Clinical guidelines for posterior restorations based on Coverage, Adhesion, Resistance, Esthetics, and Subgingival management

The CARES concept: Part II – full-contour resistive crowns with vertical preparation

Jorge André Cardoso, DMD
Porto University, Portugal
MClinDent and Postgraduate Tutor in Prosthodontics, Kings College London, UK
Private Practice, Espinho, Portugal

Pasquale Venuti, DMD
Naple Frederico II University (cum laude), Italy
Private Practice, Mirabela Eclano, Italy

Paulo Julio Almeida, DMD, PhD
Porto University, Portugal
Visiting Professor, Porto University, Portugal
Private Practice, Gaia, Portugal

Raul Costa, DMD
Lisbon University, Portugal
Private Practice, London, UK

Hugo Costa Lapa, DMD
Lisbon University, Portugal
Private Practice, Lisbon, Portugal

Luis Afonso, DMD
Porto University, Portugal
Private Practice, Viseu, Portugal

Correspondence to: **Dr Jorge André Cardoso**
Oral Clinic, Rua 23, 344, 3C, 4500-142 Espinho, Portugal; Tel: +351 916121312; Email: jorge.andre@ora.pt

Abstract

Restoration of posterior teeth with different extents of tissue loss has been a matter of debate in the literature. There are several recommendations and guidelines on when, how, and why to perform adhesive restorations (onlays, overlays, and endocrowns) or resistance form restorations (full-contour resistive crowns). In Part I of this three-part article series, the authors focused on adhesive partial restorations. In that article, the evidence was extensively described, and a clinically reasonable thought process was suggested for these decisions based on Coverage of susceptible cusps, Adhesion advantages and limitations, Resistance forms to be implemented, Esthetic concerns, and Subgingival management – the CARES concept. Now, in Part II, the focus is on clinical decisions for full-contour resistive crowns regarding their indications based on remaining tooth structure, materials, and different preparation designs as well as the particularities of vertical marginal preparations, perio-restorative considerations, and esthetic challenges.

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Introduction

Part I of this three-part article series discussed the specific characteristics of posterior teeth and detailed the thought process for clinical decisions for partial adhesive restorations. A comprehensive analysis was presented regarding when to perform cusp **c**overage or rely mainly on **a**dhesion or when to implement additional **r**esistance form (resistive) designs, the implications of **e**sthetic concerns in the preparation, and how to deal with **s**ubgingival areas – the basis for the CARES concept. Decision criteria, which serve as mere indications, within partial adhesive restorations are described in detail and summarized in Figure 1. The transition from partial adhesive to full-contour resistive preparations, including the specific considerations, is discussed in this article.

When to transition from an adhesive to a resistive restoration?

Due to different study methodologies and the lack of standardization on tissue loss and preparation design, it is difficult to compare the outcomes of onlays (on non-resistive preparations) versus crowns (on resistive preparations). Both restorative modalities can provide excellent long-term clinical performance.[1] It is clear that minimally invasive approaches favor long-term tooth survival.[2,3] However, restorations that rely mainly on adhesion can have a poor clinical performance when the amount of remaining structure is limited and the enamel is compromised beyond a certain threshold.[4] The difficulty is where to set that threshold for posterior teeth, ie, when would a crown (resistive preparation) be a better treatment option than an onlay (adhesive preparation)?

Once the decision for cusp coverage has been made, the present authors use the height of the peripheral walls above the tooth equator, which is located around 3 mm from the cementoenamel junction (CEJ), to classify three degrees of tissue loss. Based on that, a restorative approach is suggested, as was extensively explained in Part I of this article series (Fig 1):

- *Mild tissue loss:* partial adhesive restoration limited to the occlusal area – 'table top' or 'occlusal veneer' overlay.
- *Moderate tissue loss:* partial adhesive restoration with occlusal reduction and additional resistive design such as axial reduction (overlay and adhesive crown) or pulp chamber occupation (endocrown).
- *Severe tissue loss:* resistive full-coverage restoration – traditional crown.

Deciding on the degree of tissue loss can be challenging, but it should be borne in mind that this categorization represents an indicative or logical thought process for clinical decisions rather than a strict recommendation. The presence of erosion, non-carious cervical lesions (NCCLs), cracks, and other signs of heavy mechanical stresses such as parafunctional activity are other parameters that factor into the decision-making process.

Using the above criteria, a full-contour resistive crown would need to be considered when the remaining walls above the equator are less than one third of the tooth's periphery. The amount of enamel for a reliable adhesion would be limited in these situations, and a restoration that relies mainly on resistance rather than adhesion is likely to be more appropriate, even though adhesive endocrowns must also be considered in some of these situations (Fig 1). The transition from a bonded restoration to a resistive one reflects a few different strategies in terms of preparation and materials used.

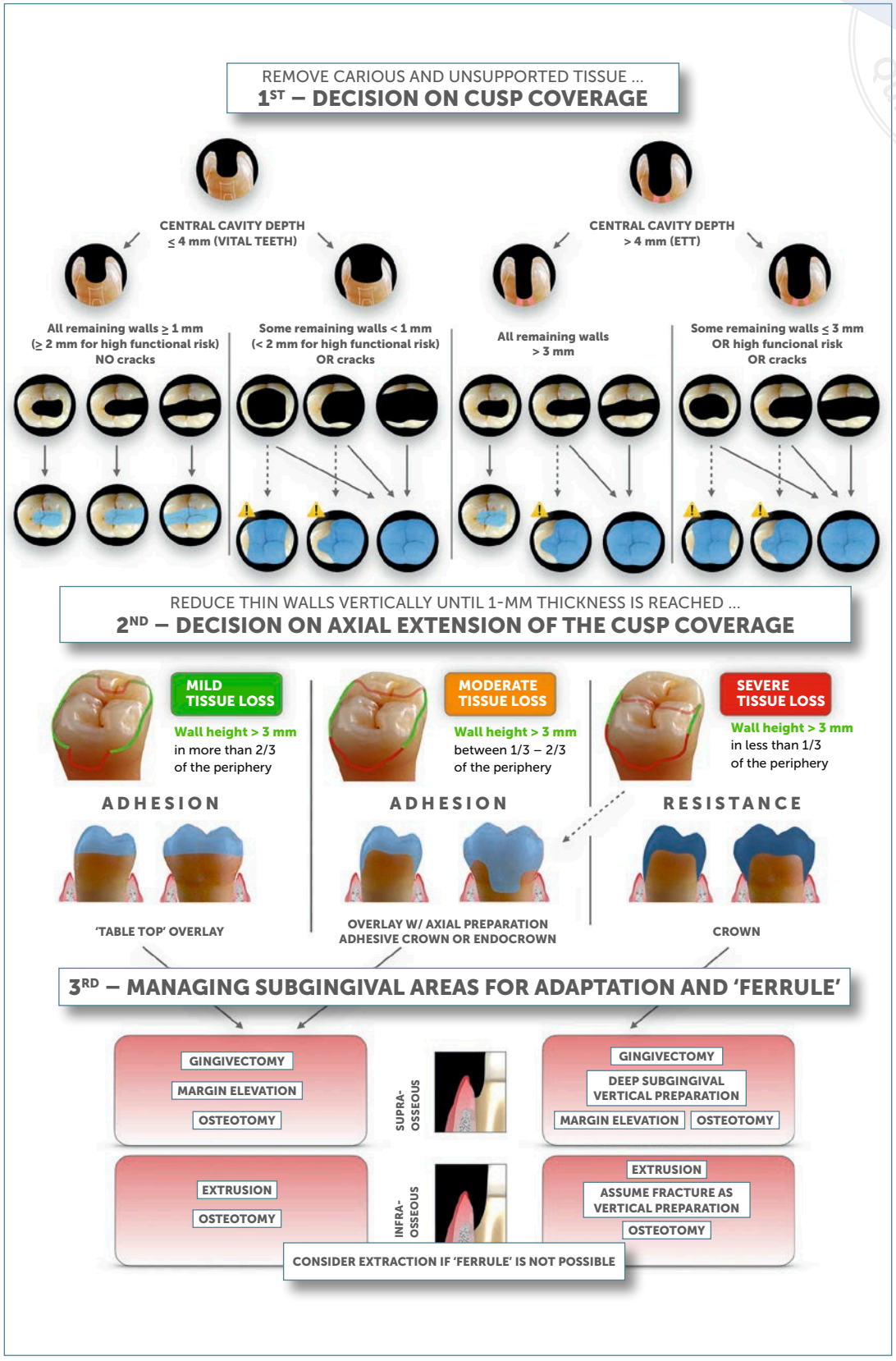


Fig 1 Decision chart for posterior teeth for cusp coverage, axial extension, and subgingival management. The complete decision process is explained throughout Parts I, II, and III of this article series.

Materials for full-coverage retentive posterior restorations

For full-contour resistive restorations (crowns), zirconia polycrystalline ceramic is the material with the highest scientific consensus; it combines acceptable optical properties with high flexural strength that, with adequate thickness, can rely less on adhesive bonding.[5] The use of monolithic zirconia prevents common problems associated with the chipping of veneering ceramic.[6] The evolution of the material in terms of different percentages of cubic phase has allowed for more translucency but also a lowering of the mechanical properties. Due to their different formulations/compositions, it can be assumed that zirconia is a group of materials with distinct clinical indications. Since these restorations rely mainly on the intrinsic strength of zirconia, only first, second, and fourth generation zirconia are indicated for conventionally cemented posterior crowns.[6,7] Former generations will provide improved resistance but will also be more opaque and with a less natural color, which may be important even for posterior teeth, depending on the patient's demand and tooth visibility as well as on the experience of the clinician or dental technician in choosing the ingot/block and performing the staining procedure. Polished zirconia seems to cause similar or minimal wear on the opposing natural dentition, especially if proper polishing is performed after occlusal adjustment and before final cementation.[8]

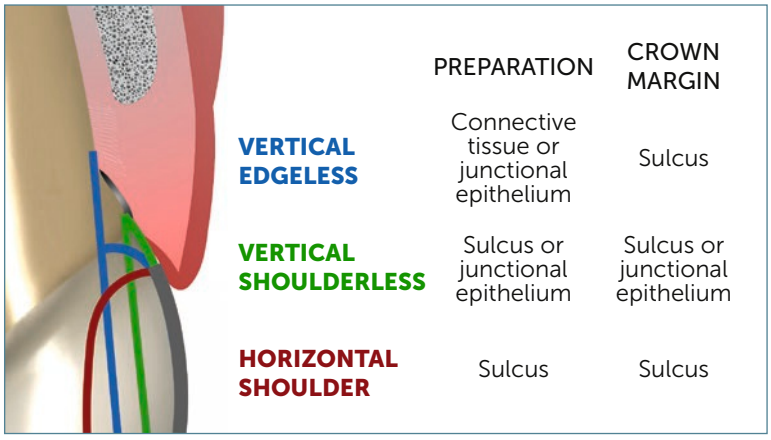


Fig 2 Vertical 'edgeless' and 'shoulderless' versus horizontal shoulder preparations – marginal design, preparation level, and marginal position.

Preparation and design for posterior full-coverage retentive crowns

Over the last decade, significant attention has been given to preparations with a feather- or knife-edge marginal design. These have been referred to as vertical preparations, as opposed to shoulder or chamfer (known as horizontal) preparations (Fig 2). Reasons for the increased interest in this marginal design are its higher conservation of tooth structure, its apparently favorable periodontal response, and the recent possibility of milling high-strength ceramics such as zirconia with thinner margins. Vertical preparations demand specific preparation strategies, marginal management, provisionalization, restoration design, and cement spacing. They are technique sensitive and can be traumatic for the soft tissue. Reasons for this include the difficulty to control and visualize the depth of the preparation and the concerns regarding plaque accumulation in the crown margin. Therefore, it is imperative that patients are periodontally stable, the clinician is sufficiently knowledgeable, the dentogingival complex is examined, proper instruments are used, there is adequate communication with the dental laboratory regarding the fabrication of the restoration, and there is adequate patient follow-up. Several in vitro and in vivo studies have been performed comparing horizontal and vertical crown preparations, but the diverse methodologies regarding the type of zirconia used, die material, cement type, and

cement space make it difficult to draw consistent and specific conclusions. However, clinical studies show similar or improved clinical performance when compared with horizontal preparations across several parameters such as survival and soft tissue stability.[9-14] Given the scientific support for vertical preparation margins in monolithic zirconia restorations, allied with cervical tissue preservation, it is difficult to ignore the significant advantages of this approach.

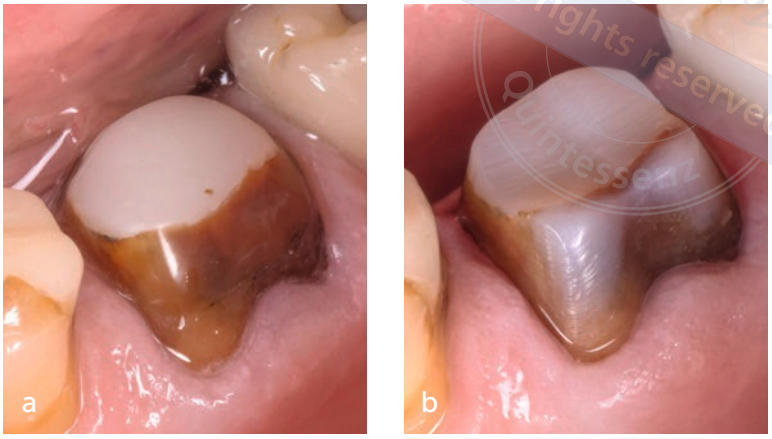


Fig 3 (a) Abutment of an existing crown that dislodged, with excessive taper design. (b) New abutment with corrected taper, created by a combination of adding composite to the excessively prepared areas axially as well as further cervical and subgingival vertical preparation.

Axial reduction

In order to maximize cervical esthetics in porcelain-fused-to-metal (PFM) restorations, and more recently with the widespread use of CAD/CAM restorations, horizontal preparation techniques such as shoulders and chamfers have become the standard to allow sufficient space and thickness for milling and layering. Due to these techniques, the pioneering technique of feather-edge preparations (in the initial historical steps of PFM restorations) has been almost completely abandoned.[15] More recently, significant attention has again been given to the vertical preparation techniques due to advances in milling precision, good mechanical properties, the esthetic advances of monolithic stained zirconia with thin margins, and, to some extent, good periodontal behavior.[16]

One of the most important advantages of vertical preparations is more cervical tissue preservation compared with less conservative horizontal preparation techniques. Vertical preparations allow more axial wall tissue to be preserved, maximizing the 'ferrule' design (Fig 2) – a minimum amount of tooth structure of approximately 2 mm in height and 1 mm in thickness where the restoration can engage or grasp for acceptable clinical performance.[17,18] The axial thickness of the crown depends on the taper and location of the vertical margin but also on the tooth anatomy and insertion path. In general, a preparation taper of about 4 to 6 degrees, with a subgingival margin in the sulcus, often results in a reduction of about 0.5 to 1 mm in the middle axial area, depending on the tooth anatomy. The deeper the margin, the more axial reduction will result if the same taper is maintained. Zirconia restorations made with a vertical preparation (feather- or knife-edge margins) with a preparation taper between 4 to 6 degrees show appropriate resistance to occlusal loads in the posterior region in vitro.[19,20] Due to the reduced axial reduction, vertical preparations are more likely to result in undercut areas for clinicians who are more used to horizontal preparations and who start to adopt the technique.

Crowns with traditional horizontal preparations that need to be replaced can be conservatively transformed into vertical preparations by adding restorative material to the existing axial areas of chamfers and shoulders and repreparing the cervical area according to the vertical margin concept (Fig 3).

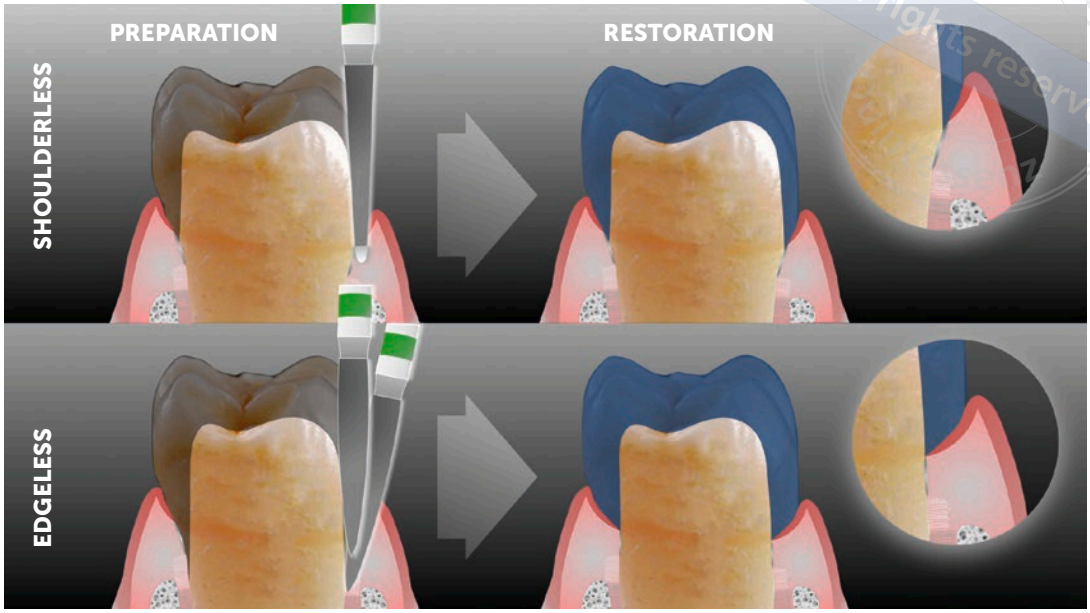


Fig 4 Differences in the preparation and design of 'shoulderless' and 'edgeless' restorations.

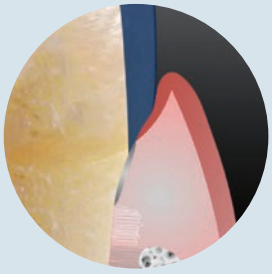
Margin design: 'shoulderless' and 'edgeless'

Although feather- and knife-edge preparations have been described interchangeably, in the latter there is a detectable margin that separates prepared and unprepared tissue. In the feather-edge margin, the preparation surface is smoothed into the tooth surface in such a way that there is no detectable distinction between prepared and unprepared surfaces. It is also important to distinguish between the two different clinical strategies for vertical margins: 'shoulderless' and 'edgeless' (Figs 2 and 4; Table 1).[16,21]

The 'shoulderless' approach was the original technique proposed for PFM restorations, also known as the knife-edge or bevel technique, where a small edge or margin can be identified after the conservative vertical preparation (Figs 2 and 4; Table 1). More recently, it has been suggested to use this technique by preparing the tooth with burs with an inactive tip to reduce the risk of undercuts, avoid supracrestal connective tissue attachment violation, and minimize periodontal trauma. The use of soft tissue retraction with Teflon tape during preparation has also been suggested for further protection of bur action and to facilitate the impression or scan, although a double-cord technique can also be used (Figs 5 and 6). This more recent 'shoulderless' approach has been described as 'vertiprep.' Since there is minimal soft tissue trauma, with some experience, impressions can take place on the same day, and the resulting margin remains no deeper than the sulcus or junctional epithelium, avoiding connective tissue attachment[21] (Figs 2 to 6; Table 1). Regarding the marginal edge, 0.2 mm has been considered the maximum thickness of the restoration to avoid a negative periodontal response.[22]

The 'edgeless' approach refers to the strategy – initially proposed by Pollard, Ingraham, and Amsterdam, and further developed by Carnevale and Di Febo[23] – applied to periodontally affected teeth where no edge or margin is present after the preparation, which can also be characterized as a feather-edge margin (Figs 2, 4, and 7; Table 1).

Table 1 Different types of vertical preparation strategies, indications, and particularities

	SHOULDERLESS	EDGELESS	
		Anterior region or esthetic areas (example: BOPT)	Compromised teeth to gain 'ferrule' with deep subgingival vertical preparation
			
Indications	• As a first-option alternative to a shoulder or chamfer in posterior crowns	• For crowns in the anterior region or in esthetic areas, allowing some degree of change in the soft tissue position and maximizing its stability	• To save severely compromised teeth, to increase 'ferrule' subgingivally • Periodontal risks are balanced with the alternative of tooth removal
Preparation depth	• Burs with an inactive tip will limit the preparation into the sulcus or junctional epithelium area • Teflon correctly packed in the sulcus will protect against connective tissue damage	• Burs with an active tip are more difficult to control and may go deeper into the attachment, depending on the operator's expertise	
Presence of visible finishing line	• The margin is usually visible (so-called knife-edge)	• The margin is usually non-visible (so-called feather-edge)	
Bleeding during preparation	• Minor or no bleeding	• Significant bleeding due to disruption of the soft tissue	
Provisionals	• Provisional is advised not to reach the margin to allow faster healing • During cementation, the healed gingiva will be repositioned prosthetically	• Provisionalization steps will create a new 'prosthetic CEJ' to guide the soft tissue healing for 6 weeks	• Provisional is advised not to reach the margin to allow faster healing • During placement, the healed gingiva will be repositioned prosthetically
Healing period for impressions	• Same-day impression possible since minor bleeding is present • A few weeks healing period is recommended for less experienced clinicians	• Impression at 6 weeks with healed tissue	• Same-day impression is advisable to immediately capture deeper areas because tissue will rebound after healing
Impression/ retraction technique	• Traditional double cord or Teflon tape for soft tissue retraction • Teflon will further serve as an optical contrast for intraoral scanning	• Traditional double cord for soft tissue retraction	• Electrocautery and hemostasis agents such as aluminum chloride • No cords or tape to capture deep areas to maximize 'ferrule'

	SHOULDERLESS	EDGELESS	
		Anterior region or esthetic areas (example: BOPT)	Compromised teeth to gain 'ferrule' with deep subgingival vertical preparation
Dental tissue captured during impression	• Gentle soft tissue retraction technique during preparation and impression will not place the margin deeper than the sulcus or junctional epithelium area	• Gentle soft tissue retraction technique of healed tissue will not capture deeper than the sulcus area	• Supracrestal tissue attachment is intentionally removed to expose areas for 'ferrule' • Junctional epithelium and bone may be captured during impression
Margin placement	• At the visible margin; if no margin is visible, the ceramist is instructed to go as deep as possible since gentle preparation/impression will not capture risky depths	• No margin visible, therefore the ceramist is instructed to leave the margin in the sulcus and create a 'prosthetic CEJ' similar to the provisional	• No margin visible, therefore the ceramist is instructed to leave the margin at a minimum of 1 mm away from the bone (avoiding the connective tissue attachment) while maximizing the 'ferrule'
Periodontal risk	• Margin within sulcus or junctional epithelium area with minor risk	• Margin within the sulcus with minor risk • Initial preparation is deeper than the area covered by the final crown, which will increase the horizontal component of the supracrestal attachment, maximizing its stability	• Margin into the junctional epithelium area • Only used when the benefit of creating a 'ferrule' to save the tooth is balanced with periodontal and esthetic risks

BOPT: biologically oriented preparation technique

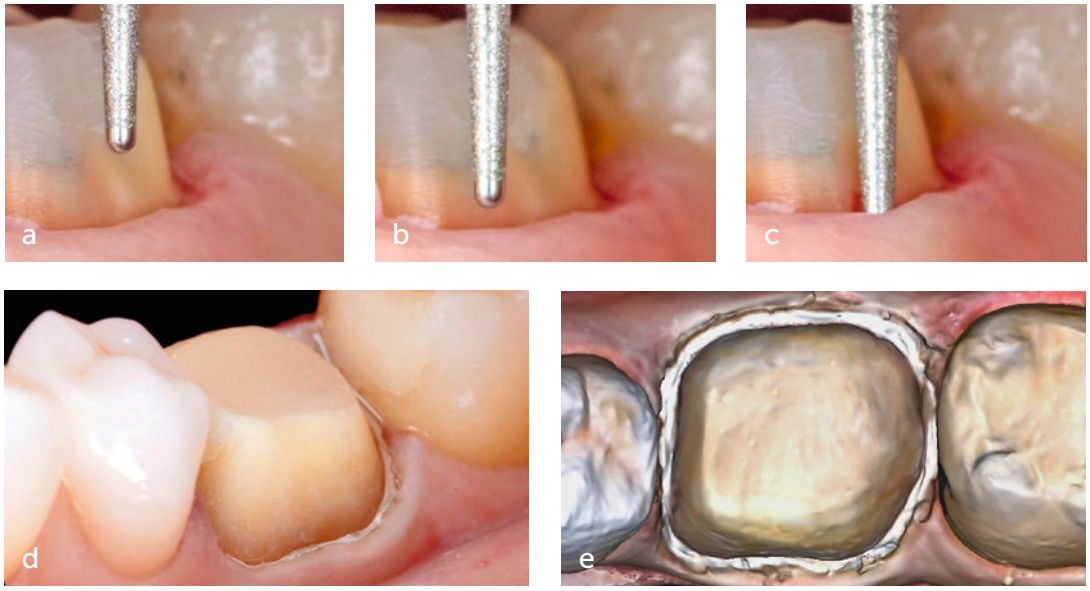


Fig 5 (a to d) Bur with an inactive tip used in the 'shoulderless' approach to limit the depth of the preparation, avoid undercuts, and minimize soft tissue trauma to allow same-day impressions. (e) Teflon tape during preparation can limit the bur action by avoiding the supracrestal connective tissue attachment. Retaining the Teflon tape during the intraoral scanning process can be helpful as it allows a clear color distinction to facilitate the placement of the margin.

Fig 6 (a) Initial situation of tooth 34 extensively restored with very limited enamel in the periphery, with the indication for a full-contour resistive crown. (b and c) 'Shoulderless' preparation with a vertical finishing line, ready for a same-day digital impression after soft tissue retraction with the double-cord technique, leaving the deeper 000 cord in the sulcus. (d) Final result 3 years after the cementation of the monolithic, stained zirconia crown.

The action of a bur with a regular active tip is used deeper than the sulcus, reaching the supracrestal connective tissue attachment, close to the bone, both for root planing and for curettage or gingitage of the soft tissue. Animal studies show that this results in a newly formed, healed junctional epithelium in the prepared portion of the root at 3 weeks.[24] Loi and Di Felice revisited the technique, naming it the biologically oriented preparation technique (BOPT).[25] The technique emphasizes not only the thickening of the periodontal tissue after preparation, but also the esthetic possibility of establishing a new final prosthetic cervical contour on the prepared root, similar in shape to the CEJ. This can be achieved with provisional manipulation of the soft tissue contour, and impressions are recommended only after the tissue has healed after the preparation, leaving the final margin no deeper than the sulcus (Fig 7). One human study of the BOPT technique found that the histology of the newly formed tissue around the restoration is similar to the healthy dentogingival complex.[26] Since an important advantage is management and stability of the soft tissue level, this technique is particularly indicated for anterior teeth or esthetic areas that have an indication for a full-contour resistive crown.

From the present authors' perspective, the 'edgeless' technique can also be adapted to create a deep subgingival vertical preparation. This can be helpful in compromised teeth, when maximizing the 'ferrule'

Fig 7 (a) Initial situation of two premolars with extensive restorations and thin remaining walls. (b to e) 'Edgeless' vertical preparations and provisional restorations at the initial stage and after 6 weeks of healing. (f) Monolithic zirconia crowns with a cervical shape to mimic a 'prosthetic cementoenamel junction' in the buccal areas to stabilize the gingival level. (g) Result at 5 years showing a stable soft tissue margin.

Fig 8 (a) Initial situation of tooth 15 after removal of carious and unsupported tissue and vertically reducing thin walls. More than two thirds of the periphery remained below the equator level, providing an indication for a full-contour resistive preparation for a crown. Deep vertical structure loss conditioned a proper 'ferrule,' which was absent in about two thirds of the periphery. (b to e) An 'edgeless,' deep subgingival vertical preparation was performed to create a 'ferrule' design. Electrocautery and aluminum chloride paste were used to promote access to the prepared areas as well as hemostasis. The impression was performed without cords to maximize the reach of deeper areas where bone might be exposed.

subgingivally is required. In this technique, although the preparation is deep, hemostasis with electrocautery and an aluminum chloride retraction paste or liquid is performed to take impressions on the same day, whenever possible (Fig 8; Table 1). Electrocautery should be used parallel to the tooth axis to avoid vertical soft tissue removal and allow a stable blood clot during healing to protect any exposed bone, which can cause significant discomfort. A good hemostasis strategy allows the capture of deeper areas of tooth structure with an analog or a digital impression, and, with close communication with the dental laboratory, the marginal level is managed to avoid supracrestal connective

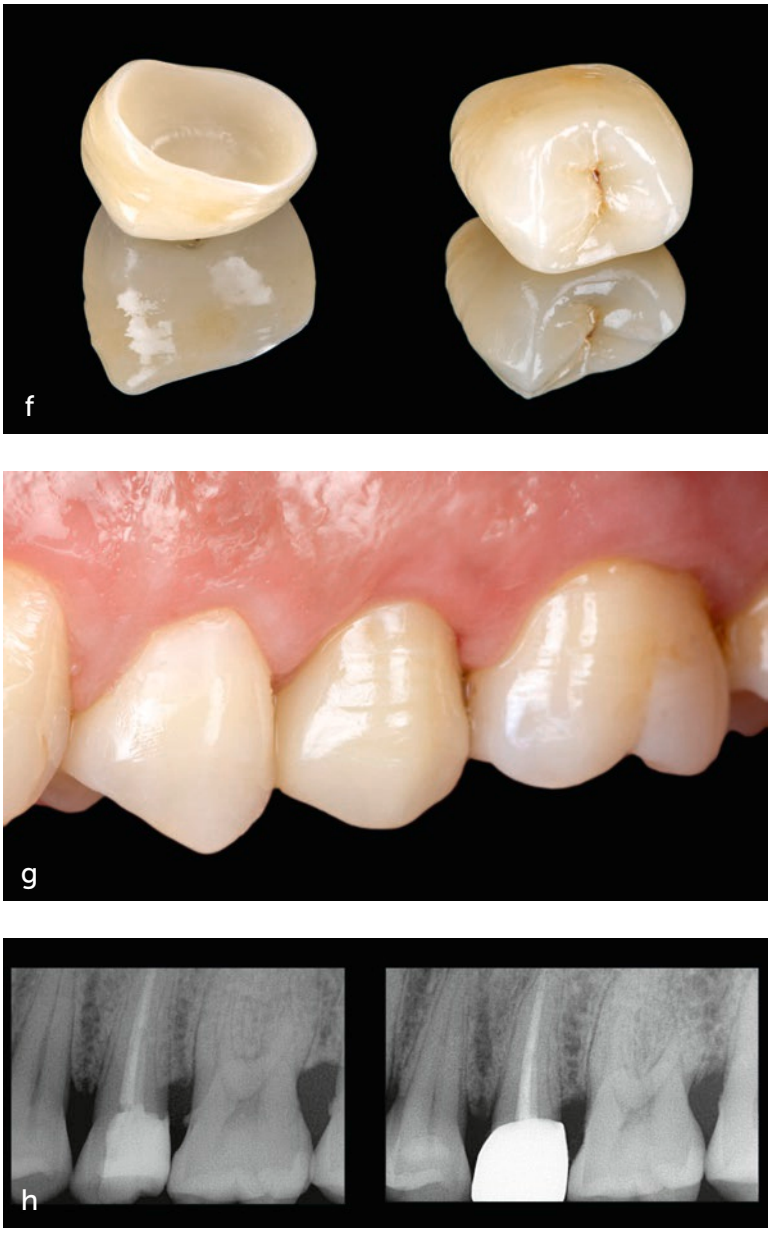


Fig 8 (continued) (f) Intaglio and occlusal views of the monolithic, stained zirconia crown with a margin placed 1 mm coronal to the deeper area of the impression to avoid supracrestal connective tissue impingement. Additionally, in every type of vertical preparation, the first 0.5 mm of the margin should be nonglazed and polished to optimize the soft tissue response. (g) Buccal view 2 years after cementation showing stable marginal soft tissue. (h) Radiographs of the initial situation (left) and 2 years after cementation (right) showing stable bone even though the margin seems to be at the junctional epithelium level.

tissue attachment. This deep subgingival vertical preparation technique should be limited to cases where the periodontal risk is balanced with the additional options such as extrusion, crown lengthening or even extraction in a patient-based clinical decision. The effects of marginal placement into the junctional epithelium may be safe in some situations, but avoiding the impingement of the connective tissue is critical to prevent periodontal damage[27] (Fig 9). This topic will be further placed in context in Part III of this article series.

Several clinical studies show that zirconia knife- or feather-edge margins have similar or better clinical performance compared with other types of finishing lines.[9-13,28,29] Interestingly, two studies show significantly better soft tissue stability of vertical preparations with the BOPT technique compared with chamfer or shoulder margins.[9,13] In deeper preparations such as the 'edgeless' technique the horizontally reduced root surface will not be completely covered by the final restoration. This results in thicker horizontal soft tissue dimensions that may contribute to the good stability of the tissue in the dentogingival unit. A similar phenomenon of coronal marginal shift occurs when creating root concavities for nonsurgical periodontal therapy.[30] Orthodontic movement in the lingual direction also seems to increase buccal horizontal soft tissue thickness and coronal migration.[31] A thicker soft tissue attachment seems to promote some tendency toward coronal migration and vice versa, which explains the diverse soft tissue behavior of different biotypes and tooth positions within the alveolar bone.[32] These dynamics can explain how root concavities, vertical preparations into the root, and lingual orthodontic movement reduce root projection into the dentogingival unit and increase the soft tissue vertical dimensions or at least make it more stable (Fig 10).

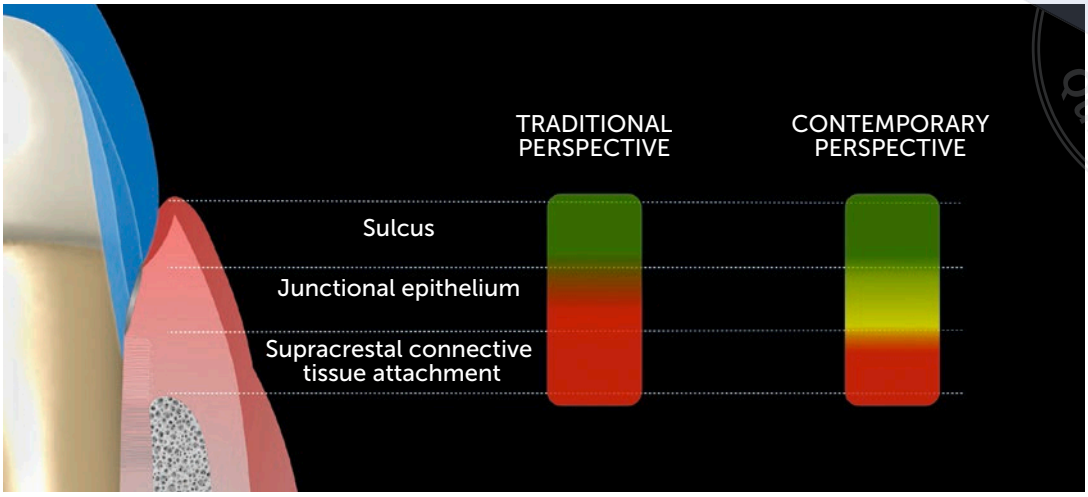


Fig 9 Risk potential of periodontal damage of the marginal placement relative to the dentogingival unit. A margin placed on the junctional epithelium may eventually be well tolerated, depending on the material used, the marginal gap dimensions, and the gingival biotype.

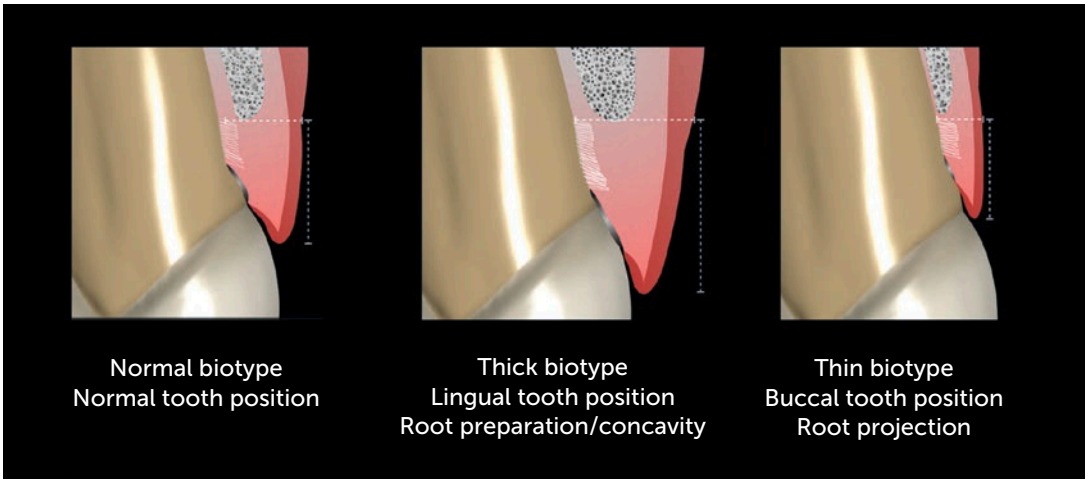


Fig 10 Dynamic influence of the horizontal dimension on the vertical extension in the dentogingival unit and possible causes (while considering a similar bone-to-CEJ distance).

NCCLs and teeth with gingival recession especially benefit from vertical preparations when crowns are indicated because minimal preparation is needed in the affected area. Nevertheless, patients with a thin periodontal biotype should ideally receive previous periodontal plastic surgery for root coverage or, at least, the tissue should be thickened to avoid further soft tissue loss[33] (Fig 11). Irrespective of the technique utilized, subgingival areas of the restoration should present polished, nonglazed zirconia to optimize the soft tissue behavior (Fig 8c).[34]

Occlusal reduction

Several in vitro studies report that an occlusal thickness of only 0.5 mm can tolerate posterior occlusal forces, especially when higher strength, adhesively bonded monolithic zirconia is used.[19,35] Although this may be appropriate for situations with reduced occlusal space, occlusal thicknesses of 1 to 1.5 mm are more reasonable, safer, and closer to manufacturers' recommendations since they provide more freedom for occlusal anatomy and increased resistance; also, they minimize fractures when more translucent, less resistant types of zirconia are used and when traditional luting is preferred (Fig 3).[15]

Fig 11 (a and b) Initial situation of the posterior teeth of the first quadrant with several degrees of tissue loss. Tooth 15 with an associated noncarious cervical lesion, discolored, and with an old porcelain-fused-to-metal crown. (c to f) Periodontal plastic surgery to increase the soft tissue thickness and prevent further recession on the future crown of tooth 15. Preparations for partial adhesive lithium disilicate overlays on teeth 17, 16, and 14, and a full-contour resistive monolithic zirconia crown on tooth 15. (g and h) Final result at 2 years showing the stability of the thick periodontal tissue, providing increased recession protection for tooth 15. The difficulty to esthetically match the translucent adhesive restorations and the opaquer zirconia crown to hide the dark substrate is explained in Part I of this article series.

Fig 12 The cement gap design needs to provide a cervical escape area to allow a proper fit and leave cement in the unavoidable gap. *Top row:* Traditional cement gap design on CAD software where a die spacer that is present in the occlusal area will prevent adequate escape. This results in cement accumulation toward the occlusal area and therefore incomplete seating, with a gap in the margin. *Bottom row:* Inverted cement space design provided in the axial areas and margin (40 µm), and not in the occlusal area, will allow proper escape and better seating, and the unavoidable marginal gap will be filled with cement.

Cementation

Cement space design

Very little attention has been given in the literature to the effect of cement space and distribution within the prepared area and its influence on marginal fit and degradation in different types of finishing lines. The few studies that exist do not provide consensual conclusions regarding the relative advantages of different finishing lines and cement space distribution within the intaglio surface. However, some principles can be summarized. Using a die spacer (on the stone cast or during the digital design process) will significantly improve the crown seating compared with no spacer.[36] It will also reduce internal friction, improve cement escape, reduce cement film thickness, and increase crown retention.[36] Regarding the location of the spacer within the intaglio surface of vertical preparations, the area close to the margin should not be designed to attempt an absolute fit and stable cervical stop as is advocated in shoulder preparations (Fig 12). This is the escape area for the cement that will fill the unavoidable marginal gap with its minimal thickness. Therefore, cement gaps of zero at the margin should not be implemented since this will prevent the complete seating of the crown. This happens because the cement escape toward the margin will be blocked when the crown first touches the preparation in the cervical area where there is no space, causing a marginal gap without

cement.[36] On the other hand, when the marginal area is relieved with a spacer, and it is the occlusal area that is not relieved to assure a stable stop, this will promote a better cement escape, and a better seating will be achieved both internally and at the margins.[37] Due to the internal friction risk, these strategies for internal relief seem to be more critical in chamfer and vertical finishing lines than in shoulders.[38] Additionally, more importantly than accepting the 120 µm suggested in the literature[39] as an acceptable marginal discrepancy is realizing that a nonresorbable cement should fully occupy the unavoidable gap to minimize leakage.[40,41] Also, the marginal gap should be aimed to be as thin as the minimum cement thickness that is clinically possible during cementation[37], which is around 25 to 40 µm, depending on the cement used.[42] In summary, a marginal and axial die spacer combined with no spacer in the occlusal area will allow more favorable cement flow. This will improve the seating and retention and will leave cement in the unavoidable marginal gap, which should have the same space as the minimal cement thickness after cementation that is clinically achievable.

Cementation clinical procedure

Although zirconia was traditionally known to have a surface that is difficult in the promotion of adhesion, long-term resin bonding to zirconia is now an accepted reality. The most studied and practical protocol involves proper cleaning, airborne-particle abrasion, and application of a primer with a phosphate monomer on the intaglio surface.[43,44] This allows the use of zirconia as a bondable material even in nonretentive restorations such as adhesive bridges, with acceptable long-term results[45]. However, for crowns with resistive preparations, the cementation process for zirconia can be carried out with self-adhesive resin cements, maintaining the same surface treatment of the restoration's intaglio surface but eliminating the step for the adhesive procedure on the natural tooth substrate. These cements have gained popularity due to this simplified protocol (without the need for dentin preconditioning), supported by extensive clinical evidence.[45] They can have high tolerance to some degree of moisture,[46] and rubber dam isolation is therefore not mandatory for resistive preparations such as crowns. However, in cases of deep subgingival margins with wet surfaces, a resin-modified glass ionomer may be considered in zirconia restorations.[43]

It is worth mentioning that vertical preparations often show a soft tissue rebound during the weeks from the impression to the delivery appointment due to the increase in the thickness of the horizontal soft tissue dimensions, as explained above, especially if the provisional is intentionally left coronal to the margin. While this phenomenon has obvious advantages, the soft tissue may create some resistance to the crown fitting and cause some concerns regarding cement removal. Fitting can be easily done with slight pressure, and cement removal is similar to traditional horizontally prepared crowns with a probe, followed by final curing and radiographic control.

Esthetics

Full-coverage, well-designed monolithic zirconia can maintain acceptable esthetic results with a good staining procedure for posterior teeth.[47] However, in more exposed areas of the posterior teeth such as the maxillary premolars more life-like restorations can be expected by some patients. In this regard, in addition to value, hue, chroma, and opalescence, fluorescence is particularly important in dark tooth substrates since it can increase value without affecting translucency.[48] It is therefore important that

fluorescence effects are implemented in the zirconia system used, or fluorescent glaze or feldspathic ceramic is layered in the buccal area in more exposed esthetic areas.

When a higher resistance zirconia is chosen, it is usually too opaque and may need some layering, which requires space. Also, when multilayered blocks are used, the occlusal area needs space so that the more translucent zirconia area creates a natural esthetic effect. However, the conservative nature of vertical preparations has limitations in terms of space for esthetics in order to maintain adequate taper for resistance. To overcome this, some authors propose the preparation of an additional area in the buccal surface of the occlusal third, referred to as 'reverse shoulder,' in order to create additional space while maintaining the preparation taper (Fig 13).[21] One study showed that this modification of the vertical preparation has beneficial biomechanical behavior in vitro.[49]

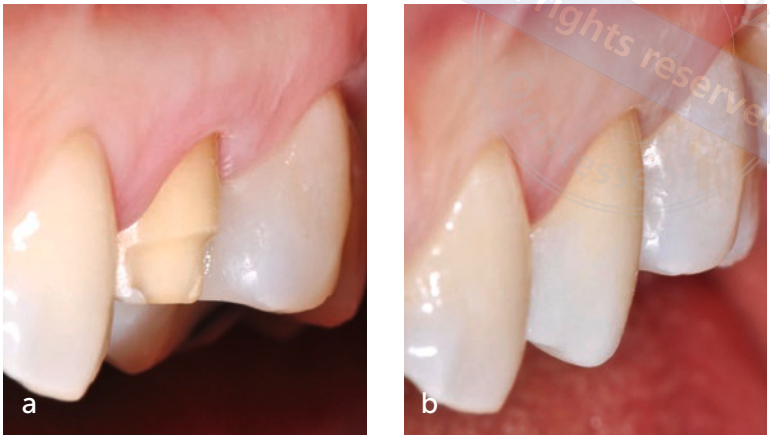


Fig 13 a and b 'Reverse shoulder' in the buccal area to provide more restorative space while still maintaining adequate taper on the preparation.

Conclusions for full-coverage retentive restorations within the CARES concept

After a certain amount of tissue loss, the use of adhesive restorations becomes less predictable, and full-coverage retentive restorations (crowns) might be needed, as explained in Part I of this article series. These restorations require different approaches compared with adhesive restorations regarding preparation, cementation, and material choice. On the other hand, they are also the last choice of treatment in extreme cases where tissue damage is extensive, which makes the use of resistive preparation forms particularly important.

Coverage and Adhesion:

- The decision regarding when a restoration needs to become full coverage, not only to avoid fracture but also to physically grasp the axial dental structure, is not always linear but is related to the remaining height of the functional tissue and enamel in the periphery of the tooth.
- Although these restorations do not need to be bonded with rigorous surface micromechanical conditioning and moist-free control, they do benefit from simplified chemical adhesion provided by self-adhesive cements.

Resistance:

- A 'ferrule' design where the restoration can engage is the major factor for long-term survival.
- There is increasing evidence regarding adequate clinical performance of crowns with vertical margins. These types of preparations can preserve more tooth structure than horizontal margins and optimize the creation of a 'ferrule' design.
- In severely compromised teeth, an interdisciplinary approach may be needed to create a 'ferrule' design. The use of posts is not clearly supported by the literature

but may be beneficial is some cases. These topics will be further discussed in Part III of this article series.

Esthetics:

- Full-coverage monolithic materials should present natural esthetics in more demanding patients for more exposed posterior areas such as the maxillary premolars.
- Adequate choice of ingot, good staining technique, fluorescent materials, and in some cases buccal layering may be needed.

Subgingival management:

- There is increasing evidence supporting the fact that vertical margins seem to provide tissue preservation, improved marginal fit when proper cement space distribution is designed, and in some cases increased soft tissue thickness as well as potentially more periodontal stability.
- Vertical preparations, especially where margins are planned to be closer to the supracrestal attachment, are technique sensitive, and a correct diagnosis, treatment approach, and case selection are essential.

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