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Posterior Indirect Adhesive Restoration

A Project Submitted to the College of Dentistry, University of Baghdad, Department of Conservative Dentistry in Partial Fulfilment for the Bachelor of Dental Surgery

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Certification of the Supervisor

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Dedication

I dedicate this research to my family who have always believed in me and supported me throughout my life.

Acknowledgment

I would like to express my gratitude to **Prof. Dr. Raghad Al-hashimi,** Dean of College of Dentistry, University of Baghdad .

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Introduction

As life expectancy has been increasing, as well as the number of natural teeth maintained in the mouth at an older age, and as dental caries and non-carious lesions resulting from parafunction are among the main problems worldwide, the clinical use of posterior indirect adhesive restorations is very frequent **(Abduo J, Sambrook RJ. 2018)**.

Today, minimally invasive dentistry has become a field of great interest in modern restorative dentistry. The development and improvement of adhesive materials and techniques has shifted the focus from conventional, mechanical retention-oriented practice to a biological, adhesive and biomimetic one **(Schiffenhaus S.2021)**

In modern restorative dentistry, the development of adhesive procedures has led to an important cultural and methodological revolution. Likewise, the evolution of restorative materials and adhesive systems has influenced the approach to restoring posterior teeth, modifying the treatment plan considerably **(Nathanson D.1991).**

Teeth can be restored using indirect techniques, in which restorations are fabricated outside of the mouth. Most indirect restorations are made on a replica of the prepared tooth in a dental laboratory by a trained technician. Tooth- colored indirect systems include laboratory-processed composites and ceramics, such as porcelain fired on refractory dies or hot pressed glasses **(Edward J. Swift, Jr. 2014).**

Posterior indirect adhesive restorations are currently admitted as a common treatment modality used in contemporary dentistry to restore large areas of decay and to replace old restorations. Besides, with the availability of newer high-strength materials such as lithium disilicate and processing technologies like CAD/CAM, dental professionals are now able to produce highly esthetic restorations that blend seamlessly with the natural dentition while withstanding posterior occlusal forces. This has resulted in innovative methods of providing minimally invasive dentistry **(Mc Laren EA .2015).**

The daily clinical use of posterior indirect adhesive restorations (PIAR) is very frequent in cases of cavities with extended coronal destruction **(Roulet,**

1997, Federlin et al., 2006). The preparation for an adhesive partial restoration allows for a greater preservation of healthy tissue than one for a full-crown metal-free preparation **(Edelhoff and Sorensen, 2002, Alfouzan and Tashkandi, 2013, Murphy et al., 2009).**

Recently, the esthetic restoration and rehabilitation of posterior teeth and full arches has, through necessity, created a new paradigm and balance between operative "restorative" dentistry and prosthodontics **(Dietschi D, Argente A. 2011).**

However, the strict observance of their indications, the choice of materials, the form of preparation adapted to the material, and the mastery of the adhesive techniques determine their success rate and durability **(Hajtó J .2013).**

Aim of the review

The aim of this project is to have an overview on posterior indirect adhesive restoration, and to review the importance of using this restorations in modern dentistry.

Review of literature

Posterior Indirect Adhesive Restoration

Posterior indirect adhesive restorations have become viable restorative alternatives for moderately broken down posterior teeth and an integral means of restoring teeth. Advances in adhesive technology and esthetic dental materials, for example, composite resins and ceramics have enabled clinicians to use conservative preparations to place restorations that also reinforce the remaining tooth structures. In addition, these restorations satisfy the increasing patient expectations for a natural or enhanced appearance (Jackson R. 2012).

The need to perform adhesive restorations of posterior teeth is not only linked to esthetic purposes, but also to bio-economic principles, as well as to the possible biomechanical strengthening of the remaining tooth structure (Liebenberg WH.1996).

1.1 Indications

The indications for Posterior indirect adhesive restorations relate to a combination of esthetic demands and size of the restoration and include the following:

- Medium- to large-sized cavities where one or more cusps are missing.
- Cavities where the coverage of one or more cusps is advisable to improve the prognosis of the complex restored tooth.
- Morphological modification and/or raising of the posterior occlusal vertical dimension (OVO) in cases of oral rehabilitations on elements where a full-crown restoration would be too invasive.
- Cracked tooth syndrome, when the symptomatology needs to be managed with the aim of maintaining the vitality of the tooth.
- Multiple medium- to large-sized cavities in the same quadrant (even if indirect inlay restorations are not the first choice).**(Ferraris, 2017)**

1.2 Contraindications

Contraindications for indirect tooth-colored restorations include the following:

1. Heavy occlusal forces: Ceramic restorations can fracture when they lack sufficient thickness or are subject to excessive occlusal stress, as in patients who have bruxing or clenching habits (Fig 1-1).

2. Inability to maintain a dry field: Despite limited research suggesting that some contemporary dental adhesives might counteract certain types of contamination, adhesive techniques require near-perfect moisture control to ensure successful long-term clinical results **(El-Kalla IH,Garcia-Godoy F.1997 ; Sheikh H .2010 ; Meyer A.2003).**

3. Deep subgingival preparations: Preparations with deep subgingival margins generally should be avoided. These margins are difficult to record with an elastomeric or even a digital impression and are difficult to evaluate and finish. Additionally, dentin bond strengths at gingival floors are not particularly good, so bonding to enamel margins is greatly preferred, especially along gingival margins of proximal boxes **(Purk JH.2006; Ferrari M.1999).**

Fig.1-1 A, Clenching and bruxing habits can cause extensive wear of occlusal surfaces. This patient is not a good candidate for ceramic inlays **B**, Example of a fractured onlay in a patient with heavy occlusion.

1.3 Advantages

Except for the higher cost and increased time, the advantages of indirect tooth-colored restorations are similar to the advantages of direct composite restorations. Indirect tooth-colored restorations have the following additional advantages:

1) Improved physical properties: A wide variety of high- strength tooth-colored restorative materials, including laboratory-processed and computer-milled ceramics, can be used with indirect techniques. These have better physical properties than direct composite materials because they are fabricated under relatively ideal laboratory conditions. For CAD/CAM restorations, although some are fabricated chairside, the materials themselves are manufactured under nearly ideal industrial conditions **(Fasbinder DJ. 2010).**

2) Variety of materials and techniques: Indirect tooth-colored restorations can be fabricated with ceramics using traditional laboratory processes or using chairside or laboratory CAD/CAM methods.

3) Wear resistance: Ceramic restorations are more wear resistant than direct composite restorations, an especially important factor when restoring large occlusal areas of posterior teeth.

4) Reduced polymerization shrinkage: Polymerization shrink- age and its resulting stresses are a major shortcoming of direct composite restorations. With indirect techniques, the bulk of the preparation is filled with the indirect tooth-colored restoration, and stresses are reduced because little resin cement is used during cementation. Although shrink- age of resin materials in thin bonded layers can produce relatively high stress, clinical studies indicate ceramic inlays and onlays have better marginal adaptation, anatomic form, color match, and overall survival rates than do direct composite restorations **(Lange RT, Pfeiffer P. 2009; Feilzer AJ. 1989; Manhart J .2004).**

5) Support of remaining tooth structure: Teeth weakened by caries, trauma, or preparation can be strengthened by adhesively bonding indirect tooth-colored

restorations. **(Ausiello P.1997 ; Bruke FJT. 1993 ; Camacho GB . 2007).** The reduced polymerization shrinkage stress associated with the indirect technique also is desirable when restoring such weakened teeth.

6) More precise control of contours and contacts: Indirect techniques usually provide better contours (especially proximal contours) and occlusal contacts than do direct restorations because of the improved access and visibility outside the mouth.

7) Biocompatibility and good tissue response: Ceramics are considered chemically inert materials with excellent biocompatibility and soft tissue response **(St. John KR .2007).** The pulpal biocompatibility of the indirect techniques is related more to the resin cements than to the ceramic materials used.

8) Increased auxiliary support: Most indirect techniques allow the fabrication of the restoration to be delegated totally or partially to the dental laboratory. Such delegation allows for more efficient use of the dentist's time.

1.4 disadvantages

The following are disadvantages of indirect tooth-colored restorations**:**

1) Increased cost and time: Most indirect techniques, except for chairside CAD/CAM methods, require two patient appointments plus fabrication of a provisional restoration. These factors, along with laboratory fees, contribute to the higher cost of indirect restorations in comparison with direct restorations. Although indirect tooth-colored inlays and onlays are more expensive than amalgam or direct composite restorations, they are usually less costly than more invasive esthetic alternatives such as all-ceramic or porcelain-fused-to-metal (PFM) crowns.

2)Technique sensitivity: Restorations made using indirect techniques require a high level of operator skill. A devotion to excellence is necessary during preparation, impression, try-in, bonding, and finishing the restoration.

3) Difficult try-in and delivery: Indirect composite restorations can be polished intraorally using the same instruments and materials used to polish direct composites, although access to some marginal areas can be difficult. Ceramics are more difficult to polish because of potential resin-filled marginal gaps and the hardness of the ceramic surfaces.

4) Brittleness of ceramics: A ceramic restoration can fracture If the preparation does not provide adequate thickness to resist occlusal forces or if the restoration is not appropriately supported by the resin cement and the preparation. With weaker ceramic materials, fractures can occur even during try-in and bonding procedures **(Magne P. 2011).**

5) Wear of opposing dentition and restorations: Some ceramic materials can cause excessive wear of opposing enamel or restorations **(al-Hiyasat AS. 1999).** Improvements in materials have reduced this problem, but ceramics, particularly if rough and unpolished, can wear opposing teeth and restorations.

6) Short clinical track record: Compared with traditional methods such as cast gold or even amalgam restorations, bonded indirect tooth-colored restorations have a relatively short record of clinical service. They have become popular only in recent years, and relatively few controlled clinical trials are available, although these are increasing in number **(Lange RT, Pfeiffer P. 2009; Arnelund CF. 2004; Van dijken JW .1998).**

7) Low potential for repair: When a partial fracture occurs in a ceramic inlay or onlay, repair is usually not a definitive treatment. The actual procedure (mechanical roughening, etching with hydrofluoric [HF] acid, and application of a silane coupling agent before restoring with adhesive and composite) is relatively simple. However, because many ceramic inlays and onlays are indicated in areas where occlusal wear, esthetics, and fracture resistance are important, composite repairs frequently are not appropriate or successful.

1.5 Types of indirect posterior esthetic restoration

1.5.1 Inlays

These are restorations without cusp coverage, and would be indicated in teeth with preserved vitality in medium to large class II cavities (MO/DO, MOD), with well-preserved buccal and oral walls (fig.1-2, 1-3). Composite is the ideal material. Currently, this type of restoration is often performed with a direct technique, thus obtaining equal predictability with a more conservative approach **(Veneziani, 2017).**

Fig.1-2 Inadequate amalgam and composite estorations with evidence of recurrent decay (Jung M et al,2004).

1.5.2 Onlays

These are restorations that partially cover cusps, but not the entire occlusal surface. They are indicated in class II cavities of large dimensions with lateral walls partially supported without dentin cracks. (fig. 1-4, 1-5 , 1-6)

In the case of endodontically treated teeth, the presence of at least one marginal ridge, and two well-supported axial walls in continuity with the marginal ridge itself, are required. Both composite or ceramic can be used **(Magne, 2006, Hayashi, 2008).**

Fig.1-4 Inappropriate pre-existent restoration with noticeable recurrent decay. (Jung M et al,2004)

Fig.1-5 class II MO/OD cavities restored with composite onlays with noticeable cuspal coverage. (Jung M et al,2004)

Fig. 1-6 one year follow-up with excellent preservation of the morphology, function, esthetics, and marginal integrity. (Jung M et al,2004)

1.5.3 Overlays

These are total cusp-coverage restorations,indicated in class II cavities of large dimensions with unsupported axial walls and the absence of both marginal enamel and dentin (in vital teeth), and the absence of a marginal ridge in endodontically treated teeth, requires total coverage, even in the presence of residual walls of adequate thickness. Composite (Fig.1-7, 1-8) or ceramic can be used **(Veneziani, 2017).**

Ceramic (lithium disilicate glass-ceramic) is the first-choice material in the case of multiple restorations with wide coverage. Furthermore, due to its greater strength and ability to stabilize the cusp, ceramic is the first choice for teeth affected by cracked tooth syndrome, using it with a total cusps covering **(Mehl et al., 2004, Magne, 2006)** (Fig.1-9).

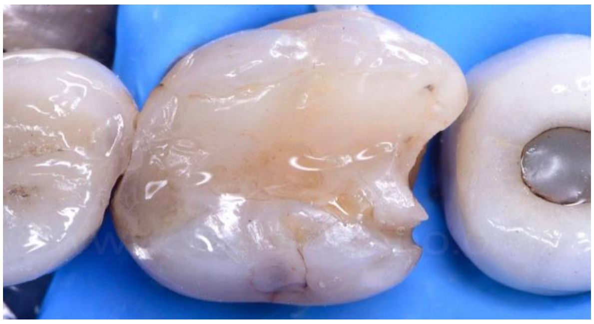

Fig.1-7 An old and extensive MOD restoration, with a mesial fracture. (Jung M et al,2004)

Fig.1-8 The same MOD cavity restored with indirect restoration (composite overlay). (Jung M et al,2004)

Fig. 1-9 Ceramic overlay after adhesive cementation in isolated field. Total cusp coverage with porcelain significantly stiffens the crown and increases cusp stabilization.

1.5.4 Additional overlay:

This is a partial or, more frequently, complete-coverage restoration performed without any tooth preparation. It is indicated in cases of anatomic restoration of teeth with loss of tissue due to erosion/abrasion or in cases of occlusal vertical dimension increase. The gold standard material is ceramic (lithium disilicate), although it is also possible to use composite.**(Veneziani, 2017)**

1.5.5 Occlusal-veneer (or “table-top”):

This is a thin (1 to 1.2 mm) bonded posterior occlusal partial-coverage preparation with a non-retentive design. It is indicated, above all, in advance erosion of the occlusal surface or in clinical restorative cases where the vertical dimension needs to be increased. **(Veneziani, 2017)**

1.5.6 Overlay-veneer (or “veneerlay”)

This is used in the case of a restoration that involves the occlusal surface that extends to the entire buccal surface due to either esthetic or functional considerations. It is indicated in teeth positioned in esthetic areas (typicall maxillary premolars) with significant loss of hard tissue, heavily discolored, and resistant to bleaching. The gold standard material is ceramic(lithium disilicate). **(Veneziani, 2017).**

1.6 Clinical procedures for the indirect technique

1.6.1 Analysis of cavity factors:

1. Complete removal of eventual decayed tissues and previous restorations.
2. Identifying, in order of importance, the presence of interproximal dentin, proximal residual ridges, roof of the pulp chamber, and residual cuspal walls. **(Ferraris, 2017)**

In order to preserve the tooth, the hierarchy of importance mentioned above **(Re et al., 2006, Fichera et al., 2003)** is relevant, with the interaxial dentin being the most important aspect to consider, and the residual cuspal walls the least important. The more unfavorable the cavity situation, the more the clinician has to consider cutting and covering the cusps to prevent possible coronal fractures.

3. Generally, if the cuspal thickness of the vital tooth (measured at the thinnest point and in axis with the cuspal apex) is < 2 mm, a cuspal coverage is suggested. **(Dietschi and Spreafico, 1997)**

• For non-vital posterior teeth, the thickness limit is 3 mm **(Becciani and Castellucci, 2002**).

• The non- functional thin cusps (with a thickness less than the aforementioned values) can be even more fragile, and special attention must be paid to them. When using adhesively bonded restorations, the thin cusps should be completely covered or reduced to avoid enamel cracks and marginal deficiency. **(Krifka et al., 2009b)**

• The remaining cusp wall thickness of nonfunctional cusps of adhesively bonded restorations should have a thickness of at least 2.0 mm to avoid cracks and marginal deficiency. **(Krifka et al., 2009a)**

• The central isthmus to the cavity must have a minimum thickness in order to meet the cavity design. **(Dietschi and Spreafico, 1997)** suggest that it should be no less than 2 mm, which is understandable in terms of the restoration's resistance, especially after cementation.

*Absence of undercuts : In fact, the presence of undercuts prevents the correct positioning of the restoration in the cavity. There are situations that are exceptions, where undercut areas can be predicted (eg, with a veneerlay in the buccal area if the axis of insertion is bucco-lingual). **(Ferraris, 2017)**

* Presence of internal rounded corners and sharp finishing lines : Internal rounded corners can allow for the avoidance of certain situations, eg, friction areas (which can displace the correct position of the restoration), steep surfaces (which can negatively interfere with the extrusion of cement excesses), and

difficulty when it comes to reproducing very pronounced corners on the cast. **(Ferraris, 2017)**

Another reason for internal rounded corners is resistance to mechanical stress, because molar teeth restored with glass ceramic in lithium disilicate with a retentive preparation design have demonstrated a lower medium resist- ance to fractures**,(Stappert et al., 2008, Stappert et al., 2006)** compared with other studies with a simple horizontal preparation design. **(Clausen et al., 2010)**

The geometry of retentive restorations is more complex, and presents relatively sharp inner corners. Due to this, some predetermined breaking points may be evident. It can be assumed that the simple geometric designs of the restorations can contribute to raising resistance to mechanical stress.

On the other hand, the presence of a finishing preparation margin on a sharp line allows the clinician to accurately indicate the end of the restoration, and to check the proper positioning of the restoration on the cavity**.(Ferraris, 2017)**

* Presence of substrates favorable to adhesion : Having substrates that respond well to adhesion and maintaining this condition over time are important considerations for a restoration of this type. The first among these substrates is a margin of well represented enamel. While the adhesion of dentin and composite (the build-up) can be favorable, enamel remains the most reliable and stable. **(Ferraris, 2017)**

According to the adhesthetics protocol, the two best substrates for adhesive cementation are enamel and composite build-up (or block out), which allow for a wider hybridization and overcoating of the dentin substrate immediately after the cleansing of the cavity. These two substrates can be adequately prepared for adhesive procedures, bearing in mind that the best guarantee of a restoration's resistance is a completely enamel preparation**.(Clausen et al., 2010)**

1.6.2 Types of preparations

1.6.2.1 Butt joint preparation:

The butt joint (Fig. 1-10) requires minimal preparation and is therefore suitable for adhesive techniques. 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.

Indications for a butt joint preparation:

- Cuspal reduction to protect the teeth from the occlusal load (Fig.1-11).
- Cuspal fracture in the area of the occlusal third (or middle third, in some cases).
- Presence of strong abrasions/erosions of the occlusal surface (with the possibility of increasing the vertical dimension).**(Ferraris, 2017)**

Fig. 1-10 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 Butt joint preparation, which is not flat but mainly follows the inclination of the occlusal plane. The more peripheral margins (buccal and lingual) have more horizontal design(Ferraris, 2017)

Fig. 1-11 Occlusal reduction for a cuspal coverage when the residual thickness is not considered adequate for a medium to long term prognosis. This kind of bur should have depth mark (Ferraris, 2017)

1.6.2.2 The bevel preparation

It 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 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. (Fig. 1-12)

Indications for a bevel preparation:

- Esthetic need for a more gradual integration of the restoration-tooth transition.
- Wider surface of external enamel, which enhances adhesive cementation procedures.
- To create more space for the restoration in the peripheral zone.**(Ferraris, 2017)**

Fig. 1-12 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.(Ferraris, 2017)

1.6.2.3 The shoulder preparation

The shoulder (Fig. 1-13) 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 (or 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.

Indications for a shoulder preparation:**(Ferraris, 2017)**

- Previous cuspal fracture to the cervical third (or middle third in some cases), and then, by effect, the central build-up automatically defines the peripheral shoulder design (Figures 1-14 and 1-15).
- Where a greater structural protection is required for a cusp coverage with a cervical grasp.

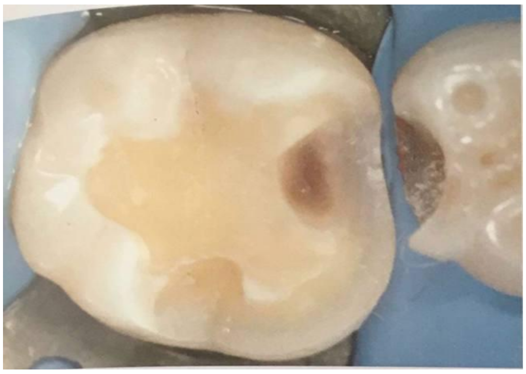

Fig. 1-13 Shoulder preparation. A rounded shoulder characterizes this preparation design. The depth of the shoulder is usually around 1 mm (Bottacchiar S, 2016)

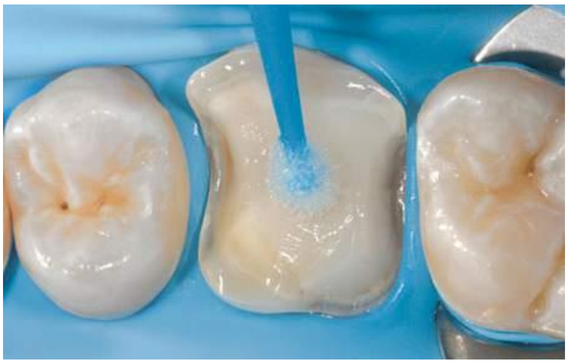

Fig. 1-14 Adhesive phases on a devitalized molar prepared for an overlay. The butt joint design represents the cuspal coverage for three cusps, and the shoulder was performed on the disto-palatal cusp where a fracture had occurred.

Fig. 1-15 The overlay made on a mixed preparation (butt joint and shoulder) prior to cementation.

1.6.3 Proximal preparation designs

There are three types of approaches for the interproximal areas according to the adhesthetics protocol: slot, bevel, and ridge up.**(Ferraris, 2017)**

- 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.1-16). 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.
- 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. 1-17), such as a good surface of enamel, which enhances the adhesive cementation procedure. This preparation is indi- cated 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.

Fig.1-16 Slot interproximal preparation. This kind of design is very common, especially when a previous carious lesion has affected the area.(Ferraris, 2017)

Fig.1-17 Bevel interproximal preparation. This approach is more conservative compared with slot interproximal preparation.

- Ridge up: the ridge preservation variant of this approach allows for the maintenance of the integrity of the marginal ridge (Fig.1-18), whereas the ridge coverage variant allows for minimal surface preparation (Fig.1-19), preserving the contact area that has not obviously suffered from carious lesions. Given that the ridge is one of the most important structural ele- ments with regard to the integrity of the nonvital tooth, in cases of reduced thickness of the adjacent cusps one can opt for a cuspal coverage with the preservation of the ridge. **(Ng *et al.*, 2010)**

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 .

Fig. 1-18 Ridge up interproximal preparation. The most conservative approach for the ridge when a cuspal coverage(Ferraris, 2017)

Fig.1-19 Ridge up interproximal preparation. the ridge is slightly prepared.(Ferraris, 2017)

1.6.4 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 (Fig. 1-20). This can 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).

The regularization of the occlusal surface can be performed with 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 secure thickness in the case of layered composite (Dietschi D, Spreafico R.1997) 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.(Chen C, et al. 2014) 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. (Seydler B, et al .2014)

Fig.1-20 Occlusal grooves represent the first step of preparation. They are useful to determine the vertical reduction.(Ferraris, 2017)

➢ 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 especially to create the bevel. To create a shoulder slot, a tapered bur with a reduced diameter can be used.

- 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 um) with a reduced number of speeds can be used. 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 adhesthetics 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. **(Ferraris, 2017)**

1.7 New cavity design (Morphology Driven Preparation Technique)

The principles of traditional cavity design (Fig.1-21) were derived from preparations meant for indirect non-adhesive restorations. These were characterized by a cavity design that ensured retention by the placement of shoulders, occlusal slots, and eventually pins, which could expose sound dentin with a significant loss of structural tissue . Apart from this, conventional preparations did not consider the real morphostructural and histoanatomical course in the tooth crown.(Veneziani, 2017)

Moreover, no clear data are reported in the literature about the correct level of the shoulders on the axial walls, leaving clinicians the task of preparing them according to their clinical experience. Furthermore, the traditional cavity design is not completely suitable for adhesive cementation because of the presence of isthmuses, shoulders, and rounded angles. Also, the width of the shoulders and of the restoration themselves seems to be excessive, and leads to an inadequate degree of luting composite conversion. **(Veneziani, 2017)**

The morphologically driven preparation technique improves resistance by preserving dentin and enamel, bond strength by improving the quality of bonding substrate, and the marginal integrity and esthetics of the restoration, respectively. **(Gupta et al.2014)**

The principles of MDPT (Fig.1-22) are intended to achieve these improvements:**(Veneziani, 2017)**

• To minimize as much as possible the loss of healthy tooth tissue by reducing the areas of dentin exposure.

• To guide tissue reduction of the occlusal surface with depth cuts or, better still, with a silicone index for thickness control.

• To reduce the width of the margins prepared as a shoulder, where indicated.

• To define a margin design that could improve the quality of the adhesion, optimizing the cutting of the enamel prisms and creating a greater surface of enamel.

• To improve the smooth insertion of the restoration during cementation.

• To improve the esthetics of the transition zone between the tooth and the restoration.

Fig.1-21 Clinical examples of old, conventional adhesive preparations of maxillary and mandibular molars and premolars.(Veneziani, 2017)

Fig. 1-22 Clinical examples of new MDPT for adhesive restorations of maxillary and mandibular molars and premolars.(Veneziani, 2017)

1.8 Build-up:

There are various advantages to 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 dentin,**(Dietschi and Spreafico, 1998)** known as immediate dentin sealing (IDS)**(Magne *et al.*, 2005),** especially when the exposed dentinal area is wide,**(Gresnigt *et al.*, 2016a)** 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**(Pashley *et al.*, 1992)** or dual bonding**.(Paul and Schärer, 1997)**

The disadvantages are:

- ❖ The clinician has to perform an additional clinical step with the field isolation, adhesion, and reconstruction.
- ❖ 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 volume.

- A simple buildup without post is often suggested for the PIAR. However, 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 same element, with the one condition that an over-preparation enlarging the canal space left by endodontic therapy is not created. In the latter case, the post would be considered to be a "mini-filler" or a coarse resin filler, cemented inside thE canal with resin-based material and capable of giving a favorable biomechanical distribution in the radicular dentin.**(Ferraris, 2017).**

1.9 Immediate dentin sealing (IDS) using a gold-standard adhesive and microselective out-blocking of undercuts

Documented gold-standard adhesives are the 3-step etchand rinse adhesive Optibond FL (KerrHawe) and the mild 2-step self-etch adhesive Clearfil SE Bond (Kuraray Noritake).(De Munck et al., 2012),(Peumans et al., 2014).The adhesive is applied according to the instructions of the respective manufacturer (Figure.53). After polymerization of the adhesive, a highly filled flowable composite is applied to micro-selectively block out undercuts in the dentin preparation (Figure.54). At the same time, deep, tight and complex cavities are corrected geometrically. The application of the flowable composite will stabilize and protect the newly formed hybrid layer and increase its degree of conversion. (Politano et al., 2018)

The immediate dentin sealing appears to achieve improved bond strength, fewer gap formations, decreased bacterial leakage, and reduced dentin sensitivity.The use of a filled dentin bonding agent or the combined use of an unfilled dentin bonding agent and a flowable composite liner facilitates the clinical and technical aspects of immediate dentin sealing.This concept lead to maximum tooth structure preservation, improved patient comfort, and long-term survival of indirect bonded restorations. **(Magne et al., 2005)**

A comparative in-vitro study by **(Gaeed and Ali, 2017)** regarding failures of porcelain laminate veneers using different techniques of bonding (DDS and IDS) concluded that such development of bonding techniques like IDS made dentin as acceptable tooth substrate for indirect adhesive restorations.

1.10 The provisional restoration – an additional procedure

A provisional or temporary restoration is necessary when using indirect systems that require two appointments. The provisional restoration protects the pulp–dentin complex in vital teeth, maintains the position of the prepared tooth in the arch, and protects the soft tissues adjacent to the prepared areas. The provisional can be made using conventional techniques and bis-acryl composite materials. Care should be taken to avoid bonding of the temporary material to the preparation at this phase of the procedure. A lubricant of some sort (e.g., glycerin) can be applied to the preparation, if desired, especially if a resin-based material was used to block out undercuts or level the floor of the preparation. Temporary restorations for PFM and cast gold restorations typically are cemented with eugenol-based temporary cements. Eugenol is believed to interfere with resin polymerization, however, and potentially could reduce the adhesion of the permanent composite cement to tooth structure **(Rosenstiel SF, Gegauff AG. 1988 ; Erkut S. 2007)** . Although some studies report this does not occur if the tooth is thoroughly cleaned using pumice, excavator, or air abrasion before cementation of the permanent restoration, use of a non-eugenol temporary cement is recommended **(Abo-Hamar SE . 2005 ; Schwartz R. 1992).**

For exceptionally non-retentive preparations, or when the temporary phase is expected to last longer than 2 to 3 weeks, zinc phosphate or polycarboxylate cement can be used to increase retention of the provisional restoration

1.11 Shade selection

Selection should be made prior to starting the preparation. If amalgam restorations are being replaced with a ceramic restoration, the shade should be selected after the defective restorations and caries are removed**. (Kern et al., 2017)**

1.12 Impression making

- When a chairside CAD / CAM system is used, the impression is made using a 3D intra-oral camera directly in the mouth.
- If the restoration is to be fabricated in the laboratory, a conventional impression (Fig, 1-20) is necessary for the indirect procedures necessary for the fabrication of the restoration by the dental laboratory.**(Kern *et al.*, 2017)**

- Taking an impression for partial restorations is made much easier by the supragingival positioning of preparation margins. If necessary, this can be achieved by lengthening the clinical crown, but obviously it is even more advantageous when the preparation margins are already located in a supragingival position without the need for intervention.
- The material used to take the impression is polyvinyl siloxane positioned in an interocclusal record impression tray when one or two teeth are involved or in a full-arch impression tray when an entire quadrant is involved. **(Bottacchiar S, 2016)**

Fig. 1-20 conventional impression of inlay made with polyvinylsiloxane impression material.

1.13 Laboratory procedures

The following steps are performed for inlays, onlays and partial coverage crowns:

- Shade selection, determination of customized coloration (shade mapping)
- Fabrication of the master cast: type IV dental stone, dentin-colored composite-resin or ceramic stumps are used (only for feldspathic ceramics)
- Use of a die spacer for cement space (in CAD / CAM milling, the software performs this step.
- Strict observance and following of manufacturer's recommendations for wall thickness to prevent internal stresses and cracking, and avoid air entrapment and surface defects during fabrication is essential for the longevity of the restoration
- Coordination of occlusal concepts with the dentist to minimalize time required for occlusal adjustments on the restoration by grinding, include adjustment of the opposing dentition. Fitting of the restoration on a solid unsectioned cast.**(Kern *et al.*, 2017)**

1.14 Try-In

- Try-in of the ceramic restoration (Fig. 1-23) without pressure and without occlusal check.
- Check the interproximal contacts and marginal fit with silicone (low viscosity) fit checker or powder disclosing agent.
- Check the shade with glycerol gel or try-in pastes.

- Ensure complete removal of residual try-in agents and completely clean the tooth and restoration after try-in.**(Kern *et al.*, 2017)**

Fig. 1-23 Initial try-in ceramic onlay
A)Facial view , B)Occlusal view

1.15 Cementation

1.15.1 Luting composite

- Resin cements are divided into three groups according to polymerization process: chemically activated cements, light-cured cements, and dual-cured cements.**(Bott and Hannig, 2003).** 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**(Peutzfeldt and Asmussen, 2000)**.
- 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. **(Politano *et al.*, 2018)**

- Several clinical trials have shown that inlays/onlays bonded with a preheated light-curing restorative composite function well in the long term.**(D'Arcangelo *et al.*, 2013, Guess *et al.*, 2013, Frankenberger *et al.*, 2008, Krämer *et al.*, 2008)**. 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.(**Politano *et al.*, 2018**)
- Preheating composite facilitates the seating of the restorations and contributes to a higher degree of conversion.**(Acquaviva *et al.*, 2009).**
- Preheating could lead to an increase in polymerization depth and greater molecular mobility,**(Borges *et al.*, 2006)** 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**(Magne *et al.*, 2011).**

1.15.2 Surface treatment of indirect composite restorations

Composite surface treatments are necessary for adhesion of indirect composite restorations.Acid-etching with phosphoric acid, acidulated phosphate fluoride, or hydrofluoric (HF) acid is one of the treatments reported in literature.**(Brosh *et al.*, 1997) (Hori *et al.*, 2008)**

The internal surfaces of indirect restorations can be abraded with aluminium oxide, using an intraoral sandblasting device.**(D'Arcangelo and Vanini, 2007, Cavalcanti *et al.*, 2007, Brosh *et al.*, 1997)**, Also, silane coupling agents are used as adhesion promoters. Another method, the tribochemical coating, forms a silica-modified surface as a result of airborne-particle abrasion with silicon dioxide (SiO_2)-coated aluminium particles. The surface becomes chemically reactive to the resin by means of silane coupling agents.**(Bouschlicher *et al.*, 1999).**

Roughening the composite area of adhesion, sandblasting, or both sandblasting and silanizing can provide statistically significant additional resistance to tensile load. Acid-etching with silane treatment does not reveal significant changes in tensile bond strength.Sandblasting treatment is the main factor responsible in improving the retentive properties of indirect composite restorations.**(D'Arcangelo and Vanini, 2007)**(Fig.1-24)

Fig. 1-24 a.Cementation of indirect composite restoration (D'Arcangelo *et al.*, 2015)

1.15.3 Surface treatment of ceramics

Ceramics can be classified in two main groups; Glass ceramics and Oxide ceramics. Glass ceramics are characterized for being etchable, property of their glass phase. The protocol of pre-treatment prior to cementation of these ceramics includes the etching with hidrofluoric acid with a concentration between 4.5-10% oramoniumpolyfluoride (Monobond etch & prime), silanization with one or two bottles or no silanization in case of the Monobond etch & prime and an adhesive or directly resin cement (Fig.1-25). Due to the glass content these ceramics tend to be more translucent. **(Ho and Matinlinna, 2011)**

The second group of ceramics are the oxide ceramics that are not etchable. They need to be sand-blasted and then primed with a phosphonic acid or MDP (Methacriloyloxydecyldihydrogen phosphate) containing primer (Fig.1-26). Then an adhesive or directly resin cement is applied depending on the type of cement. This division provides clinician orientation regarding the indication and way of cementation, with the glass ceramics being used for the more esthetic cases in the anterior region like thinner crowns, veneers, inlays, onlays and the oxide ceramics mainly used for crowns and bridges **(McLaren, 1998, Helvey, 2013).**

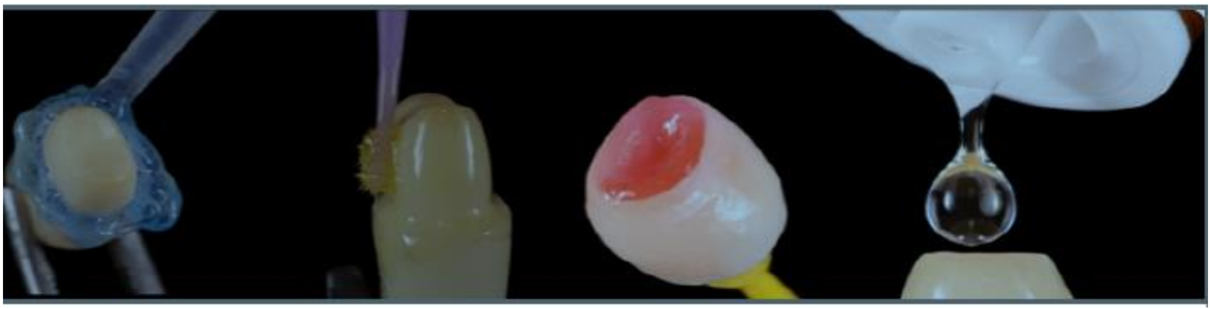

Fig. 1-25 Management protocol for glass ceramics(Helvey, 2013)

Fig. 1-26 Management protocol for oxide ceramics(Helvey, 2013)

1.16 Finishing and polishing of the restoration

1.16.1 Finishing and polishing of ceramic restoration

After light-curing the cement, the plastic matrix strips and the wedges (if used) are removed, and the setting of the resin cement is verified. All marginal areas are checked with an explorer tine. Medium-grit or finegrit diamond rotary instruments are used initially to remove any excess resin cement at the margins. Care must be taken to preserve the glazed surface of ceramic restorations as much as possible. Slender flame shapes are used inter-proximally (Fig. 1-27, A), whereas larger oval or cylindrical shapes are used on the occlusal surface. After using the finegrit diamond instruments, 30-fluted carbide finishing burs can be used to obtain a smoother finish (see Fig. 1-27, B) **(Haywood VB. 1988).**
Interproximally, a No. 12 scalpel blade can be used to remove excess resin cement when access permits (Fig. 1-28, A). Abrasive strips of successively finer grits also can be used to remove slight interproximal excesses (see Fig. 1-28, B).

Much care must be exercised to avoid damaging the gingiva or the root surfaces when using such instruments. Inter-proximally restorations can be polished to a surface as smooth as glazed porcelain using the abrasive sequence shown in (Table 1-1). **(Haywood VB. 1988).**

The same fine-grit diamonds used to adjust margins may be used to adjust contour, followed by the use of 30-fluted carbide finishing burs. Further smoothing is accomplished with a series of rubber abrasive points and cups used at slow speed with air-water spray (Fig. 1-29, A).

Final polishing of the ceramic restoration may be achieved by applying a diamond polishing paste with a bristle brush or another suitable instrument (see Fig. 1-29, B). Ceramic restorations properly polished with this series of instruments have a remarkably beautiful, smooth surface (see Fig. 1-29, C).

Premature occlusal contacts can be adjusted using fine-grit diamond instruments, followed by 30-fluted carbide finishing burs and appropriate polishing steps. Achieving a highly polished surface is critical to remove flaws that could be initiation points for ceramic fracture. In selected cases, the occlusion can be adjusted on the opposing dentition. This is feasible only if such adjustment is done to correct the occlusal plane of opposing teeth or to reduce a pronounced cusp present on the tooth opposing the restoration to avoid occlusal trauma.

Table 1-1 Instrumentation for Finishing and Polishing Ceramic Restorations

Sequence	Instruments
1	Medium-grit to fine-grit diamond rotary instrument
2	30-fluted carbide burs
3	Sequence of rubber, abrasive-impregnated porcelain polishing points
4	Diamond polishing paste

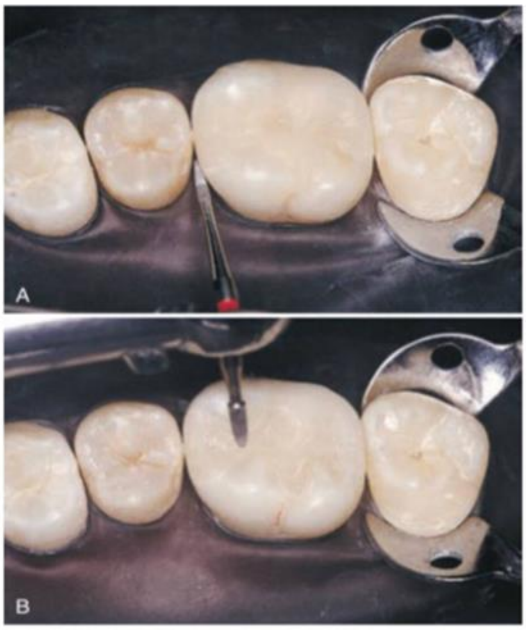

Fig. 1-27 **A,** Slender, fine-grit, flame-shaped, diamond instruments are used to remove flash along facial and lingual margins of ceramic onlay. **B,** 30-fluted finishing burs are used to smooth areas that were adjusted with diamonds.

Fig. 1-28 **A,** Removing excess resin cement using a surgical blade. **B,** Smoothing the interproximal area with an abrasive finishing strip.

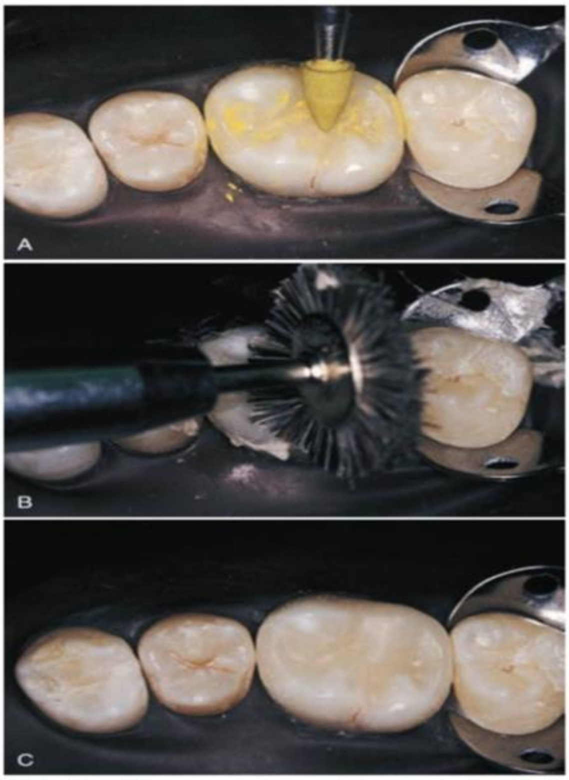

Fig. 1-29 Polishing sequence for ceramic inlays and onlays. **A,** After using fine-grit diamonds and 30-fluted carbide finishing burs to adjust contours and margins, rubber abrasive points and cups of increasingly fine grits are used at slow speed. **B,** Final polish imparted by diamond polishing paste applied with bristle brush. **C,** Occlusal view of the polished ceramic onlay.

1.16.2 Finishing and polishing of composite restoration

Gross composite excesses and surface defects should be limited. Already at this point, the accessibility and relief of the margins have to be taken into consideration as they will determine which kind of instrumentation is best indicated (Fig 1-28). (Bottacchiar S, 2016)

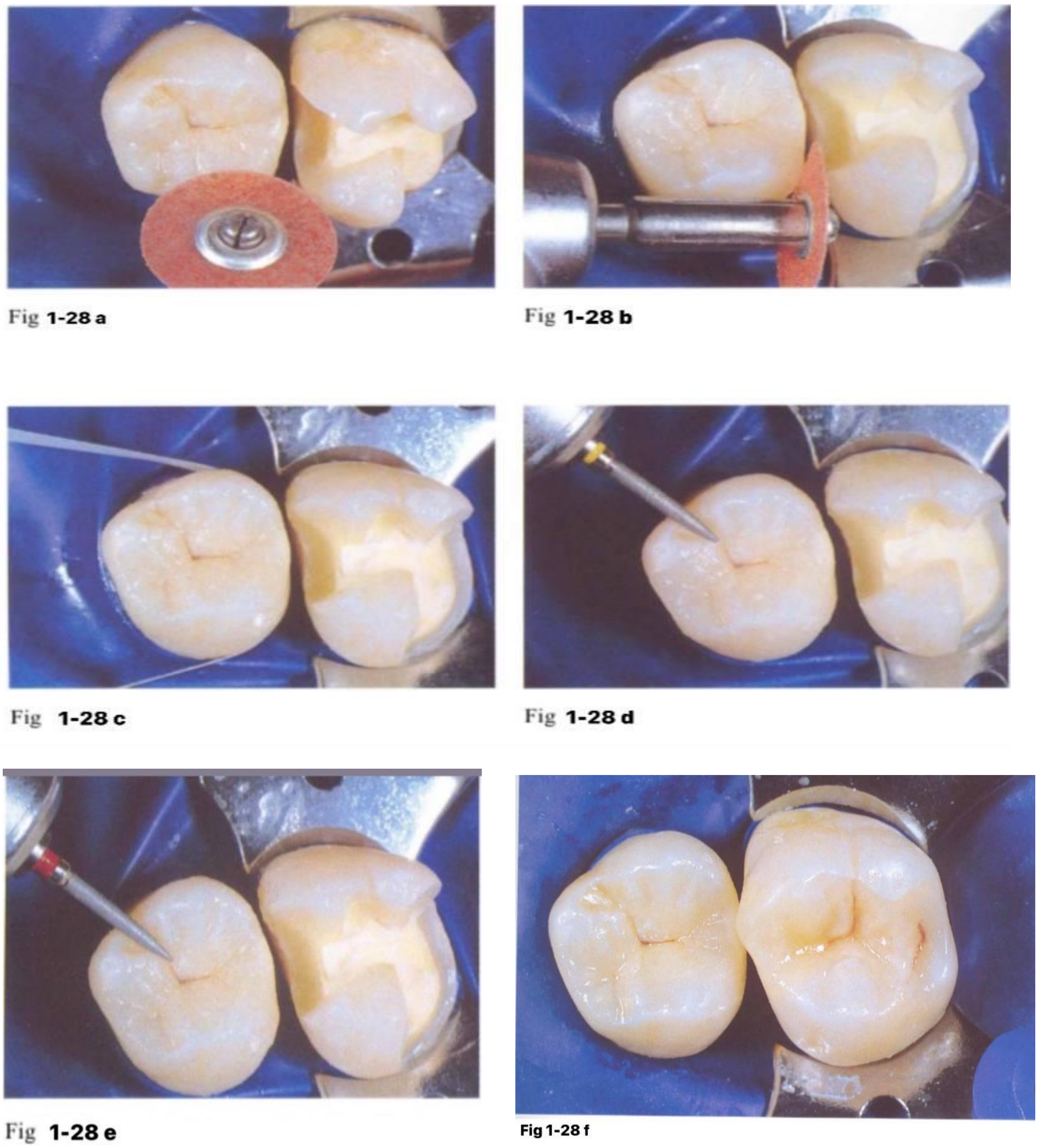

Fig. 1-28 to respect a sequential application of finishing and polishing instruments, it is mandatory to obtain a satisfactory restoration margin and surface quality. Flat accessible margins are managed with flexible disks (a-b). Gingival margins are normally finished and polished with strips (c). For occlusal and irregular margins and surfaces, rotating instruments of appropriate design and abrasivity, such as fine and superfine diamond burs, should be used (d-e). View of the cemented restorations after completed finishing and polishing (f). (Bottacchiar S, 2016)

1.17 Ceramics vs indirect composite

Regarding stress distribution **(Özkir, 2018)** showed that ceramic is a more favorable restoration material for onlay restorations. The indirect composite may also be an alternative restoration material for onlays. Besides, with the preferable stress distribution and concentration characteristics, the opportunity to fabricate restorations with better contact areas, favorable esthetics and durability, indirect restorations may be the superior alternative for onlay restorations.

The following table show the major difference between ceramic and composite regarding indirect restorations (Table 1-2).

(Table 1.2)

Differences between ceramic and composite inlays

Ceramic inlays	*Composite inlays*
Excellent esthetics	Good esthetics
Better marginal fit, thus less leakage	Poor marginal fit, thus more leakage
Good adhesion to resin cements	Poor adhesion to resin cements
Does not stain	May stain with time
Expensive	Relatively less expensive than ceramic
Complex laboratory steps	Simple laboratory steps
Intraoral finishing and polishing is time consuming	Intraoral finishing and polishing easier
Fragile and brittle, so prone to fracture while seating	Easier adjustment and seating
Abrasive to opposing enamel	Not abrasive to opposing enamel
Intraoral repair is not possible	Intraoral repair is possible

1.18 Repair of Ceramic Inlays and Onlays

Minor defects in ceramic restorations can be repaired, but before initiating any repair procedure, the operator should determine whether replacement, rather than repair, is the appropriate treatment. If repair is appropriate, the dentist should attempt to identify the cause of the problem and correct it, if possible. For example, a small fracture resulting from occlusal trauma might indicate that some adjustment of the opposing occlusion is required.

The repair procedure is initiated by mechanical roughening of the involved surface. Although a coarse diamond may be used, a better result is obtained with the use of airborne particle abrasion using aluminum oxide particles and a special intraoral device **(Panah FG. 2008**). This initial mechanical roughening is followed by brief (typically 2 minutes) application of 5% to 10% HF acid gel. HF acid etches the surface, creating further micro-defects to facilitate mechanical bonding. The next step in the repair procedure is application of a silane coupling agent.

Silanes mediate chemical bonding between ceramics and resins and may improve the predictability of resin–resin repairs. The manufacturer's guidelines should be followed when using silanes because they can differ substantially from one product to another. After the silane has been applied, a resin adhesive is applied and light-cured. A composite of the appropriate shade is placed, cured, contoured, and polished.

Conclusions

Advances in ceramic, polymer, and adhesive technologies have resulted in the development of a variety of tooth-colored indirect adhesive Class II restorations.

These restorations may even delay or prevent the progression of medium to large cavities, previously restored with amalgam, that have already been restored with amalgam from progressing to the point at which they would require a full-coverage crown. At the very least, their conservative nature, when compared with the preparation for full-coverage crowns, “banks” the tooth structure for future use.

These benefits, combined with the durability and esthetics of the indirect composite or ceramic adhesive restoration, are very important to patients and should continue to direct the nature of restorative dentistry.
These restorations offer an excellent alternative to direct composite restorations, especially for large restorations, and are more conservative than full-coverage restorations. Because the clinical procedures are relatively technique-sensitive, however, proper case selection, operator skill, and attention to detail are crucial to success.

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