



# Evidence-based concepts and procedures for bonded inlays and onlays. Part II. Updated guidelines for cavity preparation and restoration fabrication

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## Abstract

The second part of this article series presents an evidence-based update of clinical protocols and procedures for cavity preparation and restoration selection for bonded inlays and onlays. More than ever, tissue conservation dictates preparation concepts, even though some minimal dimensions still have to be considered for all restorative materials. In cases of severe bruxism or tooth fragilization, CAD/CAM composite resins or pressed CAD/CAM lithium disilicate glass ceramics are often recommended, although this choice relies mainly on scarce *in vitro* research as there is still a lack of medium- to long-term clinical evidence. The decision about whether or not to cover a cusp can only be made

after a multifactorial analysis, which includes cavity dimensions and the resulting tooth biomechanical status, as well as occlusal and esthetic factors. The clinical impact of the modern treatment concepts that were outlined in the previous article – Dual Bonding (DB)/Immediate Dentin Sealing (IDS), Cavity Design Optimization (CDO), and Cervical Margins Relocation (CMR) – are described in detail in this article and discussed in light of existing clinical and scientific evidence for simpler, more predictable, and more durable results. Despite the wide choice of restorative materials (composite resin or ceramic) and techniques (classical or CAD/CAM), the cavity for an indirect restoration should meet five objective criteria before the impression.

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## Introduction

The first part of this series of articles was presented as a comprehensive, revised treatment rationale and as clinical procedures for bonded inlays and onlays, based on scientific and long-term clinical evidence. The most relevant principles reported were the absence of tissue removal following materials' properties or technical requirements, and the effective preparation of dental tissues following Dual Bonding (DB)/Immediate Dentin Sealing (IDS) concepts,<sup>1-8</sup> Cavity Design Optimization (CDO), and Cervical Margins Relocation (CMR),<sup>1-3,9,10</sup> depending on the clinical situation and needs. The aforementioned procedures aim to avoid any additional tooth preparation and tissue removal required to create the geometry for indirect posterior restorations and to protect the pulpodentinal structures from any contamination/disturbance during the temporary phase, as well as to stabilize and improve the adhesive interface quality. When needed, the CMR technique (also known as Deep Margin Elevation – DME) helps to raise deep cervical margins to a visible and accessible level (supragingivally), easing impression and cementation procedures. Moreover, due to an even cavity design, the CDO and CMR techniques facilitate the placement of temporary restorations (non-cemented) and the restoration fabrication. Regarding cementation, the use of a highly filled, light-curing restorative material is recommended instead of a dual-curing composite cement because of its superior mechanical properties and wear resistance, as well as its practicality.<sup>3,11-13</sup> Overall, this updated clinical protocol

has the potential to resolve most of the clinical difficulties usually encountered during the preparation, isolation, impression taking, and cementation of tooth-colored inlays and onlays, while improving treatment quality and longevity.

## Occlusal considerations and tooth preparation

### Restoration material choice

Regarding the restorative material used for inlays and onlays, ceramics (pressed or fired) were traditionally preferred, as they were thought to be stronger and more reliable than their composite counterpart. However, the referred literature never clearly confirms the advantage of ceramics, especially taking into consideration disparate testing environments for both restorative materials.<sup>14-16</sup> Actually, the patient selection and clinical environment were manifestly more favorable to ceramic restorations, as indirect ceramic restorations were neither placed in social clinics nor in patients with severe bruxism, while such restrictions did not normally apply (or did not apply as strictly) to composite studies. Despite this, composite resins have been widely used for the fabrication of inlays and onlays due to a simpler manufacturing process (and thus lower cost), as well as their excellent esthetics and easier reparability. A more “recent” and increasingly used alternative is CAD/CAM restoration, made in either ceramic or composite resin blocks (ie, IPS Empress or e.max CAD, Ivoclar Vivadent; Lava Ultimate, 3M). Despite this large choice with regard to materials and fab-



rication methods, the tooth preparation for all kinds of modern bonded restorations relies on similar specific principles, which differ from those for traditional cast-gold inlays and onlays, and even the first generation of fired porcelain restorations, whose limited mechanical resistance imposes more demanding and invasive preparations.

The occlusal environment has to be evaluated, as it plays an important role in restoration longevity and can also influence material choice. Extensive restorations with generally large and deep cavities (mainly non-vital teeth) in high load-bearing areas (especially the second molars) associated with an unfavorable occlusal context (such as patients with bruxism) have to, in any case, be considered biomechanically vulnerable and more susceptible to failure. In the latter unfavorable situation, only the strongest materials should be chosen, based mainly on their superior mechanical properties. Today, new CAD/CAM composite resin blocks (ie, Lava Ultimate, 3M; Enamic, Vita) or lithium disilicate-based restorations (ie, IPS e.max Press or CAD, Ivoclar Vivadent) are preferred, the former option having some interesting stress-absorbing properties,<sup>17</sup> while requiring simpler procedures when a surface modification or repair is needed.<sup>18</sup> Recent *in vitro* studies on the fracture and fatigue resistance of direct and indirect restorations of a severely eroded tooth model demonstrated the favorable behavior of CAD/CAM composite materials.<sup>17,19-24</sup> Apart from the non-vital tooth configuration, the aforementioned findings are well supported by clinical trials.<sup>25-28</sup> However, less information is available to date

regarding the assessment of the *in vivo* performance of new monolithic ceramic restorations in a critical biomechanical environment.

### Preparation extent and restoration thickness

All tooth-colored materials (composite resin or ceramic) used for the fabrication of posterior indirect restorations are submitted to high occlusal functional stresses; consequently, their inherent vulnerability needs to be compensated for by restoration thickness and proper adhesive cementation. Although the restorations should therefore be as thick as possible, this approach is tempered by the fundamental principles of minimal invasiveness.<sup>29</sup> Moreover, an unconsidered sacrifice of enamel and dentin could also directly weaken the tooth. For example, Fennis and co-workers have demonstrated that thick overlay restorations show higher static fracture strength compared to conservative ones,<sup>30</sup> although they present more drastic and irreversible failures; ie, thicker restorations may be stronger but simultaneously imply thinner and weaker dental tissues underneath them. At the same time, extremely thin material is not systematically and unconditionally recommended. If one takes into consideration that a few tenths of a millimeter can considerably strengthen a restoration, the best compromise would be between material resistance and the clinical situation.<sup>31</sup> We should therefore move away from the blind application of “minimally invasive dentistry” to a more realistic concept of “minimally hazardous dentistry”, which is particularly pertinent to



**Fig 1** Oscillating selectively coated diamond instruments for the finishing of the interproximal zone.

large and deep cavities and to non-vital teeth.

The minimal occlusal thickness allowed for a material depends on, among many other parameters, its intrinsic mechanical features (static and dynamic reaction to stresses) and is therefore material- and even brand-dependent. Thus, usual recommendations based on clinical experience and *in vitro* testing suggest to attain at least 1 mm thickness for composite resins, and 2 mm for low-strength ceramics, such as feldspathic (eg, Vita Mark II, Vita) and leucite-reinforced (IPS Empress I, Ivoclar Vivadent) ceramics. For new lithium disilicate-reinforced ceramics (ie, IPS e.max Press or CAD), the minimal recommended thickness seems to be closer to that recommended for composite resin, ie, between 1 and 1.2 mm.<sup>21,22,31-33</sup> The presence of enamel under these thin ceramic restorations has also been recently proven to yield a certain positive effect.<sup>31,32,34</sup> Overall, a restoration thick-

ness between 1.0 and 1.5 mm seems to be advisable for all modern “white” restorative materials, including composite resins, pressed ceramics, and CAD/CAM blocks (apart from traditional feldspathic and leucite-reinforced ceramics), while the stability and impact of thinner material layers on restoration longevity is still under evaluation. Moreover, it is important to note that minimal material thicknesses should be limited to monolithic/mono-laminar restorations, as a layering procedure could mean including imperfections in the narrow available space, thus weakening the system. Finally, esthetic considerations will also have an impact on restoration thickness (see “Esthetic considerations” below).

In conclusion, a good compromise between tissue preservation and a suitable restoration thickness has to be found and adapted to each case or tooth-specific occlusal and esthetic context.

### Clinical guidelines

It follows, then, that while the cavity design and extent is largely dictated by conservation principles, together with occlusal and esthetic parameters, the overall cavity design is related to the pathology and presence of decayed tissues rather than the need for macroretention or friction.

Practically, preparation starts with the removal of the existing restoration and decayed tissues without initially finishing the enamel margins. In less accessible areas (usually interproximally), oscillating, selectively diamond-coated instruments (ie, PCS, EMS or Sonicsys, KaVo) facilitate the preparation and finishing of cavities (Fig 1). When cavity margins



violate the biological width, a crown-lengthening procedure may be needed, while for subgingival/intracrevicular cervical margins (a more frequent condition), a conservative CMR is advised. The decision to use a specific technique depends less on ultra-strict biological width considerations and more on the future accessibility of the margins to secure the clean and dry environment necessary for proper adhesive techniques. Fissures (in dentin or enamel) should ideally be included in the preparation, considering potential bacterial leakage or structural weakening, although their extension in inaccessible zones often prevents these flaws from being fully eliminated.

### Thin cavity walls and occlusal coverage

Little is known scientifically about the minimal thickness needed to maintain thin tooth walls and what is to be considered totally safe and conservable, knowing that a multitude of parameters will impact such a decision process. The presence of thin walls around an extensive cavity is, in any case, considered a strong indication for indirect restorations rather than direct fillings, as polymerization might deform the remaining facial and lingual tooth structures, potentially inducing cracks due to the inward cusp movement that follows.<sup>35-38</sup> The cavity size and design (C-factor), as much as the stratification technique, will impact such stresses on residual tooth structure.<sup>39</sup> This is why indirect techniques are generally preferred, because polymerization shrinkage is confined to the thin layer of luting resin cement.

Different options are available with an indirect approach. First, in an attempt to follow aforementioned conservation principles, thin and undermined cavity walls can be maintained and reinforced with composite resin during the adhesive resin lining of the cavity following the CDO. The authors recommend a minimum of 1 mm as minimal wall width/thickness before reinforcement. In cases where the minimal residual thickness is below this measurement, cusp coverage is indicated (this guideline seems to be the accepted general clinical consensus nowadays). The aim is to have a more homogeneous biting force distribution and offer a “protective effect” for the underlying weakened tooth structure. The resulting “invasiveness” could, however, increase the risk of irreversible tooth fracture (below the cemento-enamel junction – CEJ), as is shown *in vitro* by Fennis et al,<sup>30</sup> although such clinical observation is extremely rare in vital teeth. Finally, the systematic occlusal coverage of functional and/or non-functional cusps is not yet advocated, as it is seemingly not proven to increase the final strength of the tooth-restoration system, both for composite resins<sup>40</sup> and ceramics.<sup>41-44</sup>

In conclusion, occlusal coverage is recommended for cavity walls of 1 mm or thinner, while for “intermediate” thickness (1 to 2 mm), the occlusal context including tooth position, presence of parafunctions, and the kind of lateral guidance (canine or group guidance) should be taken into account when making the therapeutic decision. The cavity configuration, and in particular the presence or absence of the marginal ridges, can also play a role in the final strength



**Fig 2** The “smile space” of two different patients. The visibility of the treated tooth during smile has to be verified before cavity preparation. The patient’s lips can act as a curtain behind which the tooth–restoration transition can be hidden.

of the residual walls, especially in endodontically treated teeth.<sup>45</sup>

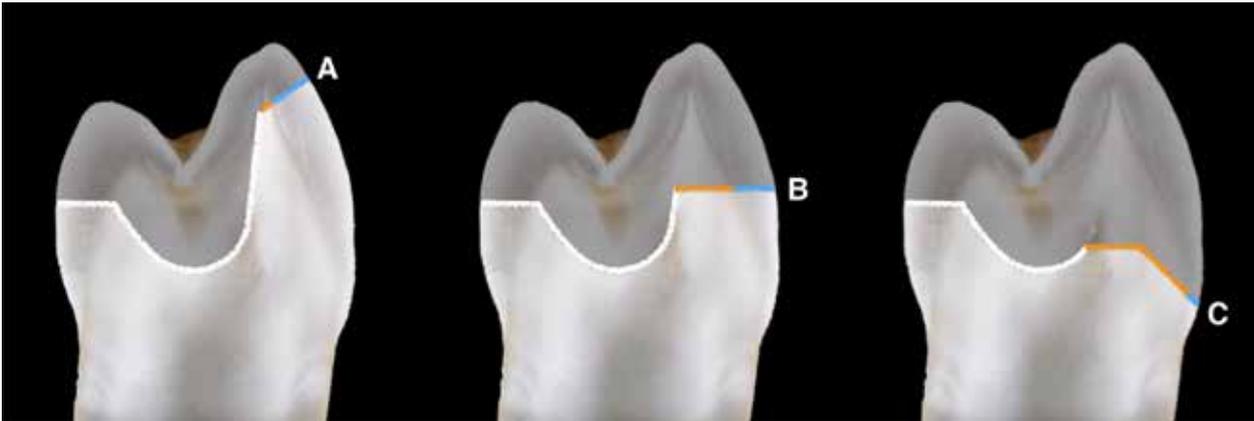
### Esthetic considerations

For restorations extending into the buccal-esthetic zone (the virtual space between the upper and lower lips during full smile), margin positioning plays an important role (Fig 2). Actually, the simplest and most ideal situation is for the restoration margins to be located in the incisal or cervical thirds. In both situations, a good esthetic integration of the restoration can easily be achieved due to a simpler tissue arrangement; practically, almost only one tissue is present – enamel in the incisal third, and dentin in the cervical third. This makes the esthetic integration of the restoration technically and optically more predictable (Fig 3). Where esthetic requirements are low, margins can be left elsewhere on the buccal cusp, depending only on the restorative needs.

While the esthetic impact of the restoration should theoretically be analyzed before the cavity preparation, the final extent of the restoration in the buccal-esthetic zone is generally unknown. As the removal of undermined, fissured or thin buccal cusps could bring the restoration into a visible and more critical esthetic zone, this occurrence must be taken into account and a shade selection systematically performed before the preparation. Otherwise, tissue dehydration will prevent the clinician from later choosing a precise and reliable shade registration because it only takes a few seconds of tissue dehydration to impact shade perception.

### Shade selection

Additionally, metallic and temporary restorations, caries, and – in general – any discolored, decayed tissue may alter dentin and enamel shades; thus, they should be removed beforehand under water spray, to preserve tissue hydra-



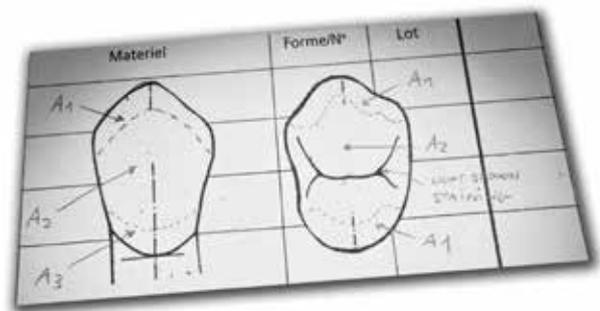
**Fig 3** Guidelines for buccal cusp coverage. **(a)** Ultraconservative buccal cusp coverage. **(b)** Conventional buccal cusp coverage. **(c)** Full buccal cusp coverage. In **(a)** and **(c)**, the restoration has to mimic practically only one tissue, with only one set of optical properties – enamel (blue) in the incisal third, and dentin (yellow) in the cervical third. Thus, esthetic outcomes are more predictable.

tion. As an alternative, tooth shade can be recorded and cross-matched with a non-restored, contralateral or neighboring tooth.

There are various techniques used to make a shade selection, depending on the material (composite or ceramic), which usually make use of brand-specific shading systems and shade guides. For ceramic restorations, particularly in posterior areas, the classical VITA shade guide (Vita) is the most widely used system for monolithic ceramic or monolaminar composite restorations (those following the VITA shading concept). For layered composite restorations, more effective alternatives exist, with either a bilaminar shade guide, including specific dentin and enamel color selection (ie, Inspiro, EdelweissDR; Miris 2, Coltene Whaledent),<sup>46,47</sup> or, for other brands, customized shade tabs produced free-hand or with a mold (My Shade Guide, Smile Line).

In addition to the basic information about dentin and enamel shade, any

other details or characteristics to be reproduced on the buccal and occlusal surfaces (white spots, stains on fissures, etc) should be communicated to the laboratory via a simple schematic drawing (Fig 4) or an intraoral photograph of the tooth. In the specific case of the buccal cusp, enamel shades should be preferred for a minimally invasive occlusal



**Fig 4** Example of a schematic drawing for communication with the dental laboratory.



**Table 2** Clinical step-by-step protocol for the cavity preparation of bonded indirect posterior restorations

• Apply local anesthesia
• Check occlusal context and esthetic needs of the tooth
• Choose tooth shade
• Remove old restoration, excavate caries, and prepare but do not finish the margins of the cavity
• Check interocclusal space in centric and during lateral movement
• Isolate the cavity with rubber dam and, in case of subgingival margins, place metal matrix
• <i>Dual Bonding (DB)/Immediate Dentin Sealing (IDS)</i> . Seal whole dentin with an adhesive system following manufacturer's instructions. This procedure also involves thin subgingival enamel margins, if present
• Light-cure bonding resin for 20 s
• <i>Cavity Design Optimization (CDO) and Cervical Margins Relocation (CMR)</i> . Apply a thin layer of composite resin to cover whole dentin, fill the retentions, and relocate margins supragingivally, if necessary
• Light-cure each increment of composite resin for 40 s
• Insulate cavity with a layer-forming glycerine gel and light-cure the resin again for 10s
• Finish enamel margins with fine diamond instruments without exposing dentin. Do this with composite margins too, if present
• Check the five criteria for cavity approval: 1. Detailed sharp margins 2. Absence of undercuts 3. Accessibility of subgingival margins 4. Absence of contact between the cavity and the adjacent teeth 5. (After rubber dam removal) Adequate interocclusal space in centric and during lateral movements
• Take impression
• Insert the temporary resin material into the cavity, check the occlusion before the material sets, remove excesses, and light-cure in occlusion for 30 s

coverage (see Fig 3a), while dentin shades should be used for crown-like preparations (see Fig 3c) in the cervical part of the restoration.

For monolithic CAD/CAM ceramic or composite resin blocks, porcelain stains or resin “paint-on-colors” should be used for a more detailed color char-



**Figs 5a and b** Rubber dam isolation is facilitated by placing a metallic matrix and interproximal wedges.

acterization of esthetically demanding cases. For CAD/CAM or pressed lithium disilicate ceramic restorations, apart from surface staining, low-fusing ceramic veneering is possible, although it may affect overall restoration strength.<sup>48</sup>

## Adhesive procedures and cavity treatment before impression

### Dual Bonding/Immediate Dentin Sealing

One of the main objectives of the preparation session is to leave the cavity with only two substrates until cementation, these being mechanically finished enamel, and composite (Table 2). All the dentinal surfaces should be properly sealed, and are usually protected by the liner. Once the cavity is prepared, the next step is the sealing of the dentin and thin subgingival enamel margins, if present, using a multistep adhesive system. An etch-and-rinse or self-etch system can be used. The early sealing of dentin provides many benefits, as has

been described by several authors (see Part I of this article series).<sup>2,4,5,8,49,50</sup> Early sealing is also necessary as an adhesive pretreatment, allowing for the placement of the composite liner or base, as previously described. This step should be performed under rubber dam isolation. In case of subgingival/intracrevicular margins, the placement of a pre-shaped metallic matrix will prevent the rubber dam from covering deeper margins, making adhesive and liner application easier (Figs 5a and 5b).



**Fig 6** Selective enamel etching for 30 to 45 s as shown in this image has to be avoided when enamel is thin, typically in a subgingival situation. There is a high risk of dentin over-etching.



**Fig 7** Dual Bonding (DB) or Immediate Dentin Sealing (IDS) with an etch-and-rinse adhesive system. This procedure also involves the thin subgingival enamel margins, if present. **(a)** Orthophosphoric acid etching of dentin and thin interproximal enamel for 5 to 10 s. **(b)** Primer application on dentin. **(c)** Bonding resin application on dentin and thin enamel. The resin is then polymerized for 20 s.

**Fig 8** DB or IDS with a self-etch adhesive system. This procedure also involves the thin subgingival enamel margins, if present. **(a)** The cavity before the adhesive treatment. **(b)** Application of the self-etching primer on dentin and thin enamel. **(c)** Application of the bonding resin. The resin is then polymerized for 20 s.



To obtain an optimal substrate for further adhesive procedures – enamel and composite only – attention should be given to enamel thickness. When it is thin and inconveniently located (typically in a juxta- or subgingival situation), difficulties will arise; for instance, it will be a lot more demanding to finish enamel margins before impressions without contacting/exposing dentin and without damaging gingiva, or obtain perfect impression taking, or quick, effective rubber dam placement. In this case, the cervical margin comprising both enamel and dentin is likely to be covered by the composite liner. Then, adhesion to this thin subgingival enamel is established at the same time as the dentin sealing. If an etch-and-rinse system is used, it is important to respect conditioning times. Indeed, the etch-and-rinse technique, based on highly concentrated orthophosphoric acid action, implies the conditioning of dentin and enamel for different time intervals, ie, 5 to 10 s, and 30 to 45 s, respectively. However, when enamel is thin, selective enamel etching is difficult to achieve without the risk of inadvertently over-etching the neighboring dentin (Fig 6).<sup>51</sup> The proposed clinical “compromise” is then to condition such thin enamel, together with dentinal tissue, for a limited time of 5 to 10 s (Figs 7a to 7c). As an alternative, a two-component self-etch system can be used, without prior selective enamel acid etching (Figs 8a to 8c).<sup>52,53</sup>

## Cavity Design Optimization and Cervical Margin Relocation

Once bonding resin is polymerized, a layer of composite is normally applied over all sealed dentin surfaces to create an optimal cavity design, unless restoration thickness restricts the placement of such a layer, as is the case with overlays used for the treatment of tooth wear. In this particular situation, a filled adhesive system is normally preferred (ie, OptiBond FL, Kerr), which plays the role of both adhesive and cavity liner. In this case only, the procedure is considered to be a “cavity coating”.<sup>54,55</sup>

As has been mentioned, the cavity lining plays multiple roles, including the reinforcement of cavity walls. It simultaneously eliminates undercuts and saves tooth structure, the leveling of the cavity floor, and, if needed, the occlusal relocation of cervical margins. Finally, it offers a physical and biological protection during the temporary phase (eliminating virtually all possible biological complications, such as tooth sensitivity and bacterial leakage), leading to a markedly improved protocol, compared to the “traditional” approach for adhesive indirect restorations (Table 1). At the time of cementation, it will also act as a physical barrier against the mechanical surface treatment (sandblasting) of the cavity, preserving the integrity of the sealed dentin surfaces (Fig 9).<sup>7</sup>

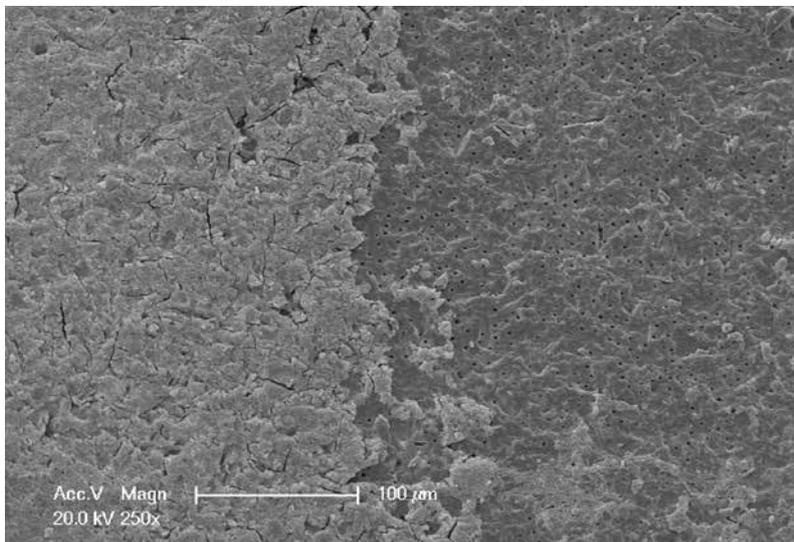


**Table 1** Comparison between the conventional and updated clinical protocol for bonded inlays and onlays

Clinical steps	Conventional	Updated
Preparation	With suction	Under rubber dam
Dentin sealing application	At cementation	Just after preparation
Base/liner	Optional	Mandatory
Luting material	Dual-curing resin cement	Light-curing restorative materials
Insertion	Manual	Assisted by sonic/ultrasonic energy

In CAD/CAM restorations, the exact same objectives must be attained, although the software can easily ignore undercuts. However, despite the lack of any interference during insertion/cementation, larger cementing gaps may be created in all retentive areas, which will induce higher polymerization stresses due to the “wall-to-wall” contraction.<sup>56</sup> As a result, gap formation and/or postoperative sensitivity could occur. The latter approach is therefore not recommended.

With regard to CMR, the amount/thickness of composite (either flowable or restorative) is limited to the minimum needed to bring the preparation supragingivally (usually about 1 to 1.5 mm), in order to both control polymerization stresses and optimize marginal adaptation, while creating a proper restoration emergence profile. A curved matrix, full or sectional, is recommended for this procedure (eg, MetaFix, Kerr; Palodent, Dentsply).



**Fig 9** SEM image showing the effect of sandblasting on IDS. In the left part of the image, dentin has been sealed with Adhese Universal (Ivoclar Vivadent). In the right part, dentin has been sealed with Adhese Universal (Ivoclar Vivadent), sandblasted with 27-µm aluminum oxide particles (5 mm distance) for 1 s and then etched with orthophosphoric acid for 10 s. The large presence of dentinal tubules on the right part of the dentin surface means that the adhesive layer has been widely removed by the sandblasting.



## Material selection (flowable vs restorative consistency)

While the clinical advantages of a composite liner/base underneath indirect bonded inlays and onlays have been clearly shown and discussed by several authors,<sup>1,5,9,10,55</sup> there is, however, no consensus regarding what resin-based material is ideal. The choice between highly filled hybrid or flowable composites is still debated today because the few existing scientific studies have failed to demonstrate any difference in terms of marginal adaptation between both materials, at least when used in thin layers (1 to 1.5 mm), in particular for CMR.<sup>10,57-59</sup>

Overall, classical restorative hybrid composites present better mechanical properties compared to flowable ones, apart from higher hydrophobicity and wear resistance,<sup>60</sup> although for the latter this “advantage” is rather insignificant in this specific application. Restorative materials do, however, have a practical shortcoming, as they require additional finishing, during which dentin areas covered by thin layers of material and adhesive are re-exposed, making a second dentin sealing procedure necessary. Moreover, when relocating deep cervical margins, the matrix can be displaced during the placement of a firmer material when the use of a wedge is impossible due to deep proximal margin position. Then, a restorative, highly filled composite (usually 75% to 85% filler weight) is recommended in extensive cavities that require more than one single increment of material (over 1.5 mm).<sup>59</sup> For endocrowns, the more important volume of material needed to

fill up the pulp chamber suggests the use of a restorative composite instead of a flowable one.

Highly filled flowable composite resins (usually 65% to 75% filler weight) otherwise offer obvious practical advantages due to their ease of use, and are indicated in all cases which necessitate a “normal” composite liner thickness (less than 1.5 mm thickness), which corresponds to the majority of inlay or onlay cavities, including those with limited interocclusal space. Due to their inherent physicochemical characteristics (slightly inferior mechanical strength and higher polymerization shrinkage, although not always higher polymerization stress), flowable composites should not be used in thick layers, regardless of the simpler application technique.

Practically, the composite liner/base (either flowable or restorative consistency) is normally light-cured separately for 20 s per area. The final or single increment will be cured, protected by a thick layer of glycerine gel (K-Y Jelly, Personal Products Co) placed into the cavity after a first 5 s period and left until complete liner/base polymerization. The aim of the glycerine gel is to eliminate the superficial oxygen inhibition layer, which can interfere with the setting of some impression materials.<sup>61</sup> Finishing and cleaning of enamel margins and excesses of composite resin liner with fine diamond instruments is the last step before impression taking, to obtain well-defined margins. One should, however, be careful not to expose dentin again during this step; if this accidentally occurs, resealing of exposed dentin would be required.



### Impression procedures

#### Checklist before impression

When the cavity is ready for impression taking, five objective criteria should be met (Figs 10a to 10e):

- 1) **Detailed sharp margins.** All cavity margins must be clearly visible and sharp, granting optimal impression quality (including readability by the CAD/CAM camera system), as well as restoration quality and fit. Finishing enamel margins of the cavity after adhesive coating/composite lining is mandatory to obtain these well-defined and sharp margins before the impression of the cavity.
- 2) **Absence of undercuts.** Undercuts must be eliminated or filled with composite (restorative or flowable) during the composite lining.
- 3) **Accessibility of subgingival margins.** Margins of the cavity, especially cervical ones, must be relocated occlusally (at least 0.5 mm over the free gingival margin) to facilitate impression and rubber dam application. Do not over-elevate the margins in order to obtain an optimal, natural proximal emergence profile of the future restoration.
- 4) **Absence of contact between the cavity and the adjacent teeth.** This should guarantee good flow of the impression material in the interproximal areas, and make optical impression recording easier. The technician or the

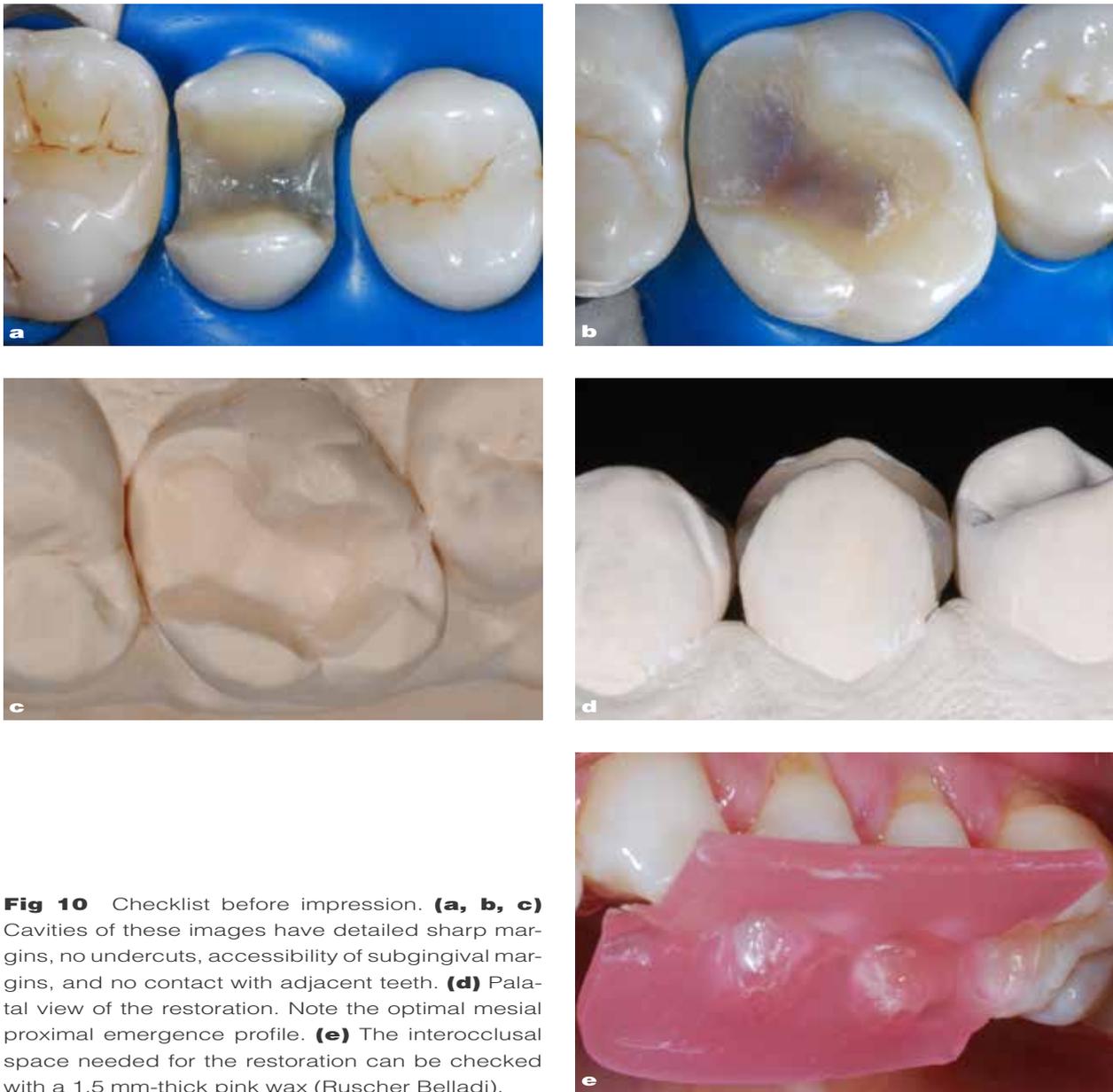
CAD software will also be able to cut the working model easily. The interproximal surfaces of adjacent teeth must be polished before impression. They can also be slightly reduced so as not to invade the normal proximal volume of the restoration.

- 5) **Adequate interocclusal space.** The suitable interocclusal space for the selected restoration's material (see "Preparation extent and restoration thickness" above) is checked after rubber dam removal in centric and in lateral movements.

The preparation checklist and guidelines are identical for both classical in-lab or CAD/CAM restorations.

#### Impression technique

Once the five above-mentioned criteria have been met, impression will definitely become uncomplicated. For a conventional approach, the use of an elastomer material such as polyvinylsiloxane (VPS) or polyether is recommended, although polyether materials are rather sensitive to the possible persistence of an oxygen-inhibited layer, which may affect their setting reaction.<sup>61</sup> A two-step technique is suggested, including both a syringe and a tray material (Figs 11a to 11e). A metallic half-bite tray will ease the impression technique while limiting the slight inaccuracy of full-arch impressions.



**Fig 10** Checklist before impression. **(a, b, c)** Cavities of these images have detailed sharp margins, no undercuts, accessibility of subgingival margins, and no contact with adjacent teeth. **(d)** Palatal view of the restoration. Note the optimal mesial proximal emergence profile. **(e)** The interocclusal space needed for the restoration can be checked with a 1.5 mm-thick pink wax (Ruscher Belladi).



**Fig 11** Impression of the cavity. **(a)** The half-bite metal tray, also known as a triple tray. **(b)** The putty material is first inserted in the tray. **(c)** The flowable impression material is injected successively in the cavity. **(d)** The setting of the impression materials while the patient is in occlusion. **(e)** Details of the impression.



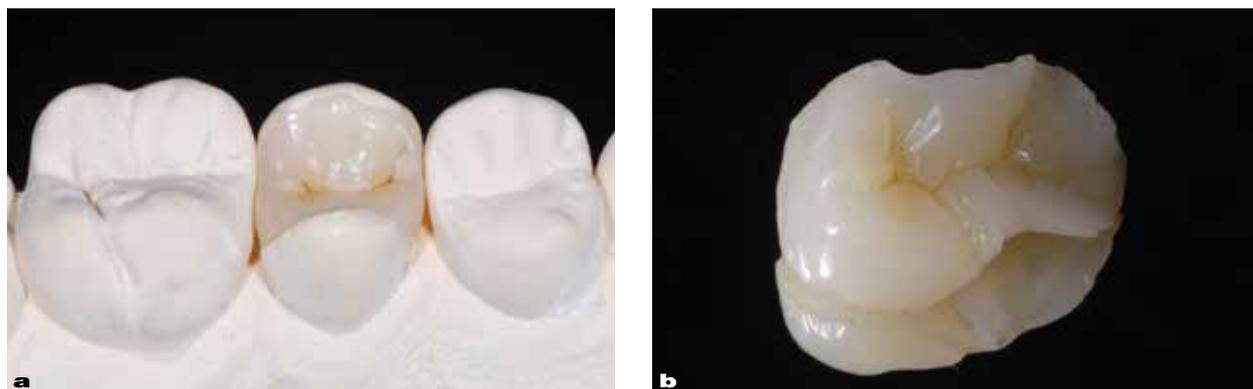
## Provisional restoration

Following the impression, cavities will be temporarily restored with, preferably, a non-cemented “semi-rigid” light-curing resin (eg, Teliotemp, Ivoclar Vivadent) (Figs 12a to 12c). Practically, the cavity first needs to be isolated with Vaseline at the periphery and over the axial walls, leaving a small central area at the cavity floor without isolation (the size of which depends on the cavity design and retentiveness) to provide “semi-adhesion” between the composite liner and provisional material, granting temporary retention. Then, an adequate amount of the light-curing material is inserted into the cavity before occlusion by the patient, who then proceeds with anterior and lateral movements in order for the temporary restoration to be shaped functionally. Thereafter, interproximal, buccal, and lingual/palatal excesses are removed and the resin is light cured in occlusion. Limited interproximal excesses contribute to temporary stabilization. The placement of such temporaries is both simple and fast, assuming adequate protection of the preparation, teeth stabilization, and the patient’s functional comfort. Due to the very short time that it remains in the mouth, the presence of triclosan as an antimicrobial agent in the temporary material (ie, Teliotemp) and the related issues that have been raised about this disinfectant’s potential side effects, is limited or insignificant.<sup>62,63</sup>

A classical provisional restoration made out of acrylic resin is not recommended any longer due to its time-consuming procedure (compared to “semi-rigid” light-curing resin), as well as the



**Fig 12** Temporization of the cavity. **(a)** The soft resin is inserted into the cavity with a “finger” technique. As the provisional resin is not cemented, it needs to be hardened inside the mesial and distal interproximal spaces. The use of interproximal wedges limits gingiva bleeding and material overfilling against the papilla. **(b)** The resin is photopolymerized while the patient is in occlusion. **(c)** The provisional resin after the polymerization (note the interproximal rinsing “tunnels”).



**Figs 13a and b** The in-lab composite resin onlays. Only A3–A2 shades and occlusal stains were used for the in-lab stratification (Tetric EvoCeram A2–A3, Ivoclar Vivadent; Kolor + Plus, Kerr).

practical shortcomings relating to the isolation of lined cavities and the need for a temporary cement, which contaminates either the liner or dentin surfaces.<sup>64,65</sup>

## Adhesive luting of the restoration

The indirect restoration is fabricated in-lab or milled from a CAD/CAM block (Figs 13a and 13b). During the next appointment, the intaglio surface of the restoration and the tooth cavity are adhesively treated, and the restoration is luted with a conventional light-cured microhybrid resin composite (Figs 14a and 14b). A comprehensive description and discussion of the adhesive cementation procedures will be presented in a future article in this series.

## Conclusions

Modern preparation concepts and guidelines are chiefly influenced by tis-

sue conservation principles. Despite the wide choice of restorative materials with dissimilar properties, preparation design should be similar for all options, with sealed dentin, detailed and overgingival margins, and a recommended minimum restoration thickness of 1 to 1.2 mm. Modern *in vitro* research has shown that new CAD/CAM composite resins and pressed CAD/CAM lithium disilicate glass ceramics should be preferred in cases of severe bruxism or tooth structural weakening, although there are no medium- to long-term clinical studies to confirm this recommendation.

The cavity preparation techniques for tooth-colored bonded indirect restorations presented in this article follow the adhesive philosophy rigorously and are different from the principles used for metal restorations or crown preparation. They allow for a more conservative and esthetic dentistry, and are a prerequisite for good cavity sealing and for minimizing postoperative sensitivity, marginal discoloration, and secondary caries.



**Figs 14a and b** The onlays 1 week after luting.

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