Novel Porcelain Laminate Preparation Approach Driven by a Diagnostic Mock-Up

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ABSTRACT
One critical step in the porcelain laminate technique is the achievement of sufficient ceramic thickness. At least two different strategies for tooth preparation can be found in the literature: (1) earlier simplified techniques included the use of depth cutters guided by the existing tooth surface—however, that approach did not take into consideration alterations of the tooth owing to aging, wear, or loss of enamel and thus led to greater risks for dentin exposures; (2) more recent and sophisticated methods have integrated an additive diagnostic procedure (ie, wax-up or mock-up) to compensate for tooth aging or severe existing loss of tooth substance. This approach allows for more enamel preservation and, as a consequence, more predictable bonding, biomechanics, and esthetics. The present article illustrates in detail the latest development in tooth preparation for porcelain laminates. This technique combines the time efficiency of earliest methods with the rationale and diagnostic foundations of the more recent techniques.

CLINICAL SIGNIFICANCE
Using this new laminate porcelain preparation approach, clinicians should be able to produce not only more accurate preparations, but also higher-quality tooth preparations in a time-efficient fashion.

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The primary preparation design for porcelain veneers, also called bonded laminates or bonded porcelain restorations (BPRs), should simultaneously allow an ideal marginal adaptation of the final restoration and reflect an optimal adaptation of the hard tissue morphology.[1] Unlike traditional cementation, the adhesive properties and physicochemical characteristics of the resin-based luting composites subject the tooth-restoration interface to substantial stresses. BPRs must be differentiated from traditional cemented crown coverage, especially with regard to retention and resistance form. A minimum amount of preparation geometry is required to facilitate insertion and positioning of the ceramic restoration during the final bonding procedure. The geometric and mechanical parameters of the tooth preparation, however, are of only secondary importance. This allows for maximal preservation of remaining sound mineralized tissue during the tooth preparation procedure and, consequently, a conservative approach (ie, approximately one-quarter the amount of tooth reduction of conventional complete-coverage crowns; Figure 1).[2]

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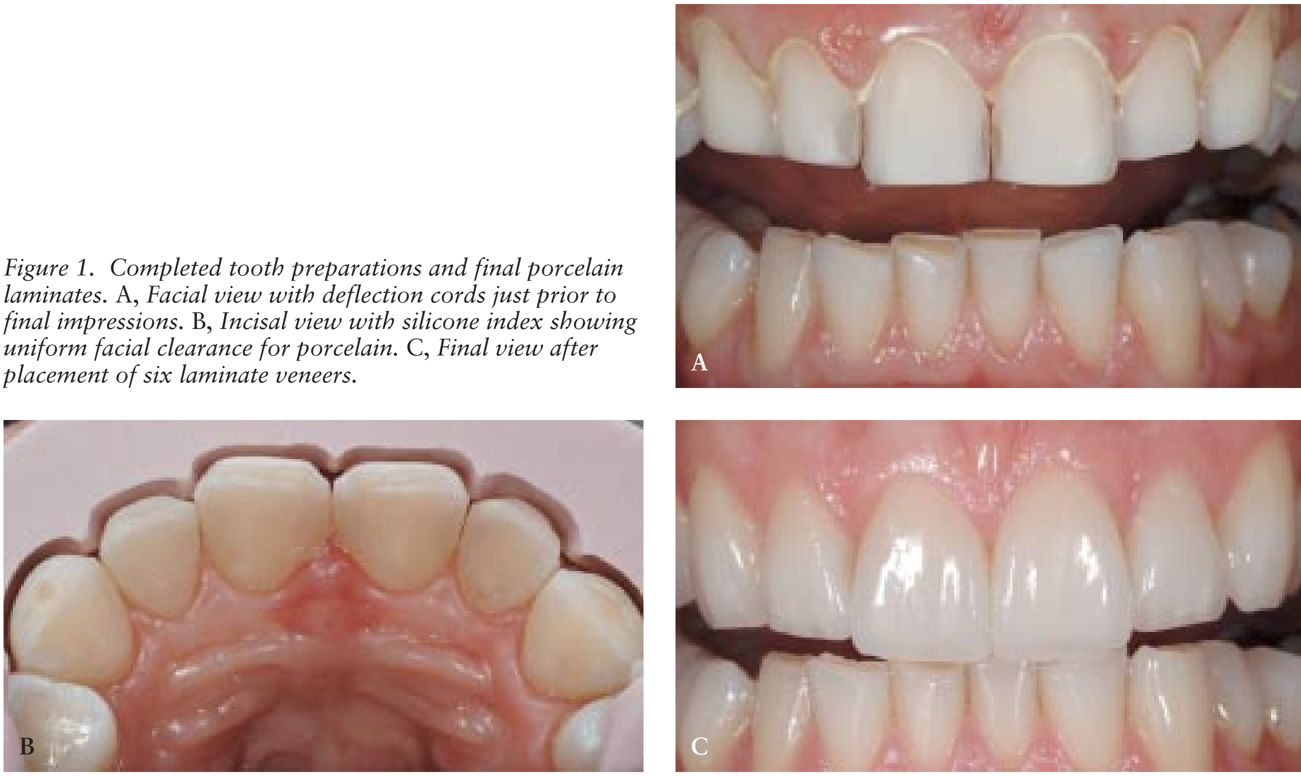

Figure 1. Completed tooth preparations and final porcelain laminates. A, *Facial view with deflection cords just prior to final impressions.* B, *Incisal view with silicone index showing uniform facial clearance for porcelain.* C, *Final view after placement of six laminate veneers.*

One essential goal—the long-term presentation of the tooth-restoration complex—requires the achievement of a sufficient ceramic thickness to provide the restoration with some intrinsic mechanical resistance. The recommended thicknesses are approximately < 0.3 to 0.5 mm in the cervical area, 0.7 mm in the middle and incisal thirds, and a minimum of 1.5 mm for incisal coverage.[1,3–7] These values are compatible with average measurements of enamel thickness.[8] Accurate achievement of such dimensions constitutes the most difficult aspect of tissue reduction because these ultimate thicknesses are intimately related to the final volume and shape of the restoration.[1]

Different tooth preparation techniques for BPRs have been described in the literature and are discussed in this review.[1,4,5,9–19] Using the respective advantages of existing methods, a recent novel tooth preparation technique is illustrated, detailed in a clinical case, that results in a more conservative and more time-efficient preparation procedure.

TOOTH-PREPARATION STRATEGIES

Tooth-preparation techniques can be divided in two groups according to their underlying principles (Figures 2 and 3): those driven by the existing tooth surface, and those driven by the final volume of the preparation.

Preparation Driven by Existing Tooth Surface

In techniques driven by the existing tooth surface, the ultimate goal is to remove a uniform layer of the tooth structure.[4,9–14,18,19] This can be achieved by freehand preparation using traditional diamond burs (round ended and slightly tapered) and silicone guides of the existing tooth. The same objective can be attained by using depth cutters (eg, burs with calibrated diamond rings), which is a more accurate and time-efficient strategy. Unlike the second method described below, in this approach reduced diagnostic steps and limited communication with the dental laboratory technician

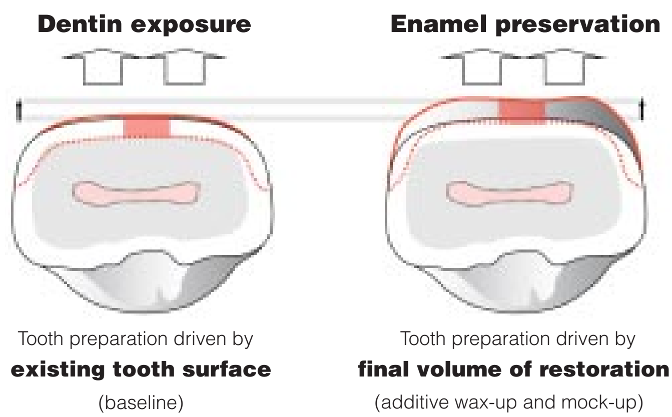

Figure 2. Two tooth preparation strategies illustrated in horizontally sectioned incisors. Left, *Use of the existing tooth surface as a guide; in the case of thin enamel, such an approach results in significant dentin exposures.* Right, *Use of the final additive volume of restoration as a guide; thin existing enamel can be preserved with this technique.*

(ceramist) are required because the intrinsic principle is the reproduction of the initial situation (in terms of form and function). However, when the initial enamel is already thin, reduction based on the existing tooth surface can lead to significant dentin exposures (see Figure 2),[8,14] which can be regarded as a possible cause of long-term failures of BPRs when not handled appropriately.[20,21]

This approach can be recommended only after a careful preoperative evaluation of the case, confirming the integrity of the original enamel thickness and knowledge that the final goal of the restoration will be limited to the reproduction of the existing tooth volume, shape, and function. Such cases are rare and typically involve patients with intact discolored teeth that are not responding to bleaching (ie, indicated for BPRs type I, according to Magne and Belser).[1]

Preparation Driven by Final Volume of Restoration

More recent tooth preparation procedures for BPRs include a specific diagnostic approach and require a high level of communication with the dental laboratory technician. In these cases the BPR aims to restore the original (not the existing) volume of the tooth, especially in the presence of thin initial enamel. Such cases typically involve patients with altered existing tooth shape (ie, indicated for BPR types II and III, according to Magne and Belser).[1,5,15–17]

A diagnostic wax-up that represents the original volume of the tooth should be used as a reference for tooth reduction. This basic principle saves a significant amount of sound hard tissue, not just enamel but also the critical dentin-enamel junction. The simplest and most important tool for enamel reduction in this technique is represented by a well-adapted horizontally sectioned silicone index from an additive wax-up.

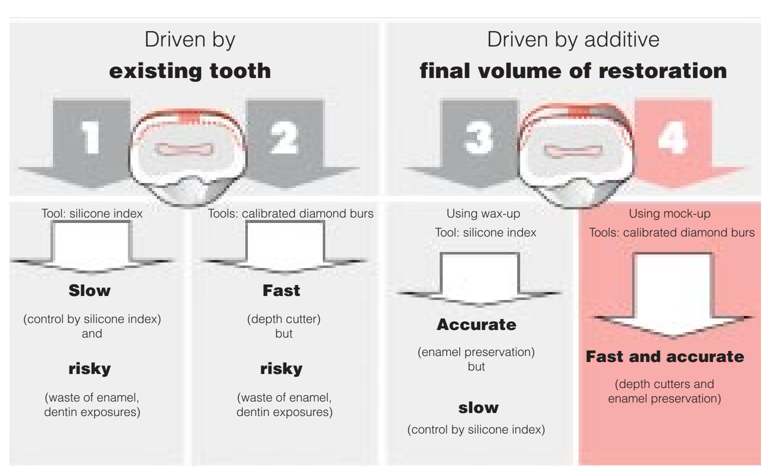

Figure 3. Various tooth-preparation methods: (1) guided by a silicone index of the existing tooth, (2) guided by depth cutters (diamond burs), (3) guided by a silicone index of an additive wax-up, (4) guided by a mock-up (obtained from additive wax-up) and depth cutters.

This method, however, can be time-consuming, inspiring researchers to develop an improved technique.

New Simplified Technique

As is the case for all types of preparations based on the final volume of the restoration, the diagnostic approach is part of the newest simplified technique, which is a modification of the original technique and is published by Gürel.[17] This new technique avoids the shortcomings of existing methods, simultaneously combining their related advantages (see Figure 3, technique 4): time efficiency, enamel preservation, subsequent improvement of adhesion and mechanics, and utmost respect of the pulp. There are practically no disadvantages associated with this new technique. It is based on the intraoral fabrication and bonding of an acrylic template reproducing the diagnostic wax-up. The remodeled tooth segment is then prepared using round calibration diamonds guided by the acrylic template itself (described below; Figures 4 to 7).

Before proceeding with the tooth preparation sequence, the bonded acrylic mock-up is used by the patient for several days or weeks to ensure that the objective represented by the wax-up is compatible with the individual's personality, face, smile, oral functions, and subjective expectations. Under some specific circumstances aimed at retracting or displacing the original tooth volume (eg, correction of tooth position), the new simplified approach requires preliminary corrections of the crown shape to allow the complete seating of the silicone index and subsequent realization of the mock-up. Only after the patient's approval or objectively justified modification of the mock-up configuration can the tooth preparations be achieved.

Detailed Procedures. The first stage of the diagnostic approach consists of defining a preliminary restorative goal, which is mostly obtained by the addition of wax onto the preliminary model (see Figure 4A and B). This procedure requires a precise knowledge of the elements of tooth anatomy but also needs intuition, sensitivity, and a good perception of the patient's individual personality. This often calls for a direct relationship between the patient and the dental laboratory technician.[22]

The second phase consists of fabricating the corresponding acrylic template directly in the patient's mouth using self-curing resin molded on the existing tooth surfaces with a silicone matrix of the wax-up (see Figures 4 and 5). The patient can easily appreciate this removable "mask." It is highly recommended that the most accurate silicone index be fabricated preoperatively by firmly applying the material onto the model and then immediately subjecting it to approximately 4 atm of pressure during setting. In this way, the silicone matrix presents an increased stiffness and facilitates handling and repositioning.

For optimal stability the silicone must overlap two teeth on each side of the modified segment. Palatal surfaces must remain accessible to allow the early elimination of palatal excess resin (see Figure 4C). For the same reason, the facial aspect of the matrix is then sectioned and ground to follow the contour of the scalloped gingival sulcus (see Figure 4D to G). Palatal tooth surfaces and facial gingiva are then appropriately isolated with petrolatum.

Existing enamel is etched partially for 5 to 10 seconds (see Figure 5A and B), rinsed, and dried to secure retention for the acrylic resin. The silicone matrix is then filled partially with a dentin-type liquid acrylic resin (eg, New Outline®, Anaxdent, Stuttgart, Germany). One must wait until the resin surface becomes dull in appearance (see Figure 5C). The index is then applied to the teeth and maintained in position while all accessible areas are cleared of excess resin (see Figure 5D). Pressure to the silicone must be applied occlusally at the level of unrestored teeth (in this case, premolars). Abundant rinsing is recommended to cool the operatory field while the resin sets.

The acrylic mask is uniform in color but provides good insight to

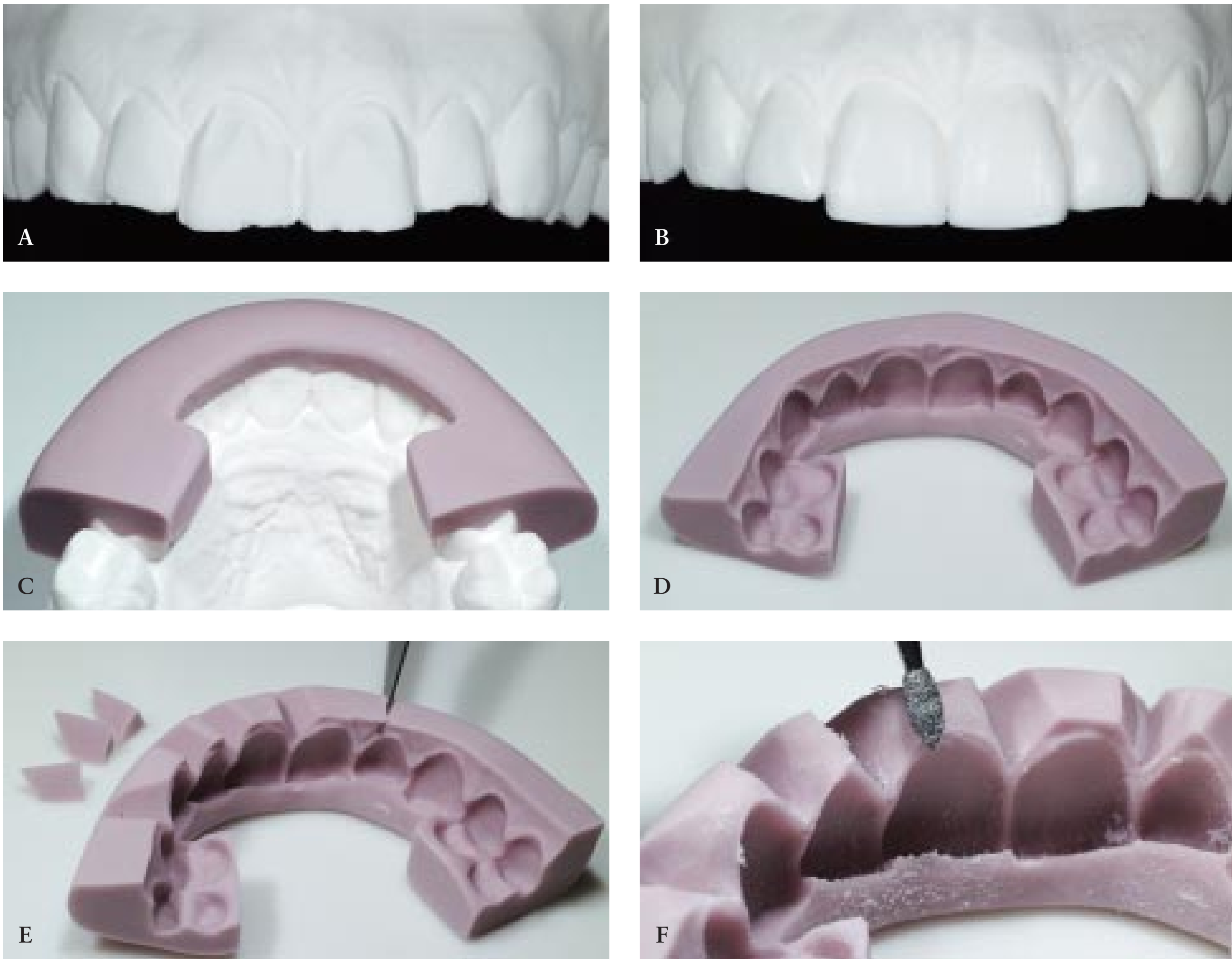

Figure 4. A, *Preliminary cast of upper anterior teeth showing severe erosions (BPR indication type IIIB), enamel wear, and breaching.* B, *Wax-up obtained by a slight addition of wax to restore original volumes of enamel on teeth no. 6 to 11. This configuration must be assessed intraorally before tooth preparations are made.* C, *Silicone index from a wax-up to be used for fabrication of a mock-up; the silicone must extend onto teeth no. 4 and 5 and 12 and 13 for improved intraoral stability. Palatal clearance facilitates premature removal of excess resin.* D, *The facial aspect of the silicone index is first sectioned horizontally at 1 mm of the gingival sulcus.* E, *A scalpel is used to remove silicone material from interdental papillae between teeth no. 6 to 11.* F, *A large diamond bur is used at a low speed for fine removal of the silicone covering the gingiva.* G, *The completed silicone index follows the facial gingival contour without exposing the teeth; this facilitates premature removal of excess resin.*

Figure 5. A, *Preliminary intraoral view.* B, *Palatal tooth surfaces and facial gingiva have been isolated with petrolatum; the facial enamel is spot etched with* H_3PO_4 *for a few seconds (then rinsed and dried) to secure the retention of the future mock-up.* C, *Silicone index loaded with A1 dentin-like acrylic resin.* D, *Silicone index positioned intraorally with axial pressure at the level of the premolars; because of the silicone shape, facial (and palatal) excess resin can be removed immediately. Silicone is cooled with water and maintained until complete curing of resin.* E, *Clinical appearance just after the removal of the silicone index.* F, *Brownish light-curing stains are mixed with glaze liquid and inserted with a scalpel at the level of cervical embrasures for optical enhancement of the interdental contact.* G, *The mock-up is glazed with a very-low-viscosity light-curing liquid (Skin Glaze).* H, *General view of the mock-up after complementary light curing through glycerin jelly (air block). (The assessment at 2 weeks reveals a harmony between the incisal edge positions and the lower lip.)*

the possible esthetic and functional outcomes of the restoration (see Figure 5E). It is recommended to increase the color saturation of interdental spaces using brownish light-curing stains (see Figure 5F) to visually "break" the bonded connection between teeth. The final luster can be obtained by glazing with a very-low-viscosity resin (eg, Skin Glaze®, Anaxdent; see Figure 5G), preliminary light curing (to fix the glaze), and complementary curing through a layer of glycerin jelly (to avoid the inhibition layer).

The mock-up should not be modified prior to completion of an assessment of 1 to 2 weeks, which is the usual elapsed time required for "deprogramming" of the patient from the previous situation. Conformity with the lower lip contour is of paramount importance in the esthetic evaluation (see Figure 5H). However, speech and occlusal comfort are also addressed during this test phase. A word of caution: inaccurate repositioning of the silicone index while fabricating the mock-up as well as over-glazing (or use of a viscous glaze liquid) can result in a diagnostic mask that is too thick. This directly and negatively influences the subsequent tooth preparation.

Tooth preparation procedures can be initiated upon agreement of the patient on the final objective, which can be easily assessed through the mock-up. The most critical step of facial reduction is assisted by two round diamond burs (see Figure 6). When used appropriately, round burs can serve as extremely accurate depth cutters.[18,19]

In the first bur the difference between the diameter of the bur (d1) and the diameter of the shaft (d2) is roughly 1.4 mm, ultimately leading to 0.7 mm of depth cut (DC) when the shaft is placed against the incisal third of the facial surface (see Figure 7A and B). A single horizontal groove is obtained and marked with a pencil (see Figure 7C). In the second bur the difference between d1 and d2 is roughly 1.0 mm, ultimately leading to 0.5 mm of depth cut when the shaft is placed against the middle third of the facial surface

Figure 6. A, *Simple round diamond burs represent ideal depth cutters. The depth of cut (DC) is easily calculated with formula shown by measuring the diameter of the bur (d1) and the diameter of the shank (d2). A DC of 0.5 mm is recommended for cervical preparations and 0.7 mm for the incisal two-thirds.* B, *Preparation of the tooth with thin initial enamel.* Left, *Omission of the additive diagnostic procedures and the use of a single depth cutter can lead to total enamel loss (red dotted line).* Right, *Use of differential depth cutters in combination with an additive mock-up (red additive line) should maintain most of the enamel (red dotted line).*

Figure 7. Step-by-step tooth preparations guided by a 2-week-old mock-up. A, *A depth cut of 0.7 mm is made with a bur to create a horizontal groove at the junction between the middle and incisal thirds of facial surfaces.* B, *The shank of the depth cutter must always stay in contact with the mock-up.* C, *The bottom of the depth groove is marked with pencil.* D, *A depth cut of 0.5 mm is made with a bur to create a slightly scalloped groove at the junction between the middle and cervical thirds of the facial surfaces. It is then marked with pencil.* E, *Remnants of acrylic from the mock-up are eliminated with a scaler.*

(see Figure 7D). The resulting cervical groove is slightly scalloped (see Figure 7D and E).

The remaining part of the mock-up can be removed (see Figure 7E). This is followed by the use of traditional burs (see Figure 7F) until the pencil marks are completely removed. Control of initial tooth reduction is improved because the bur stands at a right angle with the initial reduction grooves (see Figure 7F). All other steps are traditional.

A horizontally sectioned silicone index is recommended for double-checking the available space (see Figure 7G), and a palatal index is used to assess the 1.5 mm incisal clearance (see Figure 7H). More substance must be removed, as outlined by pencil marks. Finishing procedures first include a slight proximal separation (see Figure 7I; Vision Flex® disk, Brasseler, Savannah, GA, USA) to enhance proximal margin definition during the impression and to facilitate the subsequent fabrication of stone dies during laboratory procedures. All transition line angles are finally rounded with flexible disks at a low speed (see Figure 7J). A last but essential procedure before making final impressions is the immediate sealing of the

Figure 7 continued. F, *Traditional burs (round ended, slightly tapered) are used for the removal of remaining tooth substance between reduction grooves; sufficient space should be created automatically when the pencil marks disappear.* G, *Horizontally sectioned silicone index from the wax-up (with marked occlusal stops on premolars) is used to double-check for facial clearance.* H, *Incisal edge preparation is controlled with the palatal index. More reduction is required (pencil marks) to reach the minimum 1.5 mm incisal clearance.* I, *Finishing steps include a slight proximal separation with ultrathin diamond disks (Vision Flex) to enhance margin definition.* J, *Coarse flexible disks are used to remove all sharp transition line angles. (Completed preparations are shown in Figure 1).*

dentin, that is, the identification of possible dentin exposures and subsequent sealing of these areas with a dentin adhesive.[23–26]

Following final impressions, prepared tooth surfaces are isolated with petrolatum. The temporary restoration is then immediately fabricated intraorally with the same principles (the same silicone index) used for the mock-up. No provisional cementation should be required because the friction fit (resin shrinkage) and existing proximal undercuts (owing to gingival retraction) should ensure sufficient stability and locking of the provisional restoration.

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