

Indirect Biomimetic Restorations in Posterior Teeth - A Clinical Study of Main Principles - Case Series

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Abstract: *In the past three decades, some new materials have entered that provide more esthetic options in restoration of posterior region. The most common indirect restoration is the single unit posterior tooth. In today's dental practice there are many materials and options available to restore a tooth that has been compromised from caries.*

Keywords: aesthetic, cavity design, indirect ceramic restorations, inlay, onlay.

1. Introduction

Only two decades ago the only one option for sustainable restoration of the posterior teeth was possible with direct dental amalgam fillings or indirect metal inlays, onlays or overlays (Figure 1,2).



Figure 1. Intraoral view of gold inlays of maxillary molars.



Figure 2. Intraoral view of direct dental amalgam filling on first maxillary molar

Notwithstanding the satisfactory long-term results, especially in indirect gold restorations adhesive dentistry, as well as in the frontal zone and the posterior areas is the basis of the increased requirements for advanced minimally invasive and biomimetic treatment. This is a prerequisite for a thorough analysis of the indications and contraindications of techniques for direct and indirect tooth restoration in the distal zone and providing evidence-based clinical options available to the patient. Aesthetic restoration of posterior teeth can be grouped as direct composite, indirect composite and indirect ceramic restorations [19]. Ceramic inlays and onlays are generally considered to be appropriate for larger rather than smaller cavities, given that direct placement resin composite restorations may provide good service in small- to medium-sized cavities. The color and integrity of dental

tissue substrates to which indirect restorations will be bonded are important for clinical success [1].

Indirect ceramic restorations have more desirable physical properties than direct composite restorations because they are fabricated under relatively ideal laboratory conditions [25].

When an indirect ceramic restoration is determined to be the best treatment option for distal teeth, the clinician should determine the geometric configuration of the cavity preparation [6,21,22].

The adhesive procedures allows clinicians to restore the morphology, original mechanical loading capacity and aesthetic appearance of natural teeth [29,30]. The use of indirect ceramics restorations with adhesive techniques to fix them permits the preservation of sound tooth structure and gives more esthetic appearance of restorations in posterior teeth [3,9,31].

In 2005, an improved pressed-ceramic material - IPS e.max Press (Ivoclar Vivadent AG, Schaan, Liechtenstein) was introduced in dentistry. The E.MAX Press is comprised of high stability framework material that consists of lithium-disilicate ($\text{Li}_2\text{O}-2\text{SiO}_2$). The indirect restorations can be characterized by using either a layering or staining technique [21,22].

2. Aim

The purpose of this article is to present clinical cases in order to obtain the main principles in indirect biomimetic ceramic restorations in posterior teeth, the requirements for cavity forms in the preparation of hard dental tissues for ceramic restorations, and protect the prepared dentin wound and review the indications and contraindications.

3. Optimally defined indications and contraindications

Direct composite restorations in the posterior region are applicable in more clinical cases with extensive carious lesions, unsatisfied old fillings or extensive destruction of hard dental tissue as a result of fractures. But despite the improved physicochemical properties, improving

opportunities for reproducing specific colors, the use of stratification techniques and the implementation of zones set opacity, transparency and special effects that are the essence of direct biomimetic dentistry, there are restrictions treatment to be carried out "lege artis" [37,38].

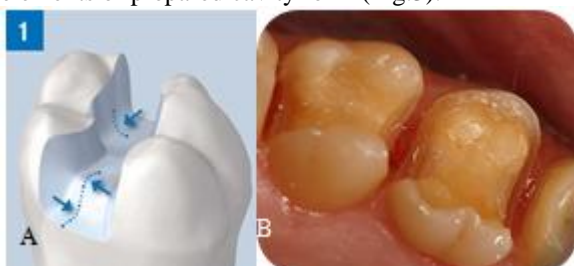
The decision to repair the clinical crown with indirect ceramic inlays, onlays and overlays is closely related to the maximum precise determination of indications and limitations of cavity form - lack of over 2/3 and more than occlusal contact points, Approximal defect over two thirds of vestibulo-lingual size of the clinical crown, which includes difficulties in recovery of the axial edge of the clinical crown. At the same time indications and contraindications for indirect ceramic restorations should not be missed. Some of them are: parafunctions (bruxism), orthodontic anomalies, missing canine protection and optimal incisal guidance, reduced vertical dimension of the clinical crown, advanced abrasion - II or III degree (in restoring single teeth), the inability to isolate the operative field, subgingival defects, lack of enamel at the gingival basis (in this clinical situation requires preparation of gingival basis), prior treatment with eugenol medicaments.

4. The maximum precise cavity resistant form

The mechanical properties of restorative materials should be analyzed before selecting the design of cavity form. The cavity preparation - the depth and width of the cavity is directly related to the resistance to fracture and deformation strength of the remaining walls and cups in the implementation of the resistant form. Sagittal and axial reduction of cusps and walls determines the type of indirect restoration - inlay, onlay, overlay. Adhesive technology allows the clinician to maintain maximum healthy hard dental tissues and restore not only the morphology and aesthetics, but to restore the stability of the natural mechanical stress and to create conditions for maintaining daily personal oral hygiene. Furthermore cavity precise form choice of restorative material is important for long-lasting treatment. The main factor that determines cavity form is the presence defect in hard dental tissue - carious process or an old filling. Preparation of the internal cavity form requires preparing rounded inner angles as in the occlusal and approximal part. The preparations with retentions are contraindicated due to the creation of tension in the ceramic restoration and increase the strength of adhesion. Requirements to cavity form can be grouped into six main criteria:

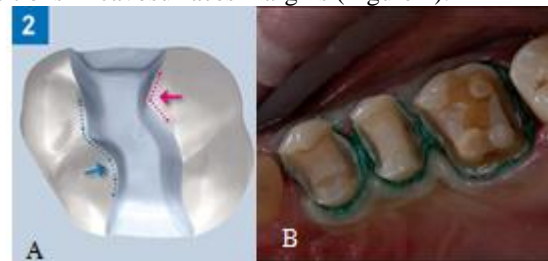
Clinical case 1

Creation of rounded and smooth transitions between the elements of prepared cavity form (Fig.3).



(c)
Figure 3: a/schematical representing of smooth transition between the walls and basics; b/intraoral occlusal view of cavity forms;c/definitive ceramic restorations.

2. Clinical case 2:Creation of rounded and smoothed transitions in cavosurfaces margins (Figure 4).



(c)
Figure 4: a/ schematically represented incorrect sharp transition (red arrow) and correct (blue arrow); b/ intraoral occlusal view of cavity forms; c/ definitive ceramic restorations.

3. Clinical case 3:Providing the necessary occlusal thickness of ceramic restoration in central fissure $\geq 1.5\text{mm}$ (Fig.5)





Figure 5: a/ schematically represented necessary occlusal thickness; b/ intraoral occlusal view of cavity form; c/ definitive ceramic restoration; d/ ceramic overlay - the necessary thickness.

4. Clinical case 4: Providing the necessary bucco-lingual size of the cavity form (Fig.6).

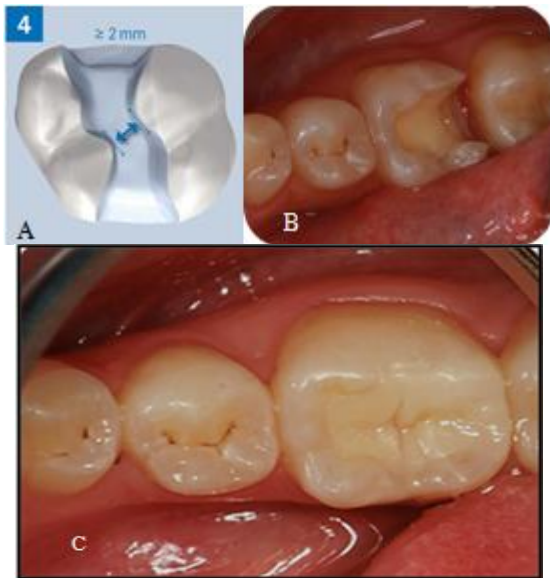


Figure 6: a/ schematically represented necessary bucco-lingual dimension; b/ intraoral occlusal view of cavity form; c/ definitive ceramic restoration;

5. Clinical case 5: Providing the necessary divergence (6-10°) of the cavity form. (Fig.7)



Figure 7: a/ schematically represented necessary divergence; b/ intraoral occlusal view of cavity form; c/ definitive ceramic restoration.

6. Clinical case 6: Providing the resistant approximal walls and ceramic margins - margins should be prepared at a 90° angle (Fig.8).

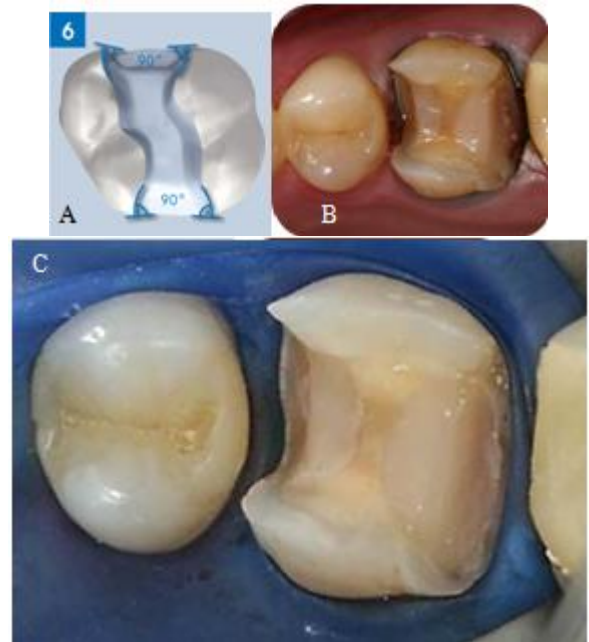


Figure 8: a/ schematically represented approximal margins; b/ intraoral occlusal view of cavity form; c/ isolation with rubber dam before cementation procedure.

5. Creation of hybrid layer

The ability of contemporary adhesive techniques to restore missing hard dental tissue is related to a change of the classical principles of Dr.G.V.Black [2] for retentive cavity form by applying the concept of minimally invasive manipulation over healthy hard dental tissue [27]. Retentive cavity forms are replaced with cavities in which carious dentin and demineralized enamel are removed. Occlusal enamel sharp edges are rounded and prepared with approximal phase. However, the extent to which carious dentin should be removed to achieve a successful mechanical, biological and biomimetic recovery is still a matter of discussion. Today there is still no defined diagnostic tool available for clinical practice in order to determine how far the removal of the altered dentin should go without running the risk of overextensive cavity form. The presence of carious dentin in the performance of an adhesive bond forms a thick film hybrid and reduced the adhesion force [39, 40]. The quality of the connection to the dentin depends mostly on the micro-mechanical retention, which is formed by infiltration of the adhesive system in a partly demineralized dentin, and subsequent formation of hybrid layer and the adhesive tags in different depths [28, 20]. To fulfill these requirements, the clinician must choose a generation adhesive system to use either total-etch technique (fourth or fifth generation) or the technique of self-etching systems (sixth or seventh generation) [7, 8]. The concept of total etching is associated with complete removal of smear layer while the etching adhesive systems include partial smear layer in hybrid by demineralization and infiltration in part of the applied acid primer. Therefore, of demineralizing potential of such systems is an important feature and depends on the nature of the acid monomer, pKa,

the applied concentration, duration of application, the osmolarity, the possibility of complete wetting, the viscosity, the concentration of water and its pH.5 [10]. Another factor that can affect the demineralization potential of self-etch adhesive is the type of smear layer. Some studies describe reduced bond strength in thick smear layer [12, 17], while other research reports indicate that this has no effect on the relationship [24]. This can partly be explained by differences in the thickness of the smear layer (0.9 to 2.6 μm) [23], at the surface, the density and the extent of binding of the smear layer to the underlying dentin structure, which is different depending on the way in which this layer is formed [15,18] (Figure 9).

6. Protection of the dentin – Immediate dentin sealing /IDS/

Tooth preparation for indirect bonded restorations can generate significant dentin exposures. It is recommended to seal these freshly cut dentin surfaces with a dentin bonding agent immediately after tooth preparation, before impression taking. Immediate dentin sealing (IDS) is a new approach in indirect restorations. A total-etch dentin bonding agent with a filled adhesive resin is recommended for this specific purpose. It is not known whether it is still possible to obtain an efficient bond between the resin-coated dentin and the restoration after 2 to 4 months of placement of provisional restorations [13, 26]. When preparing teeth for indirect bonded restorations, IDS with a 3-step etch-and-rinse filled dentin bonding agent, prior to impression making, results in improved microtensile bond strength compared to delayed dentin sealing. This technique also eliminates any concerns regarding the film thickness of the dentin sealant [14].

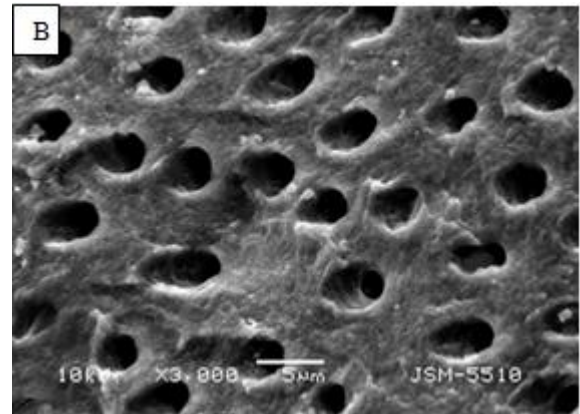
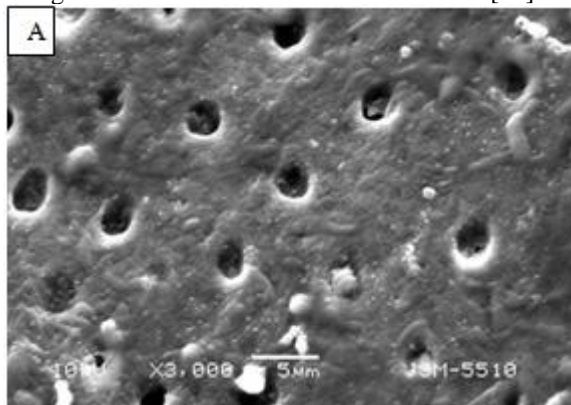


Figure 9: a/ SEM of prepared dentin with smear layer for self-etch adhesive technique; b/ SEM of acid-treated dentin (37% phosphoric acid) and prepared for total-etch technique.

7. Precise transfer of clinical information into the laboratory

7.1 Impression

Taking a final impression of the cavity on which the lab will make the inlay/onlay/overlay is a crucial step as it is shown on this model. The material used is silicone, which can take a number of minutes to set (longer than the impression for the opposing model), but it is much more accurate. The clinician will need to check that the impression has recorded every detail accurately and if not, the process will need to be repeated until a suitable impression is recorded. The materials offer features such as great detail reproduction, easy removal from the mouth and complete recovery from deformation (Figure 10). The choice of technique for impression is of a great significance. The recommended technique is - one step putty/wash technique.

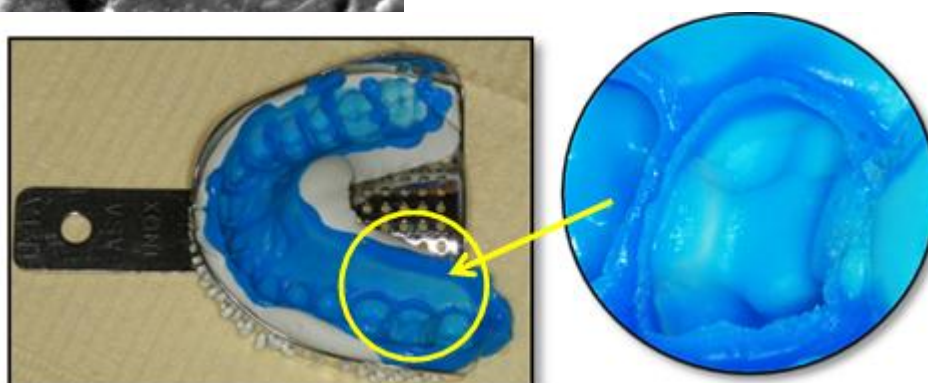


Figure 10: Impression from full dental arch for indirect inlay of second maxillary molar and zoom of the gingival base.

Gingival retraction with retraction cord, however, is required to record the root emergence profile when the cervical

margin is placed equigingivally or sub-gingivally for aesthetic or other reasons. Any undercuts created by the

cervical embrasure spaces may be filled in lingual with softened wax to avoid the risk of the impression tearing. The precise impression is very important for perfect adaptation of ceramic restoration into the prepared cavity form.

7.2 Shade selection sequence

The ability to select shades accurately and reliably is a critical stage for successful clinical outcomes in esthetic dentistry. This requires knowledge of color science and an understanding of the optical properties of teeth. Shade selection is dependent on the clinician's aptitude to interpret a multilayered structure of varying thicknesses, opacities and optical surface characteristics. The basic hue of a tooth is determined by the color of underlying dentin, while value is a quality of the enamel overlay.

7.3 Photo Documentation

With the increasing use of ceramic restoration, it is very important to have correct communication with the dental laboratory. In this communication it is very important to choose the right stump shade, especially when there are requirements to mask the remaining darkened tooth structures. A photographic series of intraoral images should be part of the documentation process. Photographs of the prepared tooth should include selected stump shade. These enable the dental team - clinician and ceramist, to select the most appropriate material for each indication (Figure 11). The use of opaque materials such as zirconia, allows better masking of underlying colored dentin, than silica based materials - feldspathic and glass ceramics. Today the introduction of new lithium disilicate materials with different opacities - high and low translucency (HT, LT) medium and high opacity (MO, HO) has allowed a customization of restorations to achieve better results.



Figure 11a-d. Photo documentation for determination of the color.

8. Discussion

There are many conflicting results in the literature today, regarding the fracture resistances of teeth restored with ceramic inlay and onlay. Yamanel et al. stated that the onlay design is more effective in protecting tooth structures than the inlay design [36]. Conversely, Morimoto et al. reported that the fracture strength of teeth structures restored with indirect feldspathic ceramics with cusp coverage was similar to that of intact teeth [16]. Soares et al. discuss that the

fracture resistance of posterior inlay and onlay leucite-reinforced ceramic restorations were significantly higher than those of intact teeth [21].

The design of cavity preparation should be based on the preservation of dental structure and on the physical properties of the chosen restorative material. Khera et al. studied the effect of depth of preparation, isthmus width and dentin thickness on the potential for tooth fracture. They concluded that the depth of the preparation was the most critical factor in tooth fracture, whereas the width of the isthmus alone was the least critical [11]. Ceramic restorations can fracture because of cracks formation and their propagation, which is especially true for this type of restorations [34]. As preparations increase in bucco-lingual size, the remaining tooth structure weakens, and occlusal loads induce greater cusp deformation. Some authors have suggested that optimal restoration design in teeth with large MOD cavity preparations refers to onlays that include cuspal coverage [16]. In contrast of these findings, Saridag et al. reported that cuspal coverage decreased the fracture resistance of the posterior tooth and lithium-disilicate glass ceramic restoration complex [35].

Dalpino et al. found that bonded indirect ceramic restorations fractured at higher loads than direct and indirect composite resin restorations [4]. Following conclusions of Esquivel-Upshaw et al. bonded indirect ceramic restorations are the ideal option for restoration of teeth weakened by wide cavity preparation [5].

Today, debate still remains regarding the clinical cases at which onlays should be recommended instead of bonded inlays [34].

9. Conclusion

In conclusion of this clinical study it was reported that patients are satisfied with the aesthetic results of indirect ceramic restorations. Thus, from a patient's perspective, if aesthetic differences are not a major factor, the question becomes why investment in the ceramic restoration might be preferable over a direct composite. From a clinical point of view a follow-up period presents a satisfying result in aesthetics, marginal adaptation, asymptomatic cases, occlusal stability and perfect position of approximal contact point, which is very important for marginal periodontal health. When a posterior tooth is compromised because of wide cavity preparations (more than 2/3), ceramic inlays/onlays offer advantages over direct composite restorations. The principles of the preparation and realization of a bilateral adhesive bond between the composite cement and ceramics on one hand and with dentin on the other hand, are the sound foundation of the biomimetic indirect restorations.

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