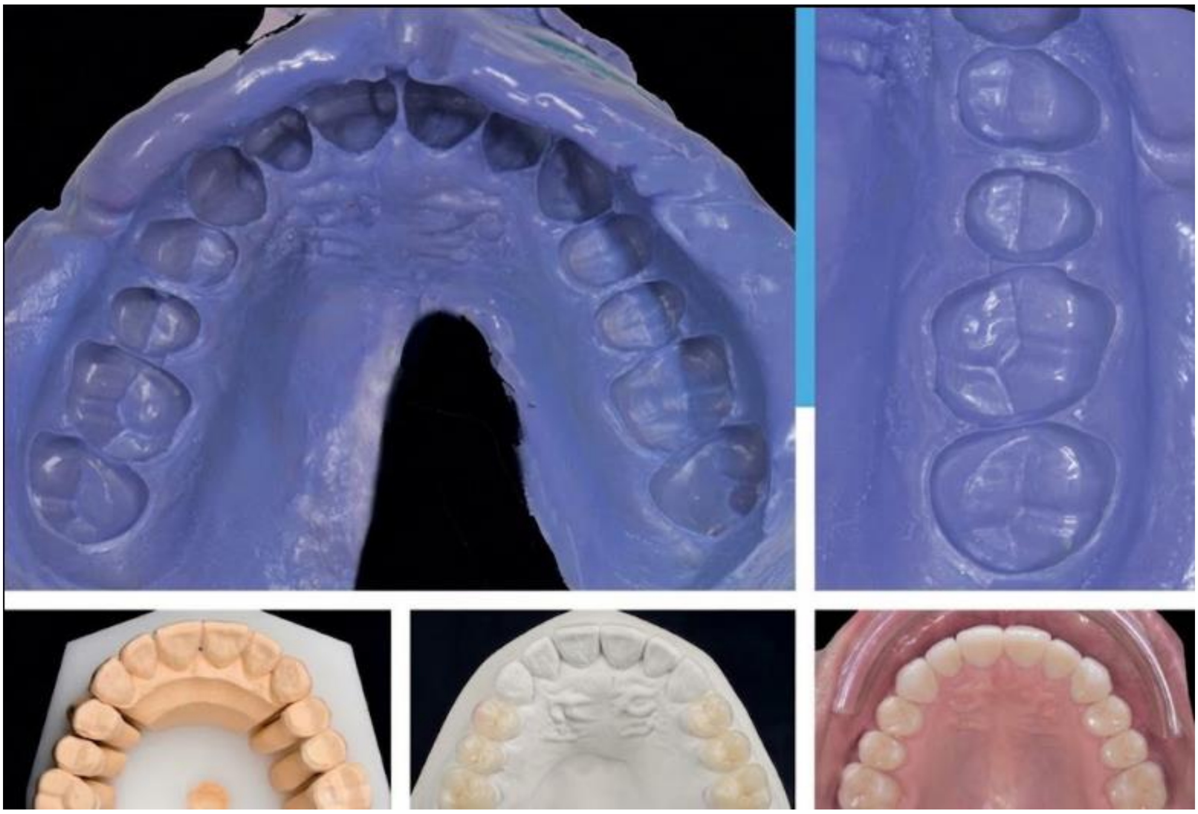


Figure 37: Flexitime Impression

Figure 38: Dentsply Sirona Impression

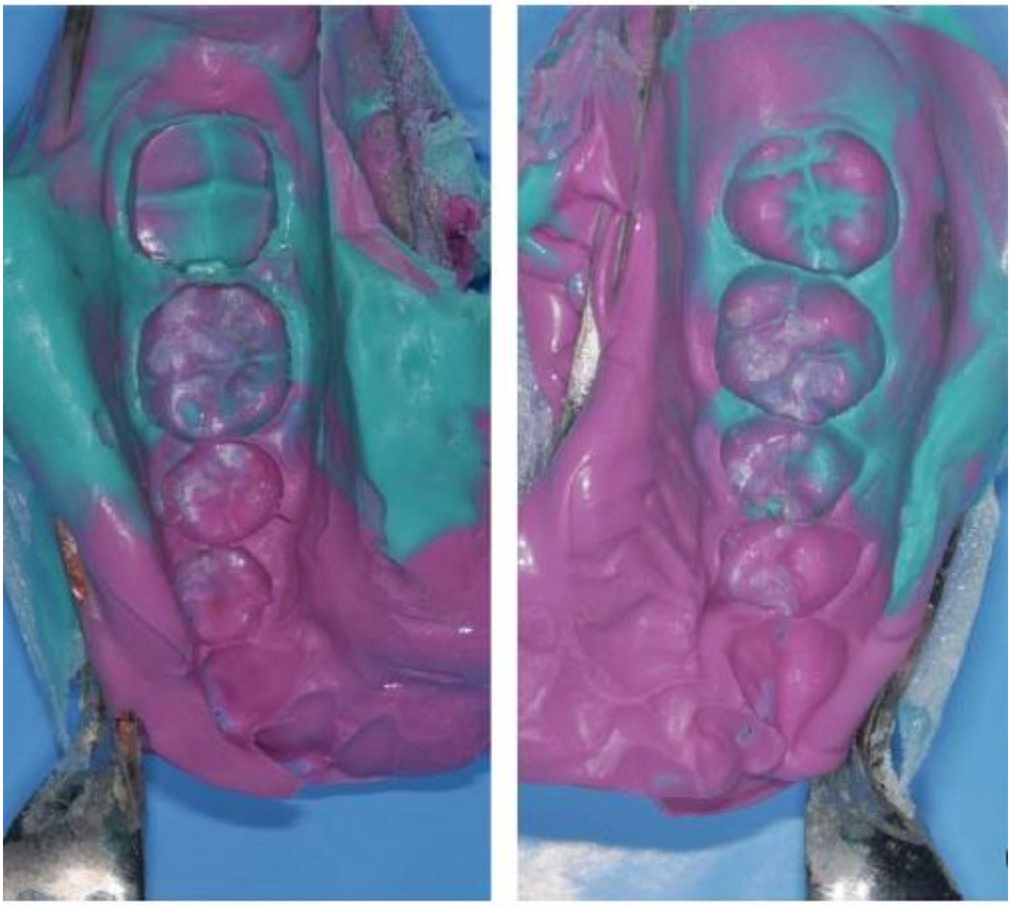


Figure 39: Dual arch half-impression habitual occlusal relationship.

Digital optical impression using a 3D intraoral scanner

Undoubtedly, it is the technique of first choice today, as modern 3D intraoral scanners (e.g. Omincam/Primescan, Dentsply Sirona; Trios 3/4, 3Shape) allow for precision acquisitions comparable to traditional techniques[8], allow the use of a series of innovative CAD-CAM millable restorative materials, allow for the execution of semi-direct chair-side or indirect restorations, are better accepted by the patient who perceives digital technologies favorably, provide STL files that can be transferred more easily and quickly to the laboratory via the web rather than by courier. The margins of the preparations are defined on the digital impressions and the stereolithographic models are obtained from the digital impressions themselves, thanks to special 3D printers, creating, especially in the case of multiple restorations, two models: one non-separated and one with removable stumps; the consistency of the interproximal and occlusal contacts is established digitally in the design phase by regulating the virtual intensity of the contacts themselves which will then be checked on the resin model. In case of preparation of a single element (Fig. 40), or even with a small number of elements, it is possible to make a half-impression: the digitally detected monolateral occlusion is perfectly "stable" and reliable. An impression of the entire arch is preferable in the case of multiple elements, even if they are ipsilateral (Fig. 42), so that the technician can have contralateral morphological reference. However, it is necessary to take a full-arch impression (Fig. 41) in the case of rehabilitation extended to all[61] .

Figure 40: half-impression 3D intraoral scanner.

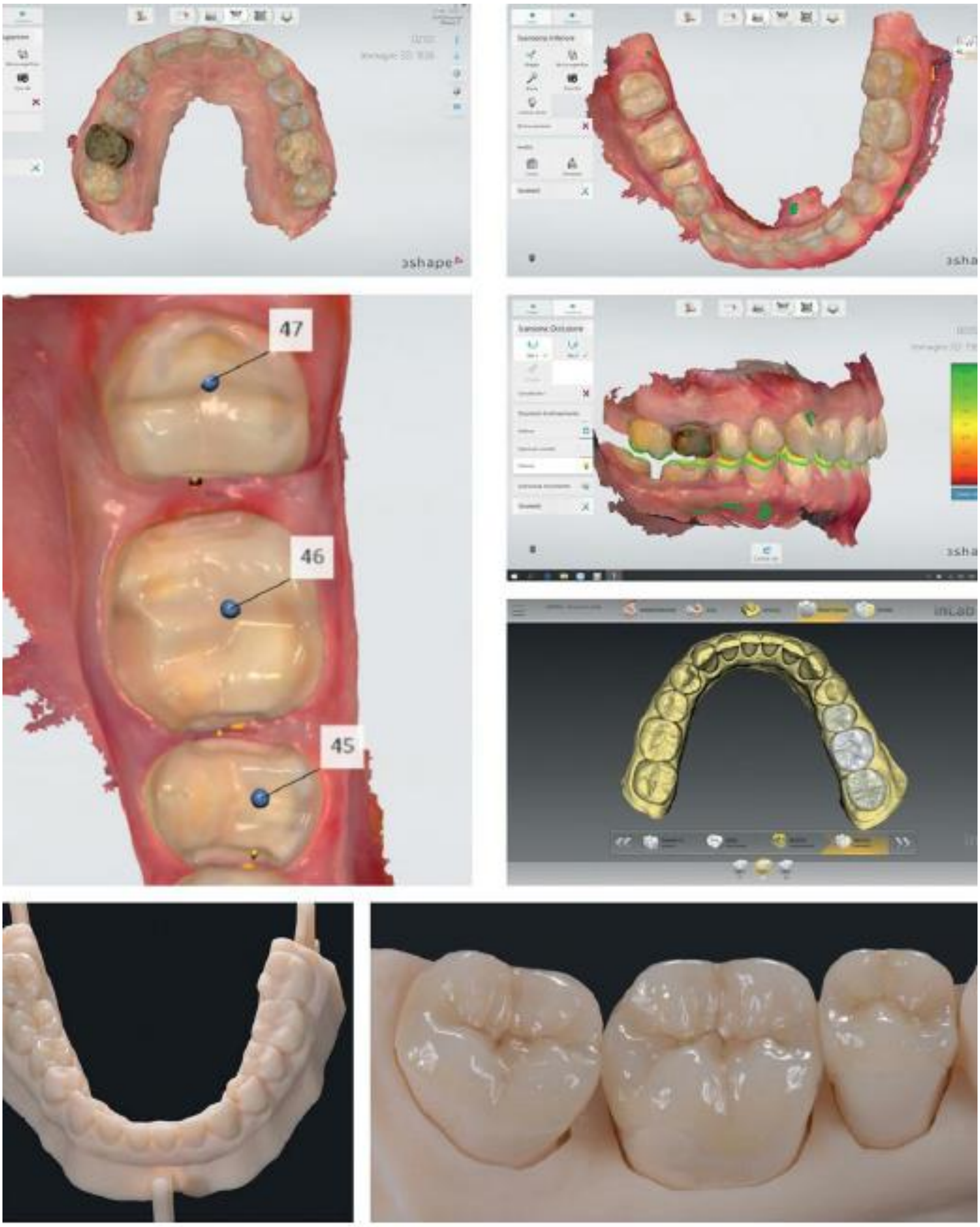


Figure 41: multiple elements 3D intraoral scanner.

Cementation protocol

1. Luting composite

- Resin cements are divided into three groups according to polymerization process: chemically activated cements, light-cured cements, and dual-cured cements[62]. Of the three, light-cured resin cements have the clinical advantages of longer working time and better color stability, but curing time, restoration thickness, and overlay material significantly influence the microhardness of the resin composites employed as luting agents[63].
- The strongest luting composite must be selected to create a good support for the partial ceramic crown; the antifragile margin preparation is a key determinant as well. Therefore, a preheated light-curing restorative composite is preferred to be used as luting agent. A restorative composite is more wear-
- resistant and has better physico-mechanical properties than a conventional dual-curing luting composite with lower filler content.[64]
- Several clinical trials have shown that inlays/onlays bonded with a preheated light-curing restorative composite function well in the long term[65,66,67,68].Cement excess removal is easier thanks to the higher viscosity of the restorative composite as compared to the significantly more fluent and thinner luting composites.
- Clinically, luting with a preheated light-curing restorative composite gives the practitioner much more control on complete removal of cement excess and substantially increases the work time to accurately remove cement excess, especially in the difficult interdental areas.[85]
- Preheating composite facilitates the seating of the restorations and contributes to a higher degree of conversion[69].
- Preheating could lead to an increase in polymerization depth and greater molecular mobility,[70] thus increasing the propagation of polymer chains, and ultimately, optimizing polymerization. It has been observed that when using preheated dual cure resin cements or microhybrid composite resin for cementation, there was a decrease in

the negative influence of restoration thickness and also an increase in the conversion rate, with some variation between different commercial brands[71].

Figure 42: conventional impression of inlay made with polyvinylsiloxane impression material.

2. Resin cements

Resin cements are considered the best choice for luting indirect posterior adhesive restorations such as inlays, onlays, and overlays due to their superior bonding ability, strength, and durability. They provide strong micromechanical and chemical adhesion to both tooth structure (enamel and dentin) and restorative materials such as ceramics and composite resins, which results in improved retention and better marginal seal. These cements are characterized by low solubility in oral fluids, which helps maintain long-term stability of the restoration and reduces the risk of marginal leakage. Resin cements are generally classified into three main systems based on their adhesive strategy. The total-etch (etch-and-rinse) system involves phosphoric acid etching followed by application of a bonding agent, offering the highest bond strength, particularly to enamel, but it is technique-sensitive and involves multiple clinical steps. The self-etch system simplifies the procedure by combining conditioning and priming steps, which reduces postoperative sensitivity while still providing acceptable bond strength. The self-adhesive resin cements are the simplest to use, as they do not require separate etching or bonding steps, but they generally provide lower bond strength, especially to enamel. In addition, resin cements are classified according to their polymerization mechanism into light-cure, self-cure, and dual-cure types. Dual-cure resin cements are the most commonly used in indirect posterior restorations because they ensure complete polymerization even in areas where light penetration is limited, such as deep or thick restorations. Overall, resin cements are preferred in indirect posterior adhesive restorations because they enhance retention, reinforce the restoration, and provide excellent esthetic and mechanical performance over time. [72]

Comparison Table: Resin Cement vs. Luting Composite

Feature (Basis for Comparison)	Luting Resin Cement	Flowable Composite (Luting)
Viscosity (Flow)	Excellent (High flow)	Good (More viscous/cohesive)
Film Thickness	Very thin (Best for crowns)	May be slightly thicker
Bond Strength	Very high (Chemical & Mechanical)	Very high
Excess Removal	More difficult (Sticky)	Easier (Stiffer)
Best Use	Crowns / Bridges (Zirconia/Metal)	Veneers

3.Surface treatment of indirect composite restorations

Surface treatment of composites is essential to enhance adhesion by improving surface roughness, surface energy, and wettability. These modifications allow stronger micromechanical interlocking and chemical bonding between the composite substrate and the luting or repair material. Surface treatments are broadly classified into mechanical, chemical, and physical methods. Mechanical treatments, such as alumina (Al_2O_3) air abrasion (≈50 µm particles), diamond bur grinding, and manual abrasion, are widely used to roughen the surface and remove contaminants. This creates micro-retentive features that significantly improve bonding through mechanical interlocking. Chemical treatments involve acid or alkaline etching and, more importantly, the application of silane coupling agents. Silane promotes chemical bonding by forming a link between the organic resin matrix and inorganic filler particles, particularly in silica-containing composites. Physical or advanced treatments include plasma, laser (e.g., Nd:YAG), and corona discharge technologies. These methods increase surface energy and introduce reactive functional groups without significantly damaging the substrate, thereby improving adhesive performance. A specialized technique, peel ply, involves removing a sacrificial surface layer to expose a clean, textured bonding surface free from contamination. For repair of aged composites, air abrasion using aluminum oxide particles is generally more effective than bur roughening. Additionally, silicatization followed by silanization has been shown to provide superior bond strength. Optimal bonding is achieved by combining mechanical surface roughening with chemical priming, particularly with adhesive systems containing functional monomers such as MDP, which enhance chemical interaction with the substrate. Overall[73]

The primary goals of surface treatment are:

- Increasing surface roughness for micromechanical retention
- Enhancing surface energy and wettability
- Eliminating surface contaminants[74]

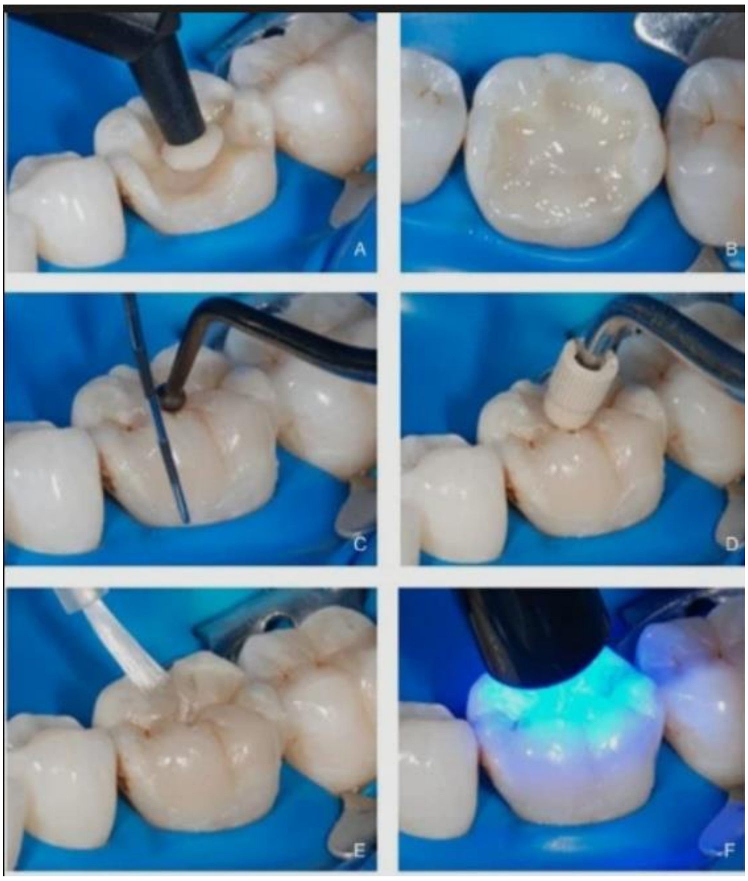


Figure43: Surface treatment of indirect composite.

3. **Surface treatment of indirect ceramics restorations**

Surface treatment of dental ceramics is essential to achieve strong and durable bonding between the restoration and tooth structure. The method used depends mainly on the type of ceramic. For silica-based ceramics such as feldspathic or lithium disilicate, surface treatment typically involves hydrofluoric acid etching, which creates micromechanical roughness by dissolving the glassy phase. This is followed by the application of a silane coupling agent, which enhances chemical bonding between the ceramic and resin cement. For zirconia (non-silica-based ceramics), hydrofluoric acid is ineffective. Instead, airborne particle abrasion (sandblasting with alumina particles) is used to increase surface roughness. Additionally, the use of MDP-containing primers or resin cements is important to establish chemical bonding. Overall, successful ceramic surface treatment relies on combining micromechanical retention (through roughening) and chemical adhesion (through silane or functional monomers), which significantly improves bond strength and longevity of the restoration.

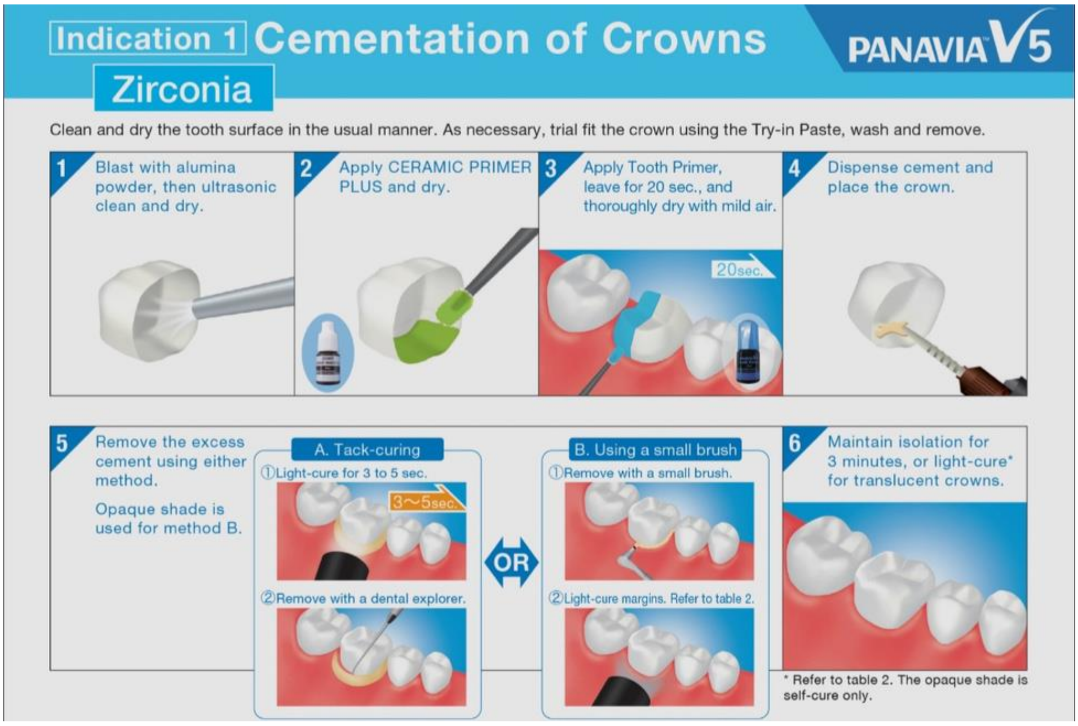


Figure 44: Surface treatment of indirect ceramics.

Finishing and Polishing

Principles of Mechanical Finishing and Polishing

The fundamental mechanisms underlying the mechanical finishing and polishing of dental materials are rooted in tribology a multidisciplinary field intersecting materials science, physics, chemistry, and surface contact engineering. The efficacy of these procedures is governed by the dynamic interplay between operational variables (such as applied pressure, rotational velocity, and instrumentation time) and the structural characteristics of the tribological system (including the nature of the contact interface and surrounding environmental media)[75].

Clinically, finishing and polishing protocols utilize specialized instruments and abrasive media to induce a controlled, targeted wear on the restorative substrate[76]. In this context, wear manifests as progressive surface degradation, where mechanical forces facilitate the transfer of energy, resulting in the displacement or micro-excision of the material as debris[77]. This material reduction typically occurs via four primary mechanisms: abrasive, adhesive, fatigue-induced, and tribochemical wear[81]. The overarching objective of these mechanical interventions is to accurately replicate natural anatomical morphology, establish occlusal equilibrium, and eradicate surface irregularities, such as striations or micro-gouges, introduced during the initial preparation phases.

Clinical Objectives and Outcomes

The meticulous execution of finishing and polishing protocols yields four critical clinical benefits: the preservation of periodontal and gingival health, the optimization of masticatory function, the enhancement of patient comfort, and the realization of superior aesthetic outcomes[78].

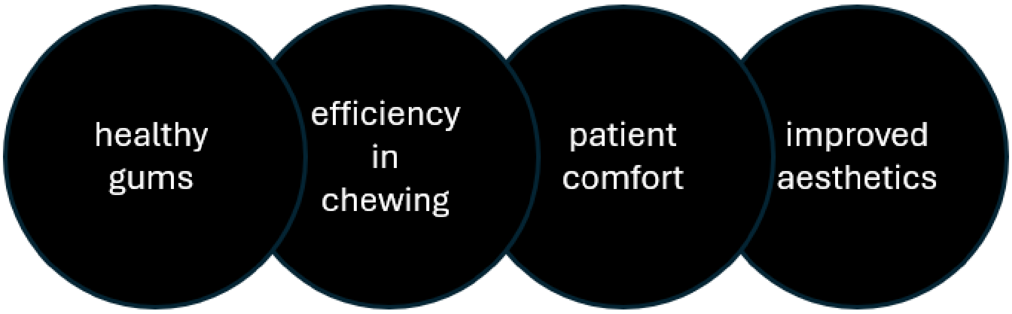


Figure 45: aim of finishing and polishing.

Specifically, the primary aim of these restorative procedures is to establish precise marginal adaptation, appropriate proximal contacts, and optimal anatomical contours. Furthermore, the elimination of surface macro- and micro-irregularities generates a highly smooth, biologically compatible restorative interface. Ultimately, satisfying these clinical parameters is foundational to ensuring the long-term functional success, aesthetic integration, and overall oral well-being of the patient[79,80,81].

Finishing and polishing composite restoration.

Initially, the composite surface was finished using medium-grit aluminum oxide discs (Sof-Lex™ XT, dark orange) to remove gross irregularities and establish the primary contour. This was followed by the application of fine-grit aluminum oxide discs (Sof-Lex™ XT, light orange) to refine the surface and reduce scratches produced during the initial finishing stage. Subsequently, a pre-polishing phase was carried out using Enhance® multi-polishing resin finishing cups, which contributed to further smoothing of the composite surface. The polishing procedure was then continued using a diamond polishing spiral (Sof-Lex™ Diamond Polishing Spiral, rose), allowing for enhanced surface uniformity and increased gloss due to the presence of fine diamond abrasive particles. In the final stages, a diamond polishing compound (Diashine® intraoral polishing paste) was applied using a soft-bristle brush, facilitating the dispersion of abrasive particles and improving surface luster. The procedure was completed with the use of a suede disc to achieve a high-gloss finish. Overall, this protocol integrates sequential abrasive systems of decreasing particle size, combining aluminum oxide discs, silicon-based polishers, diamond abrasives, and polishing paste. This multistep approach has been shown to produce the lowest surface roughness and highest gloss among the tested protocols, thereby enhancing the aesthetic and functional properties of the composite restoration. [82]

Finishing and polishing ceramic restoration

Finishing and polishing procedures are critical steps in the clinical success of ceramic restorations, as they directly influence surface smoothness, aesthetics, wear behavior, and plaque accumulation. After occlusal adjustment using fine-grit diamond burs, the ceramic surface undergoes a sequential polishing protocol aimed at reducing surface roughness and restoring gloss. Typically, this process begins with medium- to fine-grit diamond abrasives to eliminate gross irregularities created during adjustment. Subsequently, polishing is performed using rubber polishers impregnated with diamond particles, which progressively refine the surface by decreasing abrasive particle size. Further enhancement of surface smoothness is achieved through the application of diamond polishing pastes using felt wheels or soft brushes. This step allows for the production of a highly lustrous surface comparable to glazed ceramics. It has been demonstrated that properly polished ceramic surfaces can exhibit surface roughness values similar to or even lower than those achieved with glazing techniques. Moreover, polished ceramics are associated with reduced antagonist wear and improved longevity compared to reglazed surfaces after intraoral adjustments. The choice between glazing and polishing depends on the clinical situation; however, intraoral polishing is often preferred following chairside adjustments, as reglazing requires laboratory procedures and may not be feasible. Therefore, a systematic multistep polishing protocol using diamond abrasives and polishing pastes is considered essential for optimizing the functional and aesthetic outcomes of ceramic restorations.[83]

Chapter3

Discussion

DISCUSSION

Conservation of healthy tooth structure plays a critical role in maintaining tooth biomechanics, improving stress distribution, and enhancing overall resistance form. In endodontically treated teeth, bonded lithium disilicate overlays provide a more conservative alternative to full-coverage crowns by preserving axial walls while maintaining adequate strength.[84]

The morphology-driven preparation technique emphasizes the importance of enamel rod orientation, height of contour, and the enamel–dentin interface. Conventional sharp margins or shoulder preparations may expose dentin unnecessarily and create unfavorable bonding conditions due to longitudinal sectioning of enamel rods. In contrast, concave bevel (hollow-ground) margins allow transverse cutting of enamel rods, improving bonding quality while preserving the critical pericervical dentin.[85]

Lithium disilicate is highlighted as a favorable material due to its high fracture resistance and modulus of elasticity similar to enamel, allowing it to mimic natural tooth biomechanics. Immediate dentin sealing (IDS) further enhances bond strength and protects dentin. Overall, morphology-driven preparation improves resistance, bonding quality, marginal integrity, and esthetics, although maintaining adequate material thickness remains a clinical challenge. In some cases with extensive structural loss, full-coverage restorations may still be more appropriate than partial coverage options.[86,87]

Chapter4

Conclusions

Conclusions

The clinical success, predictability, and long-term longevity of posterior indirect adhesive restorations depend heavily on a comprehensive understanding of substrate optimization, biomechanical stress management, and appropriate material selection. Central to this approach is the maintenance of tooth structure that is highly responsive to adhesive protocols, with well-represented enamel margins remaining the most reliable and stable substrate for durable adhesion. Building upon this foundation, the implementation of Immediate Dentin Sealing (IDS) alongside careful cavity configuration (C-factor) analysis represent critical principles in modern adhesive dentistry. The synergistic application of IDS and C-factor control not only yields superior dentin bonding and essential pulpal protection but also effectively mitigates the polymerization shrinkage stress associated with complex cavity designs. When managing endodontically treated teeth for these restorations, current evidence generally advocates for a simplified core build-up without the mandatory inclusion of an endodontic post. However, the use of adhesive fiber posts is not contraindicated and remains a viable, sometimes necessary, option in clinical scenarios involving extensive loss of dental walls to ensure a favorable biomechanical stress distribution within the radicular dentin. Finally, the definitive success of these restorations relies upon precise cementation protocols, as the selection of an optimal luting agent is vital for providing adequate structural support to partial ceramic crowns. In this regard, preheated light-curing restorative composites are predominantly preferred over conventional dual-curing luting composites due to their superior physico-mechanical properties, enhanced wear resistance, and improved long-term color stability.

Reference

1 Nathanson D. Current developments in esthetic dentistry. Current Opinion in Dentistry 1, 206-211, 1991.
2 Liebenberg WH. Posterior composite resin restorations: operative innovations. Practical Periodontics and Aesthetic Dentistry 8, 769-778, 1996.
3 Ritter AV, Boushell LW, Walter R. *Sturdevant's Art and Science of Operative Dentistry*. 8th Edition. Elsevier, 2024.
4 Magne P, Dietschi D, Holz J. Esthetic restorations for posterior teeth: practical and clinical considerations. *International Journal of Periodontics & Restorative Dentistry* 16, 104-119, 1996.
5 Dietschi D, Spreafico R. *Adhesive Metal-Free Restorations: Current Concepts for the Esthetic Treatment of Posterior Teeth*. Quintessence Publishing, 1997.
6 Dietschi D, Magne P, Holz J. Recent trends in esthetic restorations for posterior teeth. *Quintessence International* 25, 659-677, 1994.
7 Loomans BA, Opdam NJ, Roeters FJ, et al. Comparison of proximal contacts of Class II resin composite restorations in vitro. *Operative Dentistry* 31, 688–693, 2006.
8 Veneziani M. Posterior indirect adhesive restorations: updated indications and the Morphology Driven Preparation Technique. *International Journal of Esthetic Dentistry* 12, 204-230, 2017.
9 Grippo JO, et al. Abfraction, abrasion, biocorrosion and enigma of noncarious cervical lesions: 20-year perspective. J Esthet Restor Dent 2012;24(1):10-23.
10 Wendt SL, Leinfelder KF. The clinical evaluation of heat-treated composite resin inlay. J Am Dent Assoc 1990;120:177-81.
11 De Gee AJ,Palla VP, Werner A, Davidson CL. Annealing as a mechanism of increasing wear resistance of composites. Dent Mater 1990;6:266-70.
12 Ferracane JL, Newman S, Greener EH. Correlation of strength and degree of polymerization of unfilled BIS-GMA. J Dent Res 1982;61:832.
13 Veneziani M. Solutions: Adhesive Restorative Techniques and Integrated Surgical Procedures. Edra Publishing, 2021.
14 Magne P, Schlichting LH, Maia HP, et al. In vitro fatigue resistance of CAD/CAM composite resin and ceramic posterior occlusal veneers. Journal of Prosthetic Dentistry 104, 149-157, 2010.
15 Balzer A. All-ceramic single-tooth restorations: choosing the material to match the preparation – preparing the tooth to match the material. International Journal of Computerized Dentistry 11, 241-256, 2008.
16 Gregor L, Bouillaguet S, Onisor I, et al. Microhardness of light- and dual-polymerizable luting resins polymerized through 7.5-mm-thick endocrowns. Journal of Prosthetic Dentistry 112, 942-948, 2014.
17 Sedrez-Porto JA, Rosa WL, da Silva AF, et al. Endocrown restorations: A systematic review and meta-analysis. Journal of Dentistry 52, 8-14, 2016.
18 Rocca GT, Krejci I. Crown and post-free adhesive restorations for endodontically treated posterior teeth: from direct composite to endocrowns. European Journal of Esthetic Dentistry 8, 156-179, 2013.
19 Govare N, Contrepois M. Endocrowns: A systematic review. Journal of Prosthetic Dentistry 123, 411-418, 2020.
20 Zheng Z, He Y, Ruan W, et al. Biomechanical behavior of endocrown restorations with different CAD-CAM materials: A 3D finite element and in vitro analysis. Journal of Prosthetic Dentistry 125, 890-897, 2021.
21 Dauti R, Cvikl B, Lilaj B, et al. Micro-CT evaluation of marginal and internal fit of cemented polymer infiltrated ceramic network material crowns manufactured after conventional and digital impressions. Journal of Prosthodontic Research 63, 40-46, 2019.
22 Ferraris F. Posterior indirect adhesive restorations (PIAR): preparation designs and adhesthetics clinical protocol. International Journal of Esthetic Dentistry 12, 182-202, 2017.
23 Rocca GT, et al. Evidence-based concepts and procedures for bonded inlays and onlays. Part II. Guidelines for cavity preparation and restoration fabrication. Int J Esthet Dent 2015;10(3):392-413.
24 Goel VK, et al. Effect of cavity depth on stresses in a restored tooth. J Prostht Dent 1992;2:174-83.

25 Reeh SH, Messer HH, Douglas WH. Reduction in tooth stifness as a result of endodontic and restorative procedures. J Endodont 1989;15:512-16.
26 Fichera G, Dinapoli C, Re D. Restauri estetico-adesivi indiretti:modello per diagnosi di configurazione cavitaria. Il Dentista Moderno 2003;21(2):21-57.
27 Wassel RW, et al. Direct composite inlays vs conventional composite restorations: 5-years follow-up J Dent 2000;28:299-306.
28 Magne P, Kim TH, Calcione D, Donovan E. Immediate dentin sealing improves bond strenght of indirect restorations. J Prosthet Dent 2005;94:511-9.
29 Jackson RD. Indirect resin inlay and onlay restorations: a comprensive clinical overview. Pract Periodontics Aesthet Dent 1999;11(8):891- 900.
30 Lohbauer U, et al. Degree of conversionof luting resins around ceramic inlays in natural deep cavities:a micro-raman specttroscopy analysis. Oper Dent 2010;35(5):579-86.
31 (Dietschi, D., Spreafico, R., Current clinical concepts for adhesive cementation of tooth-colored posterior restorations, Practical Periodontics and Aesthetic Dentistry, 10, 47–54, 1998.)
32 (Gresnigt, M. M., Cune, M. S., de Roos, J. G., et al., Effect of immediate and delayed dentin sealing on the fracture strength, failure type and Weilbull characteristics of lithium disilicate laminate veneers, Dental Materials, 32, 73–81, 2016.)
33 (Pashley, E. L., Comer, R. W., Simpson, M. D., et al., Dentin permeability: sealing the dentin in crown preparations, Operative Dentistry, 17, 13–20, 1992.)
34 (Paul, S. J., Schärer, P., The dual bonding technique: a modified method to improve adhesive luting procedures, International Journal of Periodontics and Restorative Dentistry, 17, 536–545, 1997.)
35 (Dietschi, D., Duc, O., Krejci, I., et al., Biomechanical considerations for the restoration of endodontically treated teeth: a systematic review of the literature, Part II (Evaluation of fatigue behavior, interfaces, and in vivo studies), Quintessence International, 39, 117–129, 2008.)
36 (Maroulakos, G., Nagy, W. W., Kontogiorgos, E. D., Fracture resistance of compromised endodontically treated teeth restored with bonded post and cores: An in vitro study, Journal of Prosthetic Dentistry, 114, 390–397, 2015.)
37 (Hayashi, M., Takahashi, Y., Imazato, S., et al., Fracture resistance of pulpless teeth restored with post-cores and crowns, Dental Materials, 22, 477–485, 2006.)
38 (Furuya, Y., Huang, S. H., Takeda, Y., et al., Fracture strength and stress distributions of pulpless premolars restored with fiber posts, Dental Materials, 33, 852–858, 2014.)
39 (Ng, Y. L., Mann, V., Gulabivala, K., Tooth survival following non-surgical root canal treatment: a systematic review of the literature, International Endodontic Journal, 43, 171–189, 2010.)
40 (Seydler, B., Rues, S., Müller, D., et al., In vitro fracture load of monolithic lithium disilicate ceramic molar crowns with different wall thicknesses, Clinical Oral Investigations, 18, 1165–1171, 2014.)
41 (Shackelford, J. F., Introduction to Materials Science for Engineers, 9th edition, Pearson, New York, NY, 2023.)
42 Sampaio F, et al. Effects of manufacturing methods on the survival rate of ceramic and indirect composite restorations: A systematic review and meta-analysis. J Esthet Restor Dent 2019;31(6):561-71.
43 Gracis S, et al. New classification system for all-ceramic and ceramiclike restorative materials. Int J Prosthodont 2015;28:227-35.
44 Vetromilla BM, et al. Treatment options for large posterior restorations: a systematic review and network meta-analysis. J Am Dent Assoc 2020;151(8):614-24.
45 (Jansen, J. P., Naci, H., Is network meta-analysis as valid as standard pairwise meta-analysis? It all depends on the distribution of effect modifiers, BMC Medicine, 2013.)
46 (Vetromilla, B. M., Opdam, N. J., Leida, F. L., et al., Treatment options for large posterior restorations: a systematic review and network meta-analysis, The Journal of the American Dental Association, 151, 614–624, 2020.)
47 (Laske, M., Opdam, N. J. M., Bronkhorst, E. M., et al., Risk factors for dental restoration survival: a practice-based study, Journal of Dental Research, 98, 414–422, 2019.)
48 (Van de Sande, F. H., Collares, K., Correa, M. B., et al., Restoration survival: revisiting patients' risk factors through a systematic literature review, Operative Dentistry, 41, S7–S26, 2016.)
49 (Mahoney, E., Holt, A., Swain, M., et al., The hardness and modulus of elasticity of primary molar teeth: An ultra-micro-indentation study, Journal of Dentistry, 28, 589–594, 2000.)
50 Angker, L., Swain, M. V., Kilpatrick, N., Micro-mechanical characterisation of the properties of primary tooth dentine, Journal of Dentistry, 31, 261–267, 2003.)

51 (Yi, Q., Feng, X., Zhang, C., et al., Comparison of dynamic mechanical properties of dentin between deciduous and permanent teeth, Connective Tissue Research, 62, 402–410, 2021.)
52 (Hosoya, Y., Marshall, G. W., The nano-hardness and elastic modulus of sound deciduous canine dentin and young premolar dentin--preliminary study, Journal of Materials Science: Materials in Medicine, 16, 1–8, 2005.)
53 (Souza, I. V., Finck, N. S., Rodrigues, C. S., et al., Laboratory processing methods and bonding to glass ceramics: Systematic review, International Journal of Adhesion and Adhesives, 129, 103572, 2024.)
54 (Honma, T., Maeda, K., Nakane, S., et al., Unique properties and potential of glass-ceramics, Journal of the Ceramic Society of Japan, 130, 545–551, 2022.)
55 (Bi, J., Hu, X., Liu, J., Wear properties of dental ceramics, Chinese Journal of Tissue Engineering Research, 27, 406–412, 2023.)
56 (Yi, Q., Feng, X., Zhang, C., et al., Comparison of dynamic mechanical properties of dentin between deciduous and permanent teeth, Connective Tissue Research, 62, 402–410, 2021.)
57 (Ellakwa, T. E. S., Sabry, A., Gomaa, H., et al., Advancements in glass-ceramic production processes and diverse applications: an article review, ERU Research Journal, 2025.)
58 (Zhou, S., You, Y., Hu, C., et al., Fractographic analysis of lithium disilicate ceramics and monolithic zirconia ceramics, Journal of Mechanics in Medicine and Biology, 22, 2240012, 2022.)
59 Wilson EG, Werrin SR. Double arch impressions for simplified restorative dentistry. J Prosthet Dent 1983;49(2):198-202.
60 Ahlholm P, et al. Digital versus conventional impressions in fixed prosthodontics: A review. J Prosthodont 2018;27(1):35-41.
61 Gintaute A et al. Precision of maxillo-mandibular registration with intraoral scanners in vitro. J Prosthodont Res 2020;64(2):114-9.
62 Bott B, Hannig M. Effect of different luting materials on the marginal adaptation of Class I ceramic inlay restorations in vitro. Dental Materials 19, 264-269, 2003.
63 Peutzfeldt A, Asmussen E. The effect of postcuring on quantity of remaining double bonds, mechanical properties, and in vitro wear of two resin composites. Journal of Dentistry 28, 447-452, 2000.
64 Politano G, Van Meerbeek B, Peumans M. Nonretentive bonded ceramic partial crowns: concept and simplified protocol for long-lasting dental restorations. Journal of Adhesive Dentistry 20, 495-510, 2018.
65 Frankenberger R, Taschner M, Garcia-Godoy F, et al. Leucite-reinforced glass ceramic inlays and onlays after 12 years. *Journal of Adhesive Dentistry* 10, 393-398, 2008.
66 D'Arcangelo C, Zarow M, De Angelis F, et al. Five-year retrospective clinical study of indirect composite restorations luted with a light-cured composite in posterior teeth. *Clinical Oral Investigations* 18, 615-624, 2013.
67 Guess P, Selz C, Steinhart YN, et al. Prospective clinical split-mouth study of pressed and CAD/CAM all-ceramic partial-coverage restorations: 7-year results. *International Journal of Prosthodontics* 26, 21-25, 2013.
68 Krämer N, Taschner M, Lohbauer U, et al. Totally bonded ceramic inlays and onlays after eight years. *Journal of Adhesive Dentistry* 10, 307-314, 2008.
69 Acquaviva P, Cerutti F, Adami G, et al. Degree of conversion of three composite materials employed in the adhesive cementation of indirect restorations: A micro-Raman analysis. Journal of Dentistry 37, 610-615, 2009.
70 Borges GA, Spohr AM, Oliveira WJD, et al. Effect of refrigeration on bond strength of self-etching adhesive systems. Brazilian Dental Journal 17, 186-190, 2006.
71 Magne P, Paranhos MP, Schlichting LH. Influence of material selection on the risk of inlay fracture during pre-cementation functional occlusal tapping. Dental Materials 27, 109-113, 2011.
72 Ritter, A. V., Boushell, L. W., & Walter, R. (2019). Sturdevant's Art and Science of Operative Dentistry (7th ed.). Elsevier.
73 Ozcan M, Vallittu PK. Effect of surface conditioning methods on the bond strength of luting cement to ceramics. Dental Materials. 2003;19(8):725–731.
74 Ritter, A. V., Boushell, L. W., & Walter, R. (2019). Sturdevant's Art and Science of Operative Dentistry (7th ed.). Elsevier.
75 (Jeffries, S. R., Abrasive finishing and polishing in restorative dentistry: a-state-of-the-art review, Dental Clinics of North America, 51, 379–397, 2007.)
76 (Gulati, G. S., Gulati, N. K., The effect of different polishing system on the surface roughness of a composite materials, Journal of Head & Neck Physicians and Surgeons, 2, 54–64, 2014.)

77 (Rémond, G., Nockolds, C., Phillips, M., et al., Implications of polishing techniques in quantitative x-ray microanalysis, Journal of Research of the National Institute of Standards and Technology, 107, 639–662, 2002.)
78 (Gupta, S., Shankar, PM, Kalgeria, SH, et al., Recent Advances in Finishing and Polishing for Restorative Materials - A Review, Journal of Evolution of Medical and Dental Sciences, 10, 2841, 2021.)
79 (Craig, RG, Dental materials: properties and manipulation, 8th ed., Mosby, St. Louis, Mo., 2004.)
80 (Mahalaxmi, S., Materials used in dentalry, Chap. 10: Finishing and Polishing, 1st ed., Wolters Kluwer India Pvt Ltd, India, 539–560, 2013.)
81 (Ferracane, JL, Materials in dentalry: principles and applications, 2nd ed., Williams and Wilkins, 2001.)
82 (Lopes, IAD, Monteiro, PJVC, Mendes, JJB, et al., The effect of different finish and polishing techniques on surface roughness and gloss of two nanocomposites, Saudi Dental Journal, 30, 197–207, 2018.)
83 Bömicke W, Schürz A, Krisam J, et al. In vitro evaluation of surface roughness of CAD/CAM restorative materials after different polishing procedures. Journal of Esthetic and Restorative Dentistry 34(3), 516-526, 2022.
84 Politano G, Fabianelli A, Papacchini F, et al. The use of bonded partial ceramic restorations to recover heavily compromised teeth. *International Journal of Esthetic Dentistry* 11, 314-336, 2016.
85 Buonocore MG. Principles of adhesive retention and adhesive restorative
materials. J Am Dent Assoc 1963;67:382-91
86 Kois DE, Isvilanonda V, Chaiyabutr Y, Kois JC. Evaluation of fracture resistance and failure risks of posterior partial coverage restorations. J Esthet Restor Dent 2013;25:110-22.
87 Ma L, Guess PC, Zhang Y. Load-bearing properties of minimal-invasive monolithic lithium disilicate and zirconia occlusal onlays: Finite element and theoretical analyses. Dent Mater 2013;29:742-51.