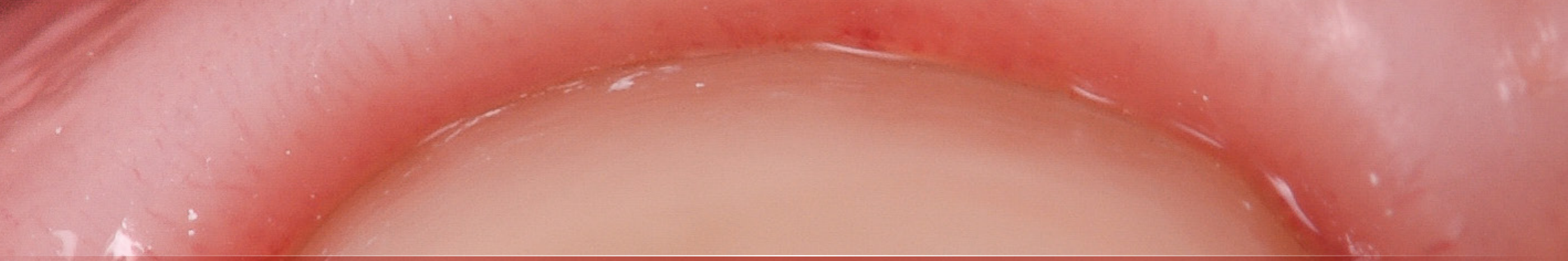

PROTHÈSE FIXÉE

PRÉPARATION VERTICALE POUR COURONNES ET FAUX-MOIGNONS EN COMPOSITE FIBRÉ SANS TENON : LES 10 POINTS CLÉS

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De nos jours, les indications pour les couronnes sont principalement limitées au remplacement de couronnes existantes. Les techniques de préparation des couronnes ont été largement décrites depuis plus de 70 ans, en distinguant généralement les préparations de lignes de finition horizontales (épaulements/chanfreins) des préparations de lignes de finition verticales (biseaux, finitions en lame de couteau). L'indication d'un type de préparation spécifique a été principalement liée au matériau prothétique choisi. Les couronnes en vitrocéramique nécessitent une épaisseur minimale dans la zone cervicale et doivent donc être préparées avec des épaulements/chanfreins ronds. Cependant, depuis une quinzaine d'années, une nouvelle céramique dense appelée zircone a commencé à être utilisée en prothèse dentaire. Compte tenu des propriétés mécaniques très élevées de ce matériau, les lignes de finition verticales sont revenues en grâce, car il était possible de réduire l'épaisseur du matériau au niveau de la zone cervicale. Dans ce contexte, la combinaison d'une préparation périphérique avec des lignes de finition verticales, associée à un faux-moignon en composite fibré sans tenon et à la zircone comme matériau prothétique, permet de renforcer les dents préalablement préparées. Cette approche améliore donc le pronostic à long terme des dents très délabrées et constitue une alternative prometteuse aux préparations conventionnelles à épaulements/chanfreins, associées aux reconstitutions à ancrage radiculaire.

MOTS-CLÉS : COURONNES, RECONSTITUTIONS CORONO-RADICULAIRES, LIGNES DE FINITION VERTICALES, COMPOSITE FIBRÉ

ACTUALISATION EN CONTINU

https://bit.ly/3JBhJek

VERTICAL PREPARATION FOR CROWNS AND FIBER REINFORCED COMPOSITE ABUTMENTS WITHOUT POST: A 10 POINT OVERVIEW

Today, the indications for crowns are primarily limited to the replacement of existing crowns. Crown preparation techniques have been widely described for more than 70 years, generally distinguishing between horizontal finish line preparations (shoulder/chamfer) and vertical finish line preparations (bevel, feather edge). The indication for a specific type of preparation was mainly related to the prosthetic material chosen. Glass-ceramic crowns require a minimum thickness in the cervical area and should therefore be prepared with round shoulders/chamfers. However, in the last 15 years, a new dense ceramic called zirconia has started to be used in dental prosthetics. Due to the very high mechanical properties of this material, vertical finishing lines came back into favor because it was possible to reduce the material thickness in the cervical area. In this context, the combination of a peripheral preparation with vertical finishing lines, combined with a post-free, fiber-reinforced composite abutment and zirconia as a prosthetic material, makes it possible to strengthen the previously prepared teeth. This approach therefore improves the long-term prognosis of severely undermined teeth and is a promising alternative to conventional shoulder/chamfer preparations and post-retained abutments.

KEYWORDS: *DENTAL CROWNS, DENTAL ABUTMENTS, VERTICAL FINISHING LINES, FIBER REINFORCED COMPOSITE*

Despite the rise of minimally invasive bonded partial restorations, the 360-degree preparation of a natural tooth as a prosthetic abutment is still a "traditional" procedure that is still one of the most common activities of prosthodontists; the main indication today being the replacement of existing crowns [1, 2]. So, is it relevant to talk about crown preparation techniques again, since the basic principles of crown preparation are known and have been widely published for more than 70 years? Probably, if we remember that the principles of prosthodontics have always been related to the choice of prosthetic material [3-6]. In this respect, the appearance of a new dense ceramic called zirconia has opened up new possibilities for less invasive crown preparations [7]. In this context, the type of finishing lines has been the subject of extensive and lively discussions between researchers and leading clinicians, both prosthodontists and periodontologists [8-11]. The purpose of this article is not to add to the controversy, but rather to provide a pragmatic 10-point overview of the possibilities for reducing the invasiveness of full-crown preparations by combining a vertically finished peripheral preparation with a post-free fiber-reinforced composite abutment and zirconia as the prosthetic material.

1. CEMENTED OR ADHESIVE DENTISTRY?

The use of a resin-based material as a luting material has overcome the strict geometric retention principles of the conventional cemented prosthesis [12]. In this case, retention is primarily related to adhesion to the dental tissue and the prosthetic material, rather than to simple geometric friction. Nevertheless, bonding to the prosthetic material assumes its ability to be roughened, with adhesive retention being primarily micromechanical. Prosthetic materials such as composite or glass-ceramic have thus been widely used for this purpose, as their surface is easy to roughen, by sandblasting and/or acid etching, the resulting adhesion providing at the same time a mandatory reinforcement of the prosthetic material [13].

However, when stronger materials, such as metal-ceramic or zirconia, are chosen, adhesive cementation of the prosthetic part becomes optional, because retention is ensured by the geometry of the preparations anyway [14-16]. This greatly simplifies the cementation procedure, especially because isolation of the preparations with a rubber dam is irrelevant with conventional cements. In addition, it is important to mention that the potential for adhesion to a dense material such as zirconia is lower than that of composite or glass-ceramic-based prosthetic materials [17-21].

Thus, the choice between conventional and adhesive cementation would be related to the following two clinical situations:

– If the preparation is easy to isolate with a rubberdam, an extensive geometric preparation is avoided in order to favor tissue preservation. In this case, a composite or glass-ceramic prosthetic material is selected and adhesively cemented [22, 23];

– If the preparation cannot be isolated properly, a geometrically retentive preparation is preferred and a strong prosthetic material such as zirconia is selected and conventionally cemented.

Therefore, for conventional crowns, the simplest clinical path is to make retentive geometric preparations and to choose a strong prosthetic material, which does not need to be reinforced by a micromechanical bonding process. Zirconia seems to be the most suitable material for this purpose today.

2. VERTICAL AND HORIZONTAL FINISHING LINES

Regardless of its shape, one of the first questions that arises when considering a prosthetic margin is its location relative to the gingival margin. For crown preparation, subgingival margins are most often preferred for three main reasons [24, 25]:

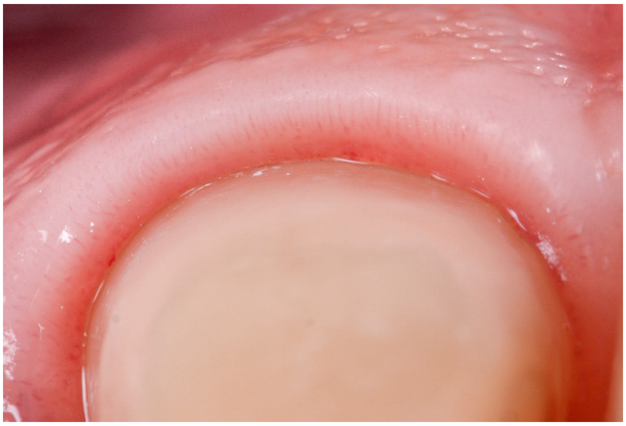
– Improvement of the aesthetics;

– Increased geometric retention by increasing the height of the preparation. This allows the re-creation of an external ferrule at the same time, which is a valuable improvement for the overall strength of the tooth, especially when less invasive vertical finishing lines are chosen;

– The possibility of extending the preparation line beyond the previous finishing lines and existing secondary carious lesions.

Nevertheless, when placed subgingival, the literature review associates the prosthetic margin with possible periodontal inflammation. This phenomenon could be influenced by four unfavorable characteristics of the crown margin [26].

The emergence profile: the ultimate goal is that the cervical emergence of the crown is to continue the emergence profile of the natural tooth that exists at the cemento-enamel junction. A horizontal finish line has the ability to create an emergence profile that follows the contour of the root without creating a vertical or horizontal overcontour; with vertical finish lines, it is impossible to generate an emergence profile that follows the contour of the root, which means that it is impossible to not create a vertical overcontour. However, it should be noted that a vertical overcontour is naturally present in human teeth at the cemento-enamel



1 **Vertical preparation for crown.**
Vertical finishing line preparations are less invasive than shoulder/chamfer horizontal preparations; despite their subgingival location, their steep inclination allows for precise marginal adjustment of the crown, which helps maintain periodontal stability.

junction and that a vertical overcontour is different from a horizontal overcontour, the latter resulting in an overhang. The presence of an overhang, combined with poor hygiene, can most certainly lead to inflammation [26-34].

The surface roughness *of* the prosthetic material and the possible exposure of the cement lead to increased bacterial plaque retention. In this regard, the high polishability and high biological compatibility of zirconia significantly reduce the possibility of plaque retention, and there is then no specific advantage to choosing horizontal or vertical finish lines [35]. Vertical finish lines, however, could help reduce cement exposure by improving marginal fit.

The degree of marginal fit: this appears to be one of the most important etiologic factors in inflammation. The literature suggests that marginal fit is more important than its placement in determining the level of marginal tissue inflammation [26, 31, 36, 37]. Mc Lean and Wilson [38, 39] demonstrated that a clinically discernible improvement in marginal fit is nevertheless only achieved when the axial inclination of the preparation is greater than 70 degrees. Vertical preparations performed with rotary instrumentation are clearly in excess of 70 degrees and therefore improve marginal closure. Other studies have also confirmed that horizontal finishing lines lead to greater marginal opening [40-42].

The extent of sulcus invasion: the closer the prosthetic margin is located to the junctional epithelium, the higher the risk of inflammation. For this reason, it is advisable to check the degree of penetration of the finishing line into the sulcus. For this purpose, compacting a Teflon tape or retraction cord in the sulcus before preparing the finishing line prevents any risk of direct injury to the junctional epithelium, as well as maintaining a free space between the most apical part of the preparation and the junctional epithelium [43].

As for the shape and as described by Pardo [44], both vertical and horizontal finishing lines are appropriate and possible to achieve by protecting the junctional epithelium, thus limiting the risk of any inflammation or adverse reaction of the periodontium. Nevertheless, compared to vertical finishing lines, horizontal finishing lines allow to define better the degree of invasion of the sulcus because they are more visible, which is an advantage.

In the past, the vertical approach was widely used in the gold era, due to the ability to finish metal margins to a minimal thickness. In the 1980s and early 1990s, the rise of so-called "all-ceramic" crowns (i.e., leucite-reinforced feldspathic ceramics, alumina-reinforced glass-ceramics, and alumina), was accompanied by requirements for minimum material thickness at the cervical level. Round shoulders and/or chamfers were logically the most appropriate to provide the recommended thickness and strength for these new materials. However, in the last 15 years, a new dense ceramic called zirconia has begun to be used increasingly in prosthodontics. Due to the very high mechanical properties of this material (see also Parts 8 and 9), it has been proposed to reduce its thickness at the margin of the preparation, allowing the practitioner to prepare less at the cervical area, which is a key area with respect to the biomechanical strength of the natural tooth [45].

Vertical finish line preparation could therefore be considered a less invasive way to prepare full crowns, recreating an external ferrule, and additionally inducing an increased marginal fit ***(fig. 1)*****.**

3. NO-POST REINFORCED COMPOSITE CORE: THE INTERNAL ADHESIVE FERRULE

Probably one of the most difficult clinical situations to manage is when endodontic treatment is involved, whether the tooth has already been treated endodontically or needs to be treated at the time of crown replacement due to secondary bacterial infiltration. How can the tooth be reconstructed in this clinical situation?

Classically, the use of posts, whether prefabricated or individualized, is expected to produce frictional retention against vertically directed forces in this regard, whereas resistance to bending forces is optimally provided by the metal ferrule of the crown [3, 5]. With glass-ceramic or composite prosthetic materials, however, the ferrule effect cannot be achieved, as these materials require a minimum thickness of 1mm at the margin [24, 25, 37]. Such a minimum preparation thickness requires horizontal finish line preparations, as mentioned above, leading to the removal of a large portion of the residual cervical dentin, which constitutes the natural ferrule [45]. The answer to reducing the effects of tensile and bending stresses can then only be found within the root, and for this reason fiber-reinforced composite root posts, so-called "fiber posts", were introduced [46]. In combination with composite resin and adhesion to the root dentin, they were thus supposed to provide both retention and stress absorption. However, in order to do so, three conditions must be met:

1. Effective adhesion to root dentin. Adhesion strength in the root canal is known to be significantly reduced after endodontic treatment, in part due to the degradation of the collagen network by endodontic solutions (sodium hypochlorite, EDTA, citric acid) [47-48]. In addition, C-factor is unfavorable in the root [49];
2. Placement of the fibers close to the dentin walls, where the highest stresses (tensile, bending and polymerization stresses) are found;
3. Strong adhesion between the fibers and the composite resin of the core.

However, numerous failures have been reported for crowns associated with fiber post abutments, suggesting that such a combination of requirements is unlikely to be realized in daily practice [49-52].

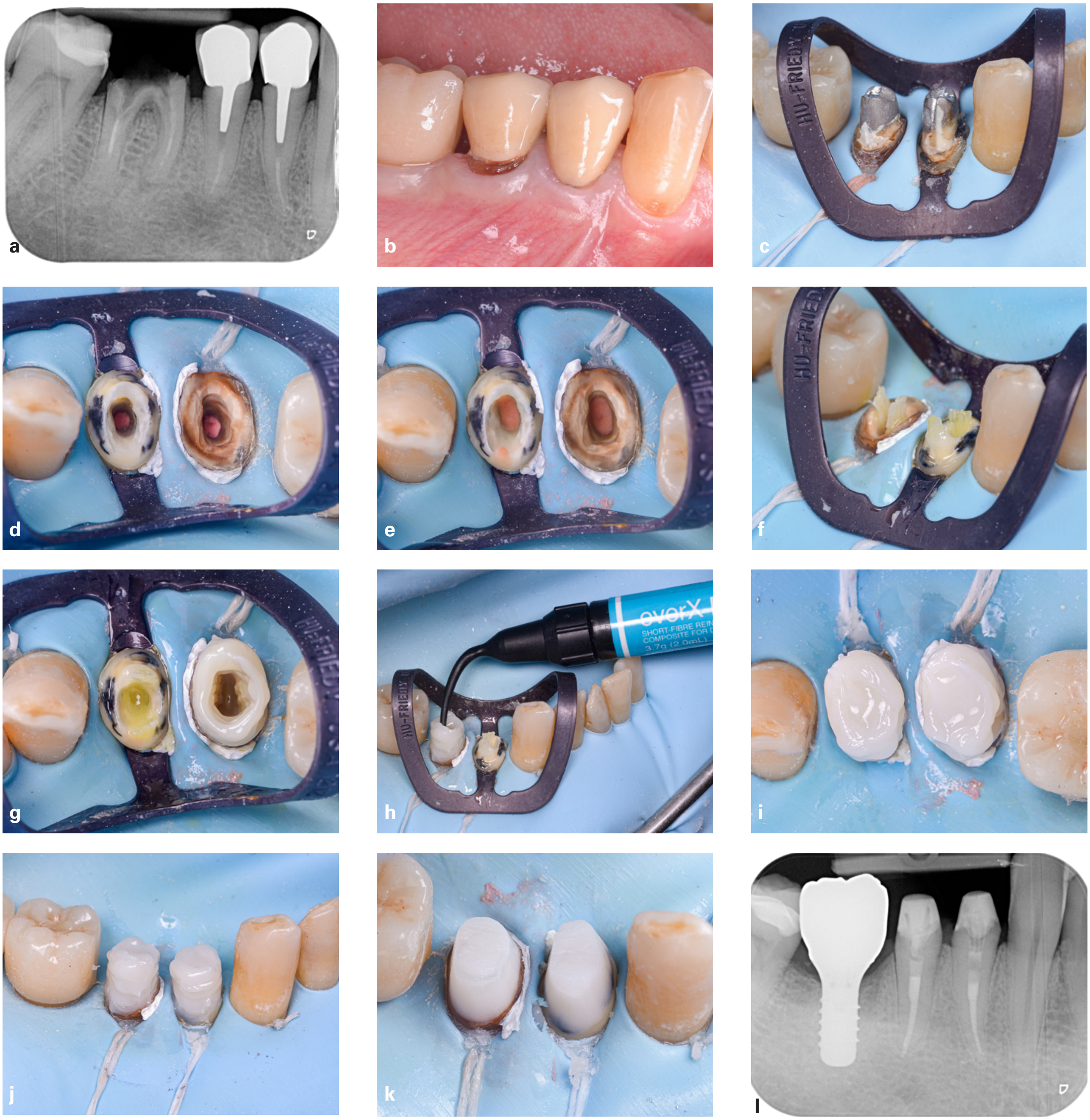
To overcome these problems, the use of short fiber composite resin and/or fiber mesh, combined with the composite resin, has been proposed [53-57]. An increase in the amount of fibers in the composite and the ability to localize these fibers near the dentin walls have been described as very promising to replace the use of posts [58-60].

In addition, recent literature suggests sealing the dentin in the pulp chamber and canal opening before performing endodontic treatment [61-64]. The bond strength of the freshly cut dentin is then significantly increased. Subsequently, and secondary to the endodontic sequences, the fiber-reinforced composite core is built up and adhesively bonded to this first thin composite layer (the latter being simply reactivated by sandblasting). In the case of pre-existing endodontic treatment, the contaminated dentin can be gently resected and adhesively sealed before the endodontic treatment is redone. In the case of very thin roots such as premolars or incisors, however, pre-endodontic dentin sealing is more difficult to achieve in practice and an alternative protocol to this is to perform the endodontic treatment first, then gently clean and resect the contaminated dentin before sealing it adhesively.

Thus, such a concept, capable of reinforcing highly undermined tooth structures and providing an adhesive abutment, without using posts of any kind, was defined as an internal adhesive ferrule. Thus, associated with a mechanical external ferrule provided by a zirconia crown prepared with vertical finishing lines, it constitutes for the authors a very promising combination, allowing to improve the prognosis of the crowned tooth to be retreated.

The current clinical sequence for constructing such an adhesive core abutment is as follows ***(fig. 2)***:

– Isolation before crown removal: this is the best chance to isolate beyond the existing finish lines [22];
– Removal of the crown and the existing post(s);
– Careful cleaning of the decayed dentin;
– If possible, pre-endodontic dentin sealing, preferably using a two-step adhesive system, covered with a thin layer of flowable composite (about 0.5mm thick);
– Endodontic (re)treatment;
– Place a thin layer (about 1-2mm) of glass ionomer cement on the gutta percha: this prevents the solvents of the adhesive system, which is used later, from dissolving the endodontic filling material [65];
– Reactivation of the composite base by sandblasting (2 bars, aluminum oxide 27µm);
– Bonding application (bottle 2 of the adhesive system), light-curing 40s;
– Optional placement of a fiber mesh on the walls of the cameral dentin. This increases the overall mechanical properties of the abutment and participate to the increase of the bond strength by absorbing part of the stresses of polymerization shrinkage [54, 58]. Note that the core of the core can also be constructed entirely using a short fiber reinforced composite. To increase the bond strength between the thread fibers and the composite resin, the fiber thread piece is immersed in the bonding liquid (bottle 2 of the adhesive system) for 10 minutes prior to use, with excess bonding liquid removed just prior to use. A very small increment of flowable composite, applied at the same time as the impregnated fiber mesh, then facilitates its placement and stabilization against the dentinal walls. Light-cure 40s;
– A circumferential wall of conventional composite is constructed on the tooth (tube shape). This prevents the fibers from being exposed to oral fluids, which could lead to eventual hydrolysis along the fibers and a subsequent decrease in its mechanical properties [55]. Light cure 40s. Please note that the conventional composite input extends over the previous shoulder/horizontal chamfer, where it exists. Even if the final preparation is not done at this stage, most of this composite input will not be trimmed off at the



2 **Adhesive postless abutment build-up**
a. Preoperative Xray. Recurrent decay under existing crowns and under metal-post abutments on teeth 44 &45. Beside premolars, tooth 46 is to be replaced by an implant-crown, tooth 47 by an onlay. **b.** Clinical view previous to premolar crowns removal. **c.** Isolation and crown removal. Isolation is preferably achieved before removing the existing prosthetics. It gives a better chance to access to the previous finishing lines, prevents any further bacterial contamination and prevents the patient to swallow metal debris. **d.** Endodontic treatment. Metal post are removed, decay is carefully cleaned and endodontic treatment is redone. **e.** Endodontic barrier. A thin layer of glass ionomer cement (Fuji Triage™, GC) is placed on top of the gutta percha: this prevents the solvents of the adhesive system from dissolving the endodontic filling material. **f.** Fiber reinforcement. Optionally, a fiber mesh (Ribbond™, Ribbond) is placed on the walls of cameral and root canal dentin. **g.** A tube shape wall is first built up using conventional composite (G_aenial Universal Injectable™, GC). **h.** Core building: Short-fiber reinforced composite (everX Flow™, GC) is preferred to build the core of the abutment. **i-j.** Final abutment completion with conventional composite (G_aenial Universal Injectable™, GC) **k.** Abutment rough preparation under rubberdam **l.** postoperative Xray.

time of the final crown preparation, thus also contributing to the increased residual stiffness of the remaining tooth structures;

–The interior space of this "composite tube" is then filled in a single increment of short fiber reinforced composite and light cured (40s). Care is taken to leave a 2mm clearance on top of the fiber reinforced composite;

– Final increment of conventional composite to close the core. Then, the final preparation is made, creating a complementary external mechanical ferrule thanks to the vertical finishing limits.

4. PREPARATION AND SEQUENCES

The vertical approach was first used in the prosthetic rehabilitation of periodontal cases. This curettage preparation originated with the work of Pollard, who was also the first to try to understand which diamond grit in dental burs was appropriate to achieve not only the ideal tooth preparation, but also root planing and gingival curettage. The dental burs he studied were initially called "Gingittage". A later development of this type of preparation was described by Ingraham and Amsterdam [66, 67], who demonstrated its application in cases of reduced periodontal support and in the presence of furcation exposure. This approach was developed by the Italian group formed by Carnevale and Di Febo (Mascarella school) [8, 9] and more recently by Loi (BOPT) [68]. Their approach, which requires a very high operative accuracy, has generated significant controversy, since the finishing lines are placed in a very subgingival position, while the prosthetic margins remain located coronally to the finishing lines, arbitrarily positioned according to the needs of the technician and the clinician. This approach has proven useful for periodontally compromised teeth, but could nevertheless lead to irreversible damage of the connective tissue attachment when periodontally healthy teeth are treated.

When periodontal disease is present, the authors' preference is to first replace existing ill-fitting crowns with properly fitted provisional crowns and treat the periodontium. A healing period of 6 to 12 weeks usually allows for reattachment of the connective tissue [69-71]. Once the periodontium is healed, the next preparation procedure is performed using an electric handpiece. Please note that reduction thicknesses are indicated based on the final crown volume, which may limit the amount of effective dental tissue to be removed, as this volume is potentially additive to the initial tooth volume [72]:

– Occlusal reduction (1mm to 1.5mm);

– Vestibular, palatal and proximal reduction parallel to the main axis of the tooth (1mm), using green- and red-grained diamond burs, flame-shaped and tapered (conicity of 3 to 6 degrees);

3 **“Gingittage”:** final preparation of the vertical finishing lines. The rubberdam is removed and Teflon tape is compacted in the sulcus to protect the junctional epithelium. Final intrasulcular preparation is done using a round-ended, conical, red-grained diamond bur (non-cutting end).

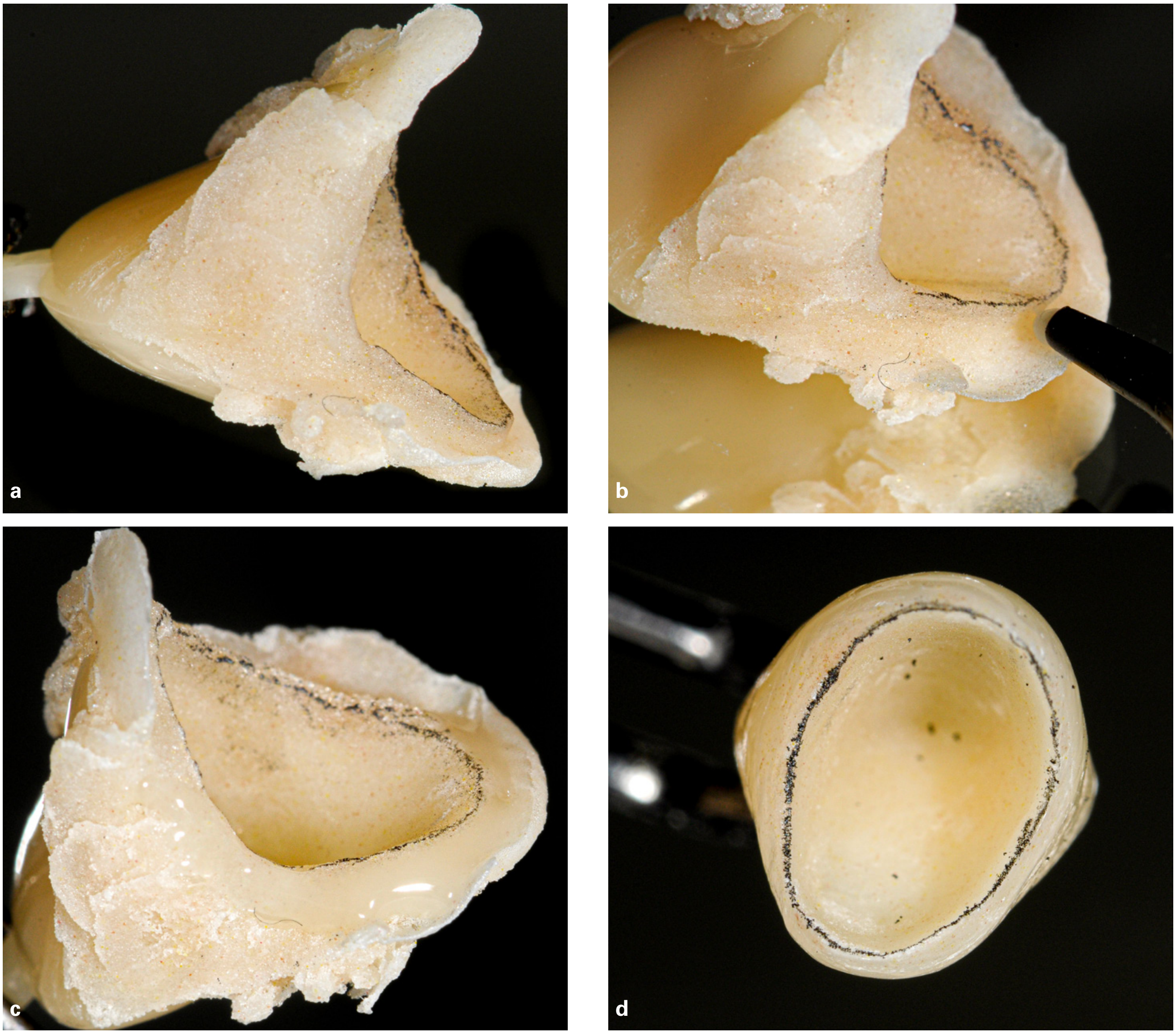
– Reduction of the cervical third using the same bur (0.3mm), changing the axis of the bur according to the inclination of the cervical third. The preparation remains juxtagingival (or “juxta rubberdam”) at this stage;

– Once the rubberdam has been removed, compacting a protective cord in the sulcus to avoid damage to the junctional epithelium and preparing the subgingival finishing lines [43]. An unimpregnated retraction cord or Teflon tape can be used for this purpose, as Teflon is better able to withstand direct contact with the rotating instruments without being evicted from the sulcus *(fig. 3)*;

– Final intrasulcular preparation using a round-ended, conical, red-grained diamond bur (non-cutting end). This type of bur, well known in the field of endodontics as a "batt-bur", is held pressed against the protective cord while its active part finalizes the preparation at the cervical aspect *(fig. 3)*;

– Fine polishing of the preparation with silicon tips (Brownies™ Shofu).

The final total thickness of the preparation generates a space of approximately 1.5 to 2mm occlusal, 1 to 1.2mm axial and 0.3 to 0.7mm cervical for the prosthetic material. During intrasulcular preparation, the bur inevitably interacts with the sulcular inner wall of the gingival margin.



4 **Provisionalization.**
a. Provisional crown just molded. The most apical point reached by the resin is marked with a pencil. **b-c.** Emergence profile build-up. The initial profile of the outer surface of the provisional (concave space) is filled with composite resin to thicken and strengthen the cervical margin. **d.** Emergence profile trimming. Using a laboratory resin bur mounted on a handpiece, taking care to create a divergent profile of 30 to 45 degrees.

This "gingittage", performed with the Teflon strip compacted in situ, triggers an inflammatory healing response in the periodontium, without risk of irreversible damage to the periodontal structures. This rotary curettage also produces a smooth sulcular wall surface, which will heal by re-epithelization of the exposed connective tissue [73].
This approach facilitates immediate impression taking and provisionalization. In addition, the sooner the final crown is delivered, the better it will guide soft tissue regeneration, following the cervical emergence profile (vertical overcontour) provided by the dental technician.

5. PROVISIONAL PHASE

Temporary restorations in fixed prosthodontics are of paramount importance and should be defined as a copy to be replicated by the final crowns. Their functions are as follows [26]:
– Protection of the exposed dentin-pulp complex;

5 **Immediate digital impression and provisionalization.**
a. Teflon is let in the sulcus and the preparations are scanned the day of preparation, right after removing the second impregnated cord ***(fig. 6)***. **b.** Immediate provisionalization **c.** 10 days after the preparation, the gum is sufficiently mature to consider a conventional cementation in acceptable conditions.

– Stabilization of the pillar in its position;
– Protection of the pillar against accidental damage;
– Function (static and dynamic occlusion) and aesthetics;
– Form guide for marginal periodontium healing during gingival maturation.

Since the subject of this article is crowns with vertical finishing lines, the first four points mentioned above will deliberately not be addressed. Instead, the focus will be on the process of achieving an ideal and stable gingival emergence profile that is capable of sufficiently conditioning the marginal periodontium prior to cementation of the zirconia crown.

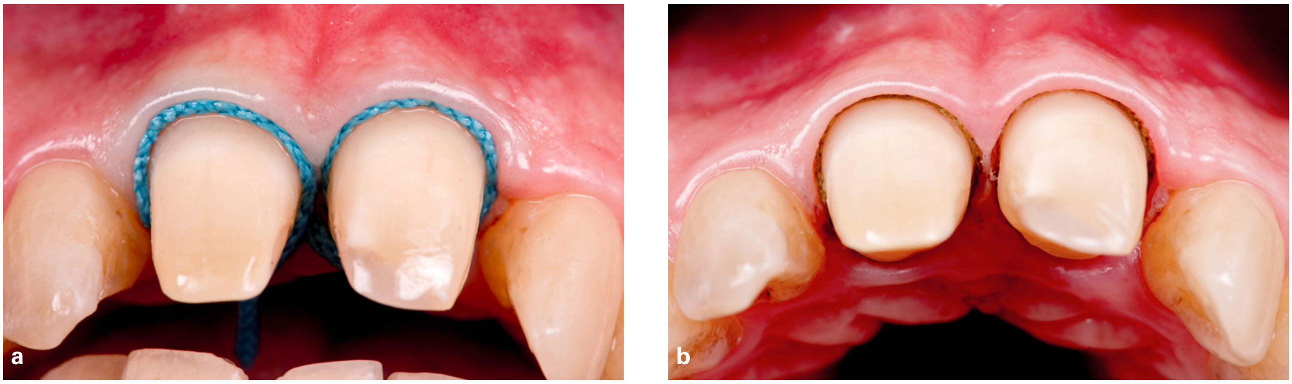
Temporary crowns can be fabricated directly or indirectly, in acrylic resin or composite resin. Again, beyond the manufacturing process and personal preferences, only the principles of fabrication are described below [68] ***(fig. 4, 5b et 5c)***:

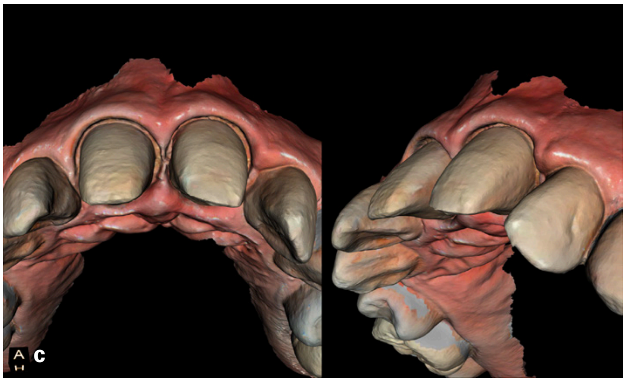
– Once molded or relined on the preparation, the provisional is de-inserted, cleaned with an air/water spray and dried;
– The most apical point reached by the resin is marked with a pencil. This corresponds to the level of the top of the protective cord and will be the effective location of the finishing line;
– The initial profile of the outer surface of the provisional (concave space) is then filled with composite resin to thicken and strengthen the cervical margin;
– The main resin excesses are then roughly trimmed off;
– The emergence profile is then carefully created with a laboratory resin bur mounted on a handpiece, taking care to create a divergent profile of 30 to 45 degrees (vertical prosthetic overcontour). The pencil mark, kept on the finishing line, allows the emergence profile and polishing of the cervical third to be achieved by meticulous grinding without affecting the finishing line level;
– The provisional is retried in the mouth. Margin location, proximal contacts and occlusion are checked;
– If frictional retention is strong, the temporary crown is left in place without temporary cement (immediate dentin cementation having been done beforehand in case of a vital abutment, even if the final restoration is to be cemented and not bonded) [74]. This prevents any cement residue from interfering with the maturation of the marginal periodontium and accelerates it considerably. This unconventional trick allows for early insertion of the final crown (approximately one week later). The patient is advised to practice diligent oral hygiene with brushing, flossing and mouthwash. If frictional retention is poor, the temporary crown is cemented with a temporary cement though, taking care to carefully remove excess cement.

6. IMPRESSIONS

Any prosthetic margin located subgingivally is difficult to record accurately. Especially in the case of vertical finishing lines, which are inherently difficult to visualize. Nevertheless, in this concept, the most apical part of the preparation is prepared with a non-working round-ended bur. Leaning on the protective cord previously impacted in the sulcus, the passive end of the bur leaves at least 1mm of unprepared root. The objective of the impression, which can be conventional or digital, is to record at least the preparation margin and ideally a little beyond, in order to identify the root emergence profile.

Therefore, since the preparation is performed on a healthy periodontium, it does not appear to be critical to allow the soft tissue to mature around the provisional emergence profile for a long period of time, and as already mentioned, the authors encourage taking the impression on the day of preparation whenever possible ***(fig. 5)***.





6 Delayed digital impressions (3 weeks gingival maturation situation). Double-cord technique.
a-c. A first non-impregnated retraction cord is compacted against the junction epithelium. On top of it, a second impregnated cord is compacted into the sulcus for 5 min. The latter is chosen to be as thick as the sulcus allows, in order to produce additional horizontal rather than vertical retraction allowing the IOS to read the finishing line.

In practice, a double-cord impression technique is performed [75]; the protective cord is left in place and over it, a second impregnated cord is compacted into the sulcus. The latter is chosen to be as thick as the sulcus allows, in order to produce additional horizontal rather than vertical retraction. Depending on the impregnation solution used (usually 20% aluminum chloride or 20% ferric sulfate), the second cord is left in place for 5 to 6min [76]. This is then removed just before the impression *(fig. 6)*.

Depending on the clinical conditions, the location and anatomy of the tooth to be recorded and the neighboring teeth, the experience of the dentist and the equipment available to him, a digital impression or a conventional one-step two-viscosity impression with elastomers can be made.

A major advantage of the digital impression, however, is that it allows the dentist to check the quality of the preparation and registration in real time. Being able to inspect the first digital draft is a unique opportunity to identify certain deficiencies in the preparation, such as the creation of undercuts in the cervical third, which can be corrected immediately in this case.

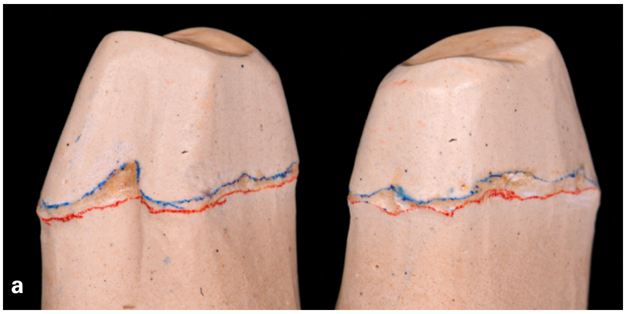
On the other hand, depending on the performance of the intraoral scanner (IOS) and the patient's compliance, it is sometimes easier and much faster to take a conventional impression. When the horizontal retraction has been properly performed, the elastomers will surely record the root emergence profile up to the protective cord. At present, an IOS lacking depth of field cannot always offer similar performance.

7. PROCESSING OF THE MASTER MODEL IN THE LABORATORY

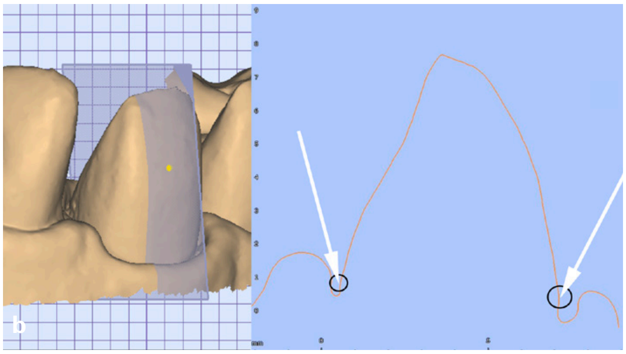
The first phase of the laboratory work is the processing of the impression.

Analog models (plaster) or digital processing of 3D impressions must allow the dental technician to easily read the finishing lines. Then, when the chosen prosthetic material is zirconia, the processing of the model must be digital, because this material can only be milled.

If a conventional impression has been made, the model is first cast as a block and scanned. It is then split, so that each die is individually trimmed, and the location of the finish line is precisely marked. The technician usually chooses one color to mark the finish line and a second color to mark the deepest registration point (at the protective cord). Between these two lines, the root emergence profile is identified *(fig. 7a)*. Then, each die is individually scanned. Any laboratory 3D CAD software will then be able to



7 **Processing the master model.**
a. On the plaster die, the technician usually chooses one color to mark the finish line and a second color to mark the deepest point registered by the impression.

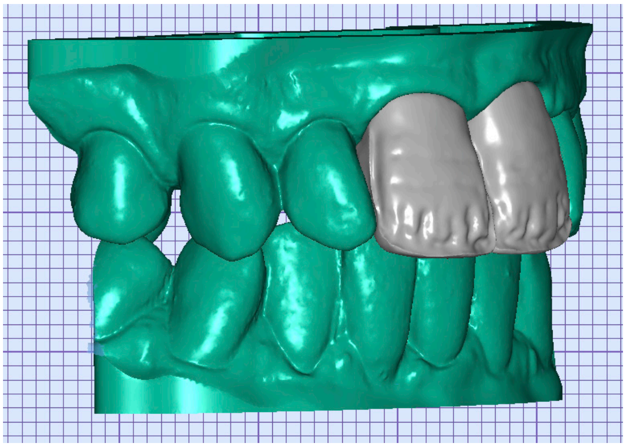


b. Using the 3D-CAD software assessment, the technician digitally locates the finishing lines at the inflection point.

reconstruct a complete digital master model, reincorporating the individual dies into the initial digital model.
If a digital impression has been taken by the dentist, the laboratory technician will import the files in .stl or .ply format directly into the 3D-CAD software and digitally locate the finishing lines on the prepared teeth at the inflection point *(fig. 7b)*.
The complete design of the crown is done on the screen in all cases. Nevertheless, many dental technicians often prefer to print the digital master, not for the design of the prosthetic elements but for the final control and validation of their vertical insertion and the intensity of the proximal contact points, especially when several contiguous crowns are made.

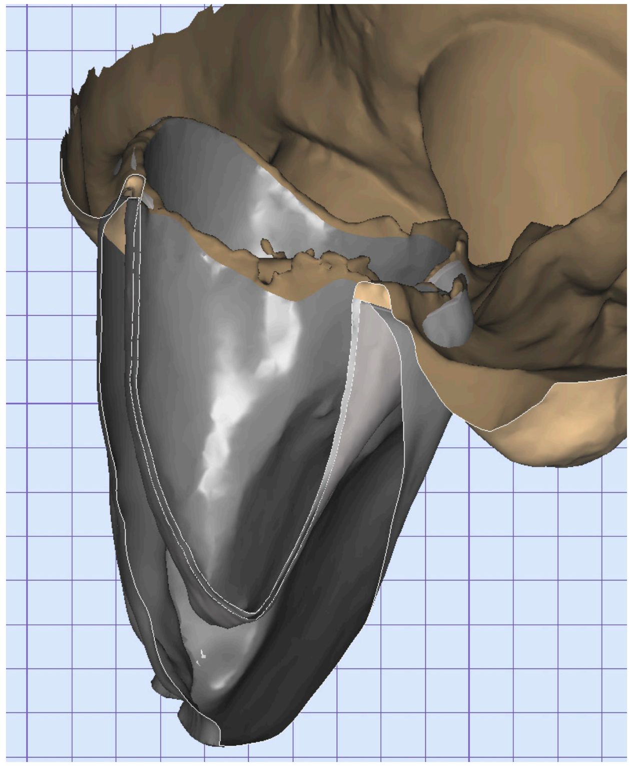
8. SELECTION OF THE PROSTHETIC MATERIAL

Among the prosthetic resistant materials, metal and zirconia are the only ones with sufficiently high mechanical properties to withstand cervical bending stress at low thickness (0.3-0.5mm on average) [14-16].
Compared to metal, the qualities of zirconia are numerous (26):
– It allows for simple, traditional cementation and a shift to metal-free concepts but using traditional prosthetic knowledge;
– It creates a very good aesthetic appearance, even at low thickness;
– It has a remarkable resistance to breakage;
– It is biocompatible;
– It has a low thermal conductivity;
– It requires less invasion of the sulcus, since the unsightly metal margin is absent;
– It is less expensive and faster to manufacture.
As a result, this material has entered daily practice in the wider market, primarily in the manufacture of prosthetics. It is used for single crowns and bridges in the anterior and posterior regions, as well as for implants, implant abutments and implant frameworks.
Zirconia has a polycrystalline structure, which is combined with other elements such as Yttrium to improve its stability at room temperature. The most commonly used zirconia in dentistry is thus called Y-TZP for Yttria-Stabilized Tetragonal Zirconia Polycrystals [7, 77].
Depending on the percentage of Yttrium added to the zirconia crystal structure (3%, 4%, 5% for dental applications), 3Y-TZP, 4Y-TZP and 5Y-TZP have different properties and indications. The lower the Yttrium content, the more opaque and stronger the material (flexural strength > 1200MPa), the higher the Yttrium content, the higher the translucency and the lower the mechanical properties (flexural strength ≥ 600MPa). So that until the recent past, the dental team had to make a choice between strength and aesthetics. However, most zirconia manufacturers have recently introduced blocks and discs often commercially called "multi" because they contain different layers of 3Y-, 4Y-, and 5YTZP in one pre-sintered piece. Thus, depending on where on the disc the prosthodontist is going to position the prosthetic design, he will be able to obtain, in the same prosthetic piece, more strength at the cervical level (3Y) and more translucency at the coronal level (4Y,5Y). As a result, monolithic or minimally-layered crowns and bridges are meeting an increasing number of clinical indications *(fig. 8)*.
In terms of processing techniques, the simplest, most accurate and most economical technique is to mill blocks or discs of partially presintered zirconia and then subject them to a final sintering with a shrinkage of about 25%. The precision of the postsintering process is so remarkable today, that the machining of already sintered blocks has no more indications.



8 **Framework conception/minimally-layered crown.** The zirconia framework provide a maximal support to the cosmetic ceramic to avoid chipping issues.

9 **Framework conception, design of the margin.** When designing the cervical profile, it is advisable to thicken slightly the profile beyond the required minimum. This makes milling the pre-sintered part safer. Once sintered and hardened, the final cervical profile will be adjusted and refined at an average prosthetic margin thickness of 0.3 to 0.5mm.

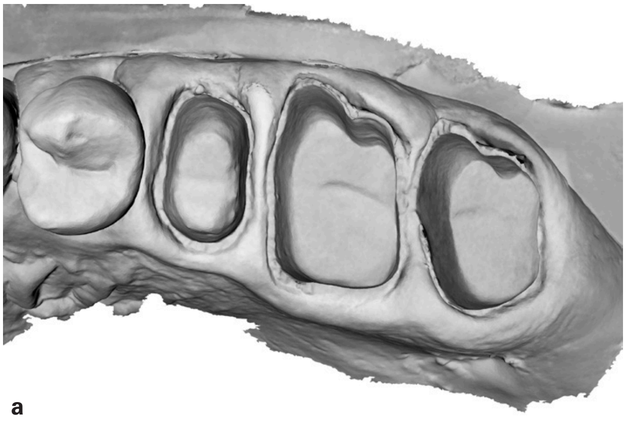


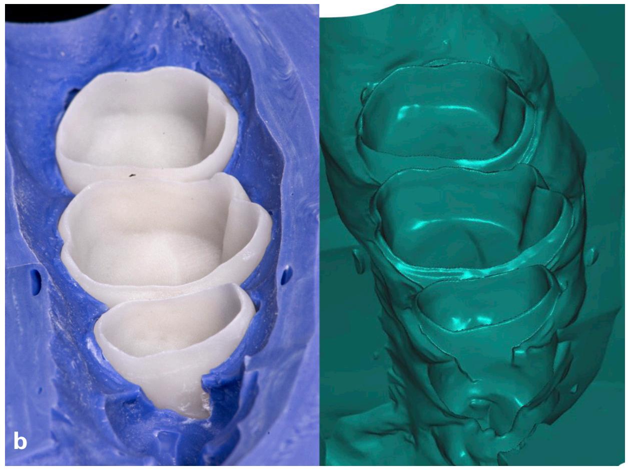
9. LAB CONCEPTION OF THE PROSTHETIC FRAMEWORK

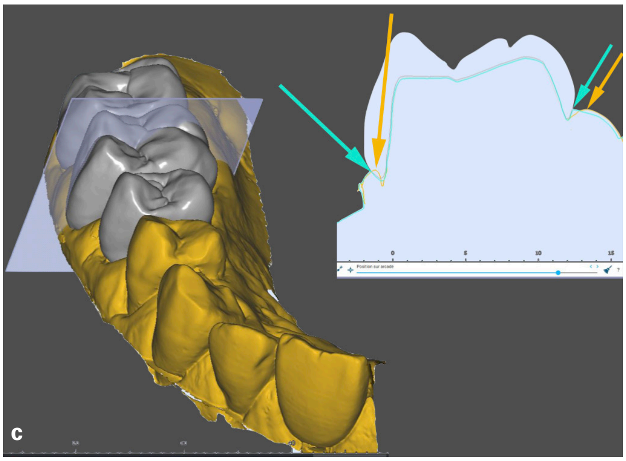
With the chipping issues caused by the layering of zirconia frameworks eliminated by the increase in monolithic or minimally layered parts, the main design concern today is the shape of the cervical emergence. The goal is to ensure the strength of the zirconia in this area while creating a cervical profile that is compatible with the physiology of the marginal periodontium. For this reason, the first 2mm of material at the cervical margin must be part of the monolithic framework, not layered with cosmetic ceramic.

Since zirconia does not have properties comparable to those of gold, it is generally considered that the safety thickness of the material at the prosthetic margin is about 0.5 mm (7). For this reason, a zirconia crown cannot, until now, have the knife-edge design of a metal-ceramic crown. This mandatory cervical material thickness creates, by definition, a slight vertical overcontour, which has already been discussed above [26-34]. When designing the cervical profile, however, it is advisable to increase the thickness of this area slightly beyond the required minimum. This makes milling the pre-sintered part safer *(fig. 9)*. Once finally sintered and hardened, the final cervical profile will be adjusted and refined with specific polishing burs (EVE™ Diacera zirconia polishing kit), finishing at an average prosthetic margin thickness of 0.3 to 0.5mm. It is absolutely crucial to use zirconia specific instruments during this step, respecting the rotation speeds defined for each bur, in order to avoid an internal crystalline transformation that could potentially weaken the material structure. According to the literature, the mechanical failure of zirconia is mainly due to the inappropriate way it is processed, rather than to a relative weakness of the material itself [7, 77-80].

If the dentist is equipped with an IOS, the emergence profile of the provisional crown can also be exactly reproduced in zirconia *(fig. 10)*. First, a "positive" oral digital impression of the abutment is made; the provisional to be duplicated is then placed, uncemented, in the mouth. A "pick-up" elastomer impression of the provisional is then made and removed; a new digital impression of the intaglio of the elastomer impression, containing the provisional crown, is then recorded. This "negative" impression shows the exact design of the resin margins and their subgingival situation, and can then be matched with the "positive" impression by the 3D-CAD software. The technician then has a preform of the final crown, whose margin anatomy has been clinically validated by the marginal gingiva *(fig. 11)*.







10 **Duplication of the provisional cervical profile: double scanning technique.**
a. Digital impression of the prepared teeth. **b.** "Pick-up" elastomer impression of the provisional crowns. The intaglio of this conventional impression is then scanned. **c.** The two digital impressions are matched together by the 3D-CAD software, offering to the technician a bio-copy of the provisional crowns. The provisional cervical emergence profile is then duplicated on the final crowns, following the contour of the provisional (green line). Please notice how different the profile of the gum can be between the first scan (orange line=retracted gum) et the second one (green line=gum profile creating by the provisional crown).

11 **Duplication of the provisional cervical profile. In-vivo validation.**
a-b: The zirconia emergence profile does match exactly the marginal gingival anatomy previously shaped by the provisional crown.

12 **Conventional cementation using Glass Ionomer Cement.**
a. Clinical view before cementation. **b.** Insertion of the zirconia bridge. Firm manual pressure is first applied to the crown, then the patient is asked to gently bite a cotton roll for 5 minutes, with the suction and cotton rolls remaining in place. **c.** Postoperative view at 2 weeks. **d.** Postoperative view at 2.5 years. Please notice the coronal migration of the proximal papillae.

Once the cervical anatomy has been completed, a cut back can be designed at the vestibular level if necessary. When it is monolithic, the piece can be stained if necessary and finally glazed to obtain a smooth surface.
Finally, the intaglio is usually sandblasted gently at low pressure (1-2 bar, aluminum oxide 30-50µm). The crystalline structure of zirconia is so dense that it is effectively impossible to roughen its surface, the goal here is simply to clean it [81]. The crown is then ready to be tried in and cemented.

10. CEMENTATION

Cementation is the final step in the prosthetic process, and it is just as important as all other steps. The prosthetic cementation of zirconia crowns will only be described to the extent that different adhesive and non-adhesive cementation options have been proposed for this material [18-81, 82]. Given the natural strength of zirconia and the high geometric retention of the preparation, traditional cementation with conventional cements is optimal; this is supported by the long and documented clinical history of cementing metal-ceramic crowns and makes the cementation procedure clinically simpler [83, 84]. Traditional cements are composed of a liquid (acid) and a powder (base): the mixture of these two substances forms the cement. These cements are supplied in two forms, a powder and a bulk liquid to be mixed by hand or pre-proportioned in a capsule to be mixed mechanically. Although more expensive and less sustainable, capsule cements are preferred because they offer a more consistent efficiency in the mixing process. Glass ionomer cements are the only cements available in capsules and are therefore preferred by the authors. The only limitation to the use of glass ionomer cements is the cementation of large monolithic frameworks, due to their limited working time and the limited amount of product per capsule. In this case, zinc phosphate cements are still more effective, as the way they are spatulated influences and possibly increases their working time. However, this is currently a very rare indication in the authors' practice.
Cementation with glass ionomer cement follows the following clinical sequence [85] *(fig. 12)*:
– Cotton rolls, and a saliva suction device are used to isolate the pillars from direct moisture contamination;

–The dentin is gently rubbed for 20s with a glass ionomer specific dentin conditioner (polyacrylic acid), to remove dentin smear layer and improve cement adhesion to dentin. The conditioner is then rinsed off and the abutment is gently dried;
–The intaglio of the prosthetic part is rubbed with alcohol or acetone and dried;
– The encapsulated glass ionomer cement is mixed and applied to the intaglio of the crown, which is immediately placed on the prepared tooth;
– Firm manual pressure is first applied to the crown, then the patient is asked to gently bite a cotton roll for 5 minutes, with the suction and cotton rolls remaining in place;
–The excess is then carefully removed.

CONCLUSION

In prosthodontics, as in any field of dentistry, precision is essential. Universal or "miracle" methodologies simply do not exist. A rational mind and a deft hand will always make for quality treatment regardless of the treatment option chosen. Thus, the authors' deep conviction is that the war is over between "horizontalists" and "verticalists", between "biomimetic non-crown dentists" and "conventional prosthodontists". Vertical preparations for crowns supported by a postless abutment made of fiber-reinforced composite should be viewed as an opportunity to improve the long-term prognosis of severely undermined teeth when an existing prosthetic treatment needs to be redone. By providing bonded internal reinforcement, the fiber-reinforced composite core provides an internal adhesive ferrule, while the zirconia crown, cemented onto a vertical preparation, provides an external mechanical ferrule. This combination of techniques and materials, which offers an easy and relatively fast clinical management, also has the claim to participate in the reduction of the global cost of dentistry, both its biological and financial cost, avoiding more complex and invasive treatments. In this respect, it is a revisited prosthetic approach, through modern and conservative principles. ■

Les auteurs déclarent n'avoir aucun conflit d'intérêts et ne bénéficier d'aucune subvention.

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LEXIQUE

1. **To roughnen:** *créer de la rugosité*
2. **Sanblasting:** *sablage*
3. **Rubberdam:** *la digue en caoutchouc*
4. **Subgingigival margins:** *limites intra-sulculaires*
5. **Steep:** *abrupt*
6. **Overhang:** *surcontour*
7. **Bending forces:** *forces de flexion*
8. **"Gingittage":** *"curetage gingival à la fraise"*
9. **Trick:** *astuce*
10. **Leaning:** *"penché sur", ici "prenant appui sur"*
11. **Undercuts:** *contre dépouille*
12. **Depth of field:** *profondeur de champ*
13. **Milled:** *usiné*
14. **Chipping:** *éclat de céramique*
15. **Deft hand:** *main habile*

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