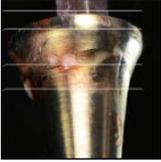


# A Biologically Driven Concept to Design the Emergence Profile Around Dental Implants: Surgical and Prosthetic Considerations to Optimize Hard and Soft Tissue Integration



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*The emergence profile is a crucial factor in facilitating favorable esthetic outcomes and maintaining peri-implant health and stability. It should be evaluated not simply in terms of morphology but as a clinical variable closely related to material properties and clinical approaches; in this way, this critical factor—which can significantly influence the integration, stability, and preservation of bone and soft tissues—can be comprehensively planned. Soft tissue integration and adherence to prosthetic components are paramount elements in the preservation and protection of bone from contamination and infection. The present narrative paper presents a prosthetic concept suggested as an operative strategy to preserve peri-implant hard and soft tissues and achieve predictable prosthetic outcomes, optimizing soft tissue integration. Achieving an ideal soft tissue seal around implants is paramount in achieving stable restorations and protecting the bone interface from possible contamination and infection. Int J Periodontics Restorative Dent 2021;41:913–921. doi: 10.11607/prd.5063*

The amount of peri-implant bone loss following implant placement and abutment connection is a major factor for long-term implant success, and a wide range of factors may contribute to the extent of early bone remodeling<sup>1–3</sup>; among these, implant connection, soft tissue thickness, collar surface and macrodesign, implant drilling protocol, surgical trauma and possible infections, restorative materials, abutment surface/design, and the connection protocol seem to significantly influence initial bone remodeling at the time of implant placement.<sup>4–9</sup> The emergence profile can be divided into two areas: subcritical and critical. The subcritical area is deeper, located immediately coronal to the implant platform and extending to the critical contour<sup>10</sup> that, in turn, is more coronal and extends from the free margin of peri-implant soft tissues, up to 2.0 to 2.5 mm apically in the esthetic region. Such areas determine the soft tissue margin levels and the architecture of final restorations. It is therefore clear how a correct morphology in the critical and subcritical zones is a crucial factor in achieving pleasant and stable results. However, there are other aspects related to the emergence profile that can significantly influence the integration and stability of the prosthetic outcomes, particularly: (1) the characteristics of restorative

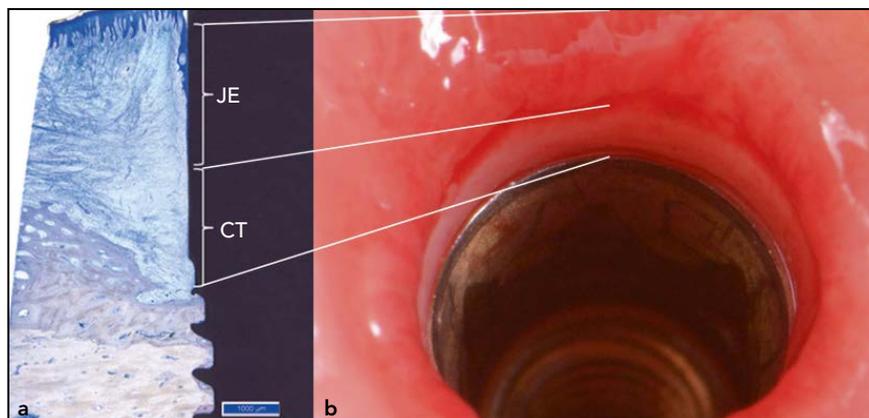
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**Fig 1** (a) Biologic width established around an implant with conical connection and platform switching. The connective tissue (CT) and junctional epithelium (JE) are located above the implant-abutment interface. (b) The CT can be identified in the deepest portion, with a whitish appearance due to the scarce presence of blood vessels. The JE is located immediately coronal, and its apical part is made up of one or two layers of cells; it is characterized by a red color, as the very thin layer of cells makes the underlying blood vessels visible. In the coronal portion of the JE, the cell layers increase and the red color gradually decreases. Hemidesmosomes are mainly located in the apical third. Histologic image courtesy of Dr P. Schupbach.

materials, such as the biocompatibility, surface chemistry, decontamination, and sterilization quality<sup>11–13</sup>; and (2) the abutment placement protocol regarding the 3D implant placement and the final abutment connection procedure.<sup>14,15</sup> The present paper describes a comprehensive workflow to correctly design the emergence profile around implants following a biologically driven concept. Such an approach aims to achieve an optimal soft tissue integration and seal; a stable, natural esthetic appearance; and preservation of crestal bone from bacterial contamination and remodeling.

### Biologic Width Topography Around Implants

The development of a stable and healthy soft tissue barrier around implants is an indispensable prerequisite for long-term success. This mucosal complex is made up of a 2- to 2.5-mm-high epithelial apparatus (ie, sulcular epithelium and junctional epithelium [JE]) and a

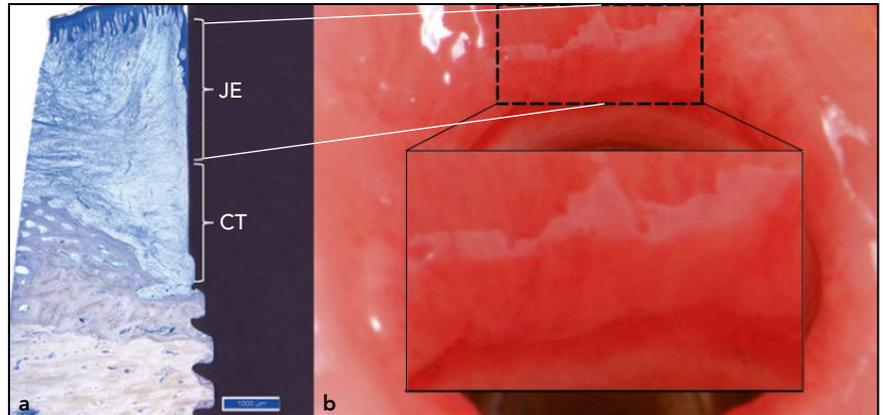
1- to 1.5-mm-high supracrestal integration of connective tissue (CT), as demonstrated in animal models<sup>16–18</sup> and in human biopsies.<sup>19,20</sup> Coronally, close to the sulcus, the JE is 15 to 30 cell layers wide and narrows toward the apical part of the tissue (Fig 1). The coronal two-thirds of the JE are composed by two strata: the basal layer facing the CT and the supra-basal layer facing the implant surface.<sup>20</sup> The apical third of the JE is made up of only two-cell layers and ends at its apical extremity in a one-cell layer of directly attached cells; the latter portion usually appears red in color because the underlying blood vessels are visible due to its ultrathin thickness. Therefore, in this apparatus, the most critical area is located in the apical third of the JE (the red area), where soft tissue adherence is more likely due to the highest presence of hemidesmosomes. Because of the rapid cell divisions, a strong funneling effect can be observed toward the sulcus.<sup>21</sup> Such a funneling effect represents the first barrier of antimicrobial defense; particular-

ly, rapid desquamation of cells and effective removal of bacteria adhering to JE cells are important parts of antimicrobial defense mechanisms (Fig 2). The JE terminates around 1 to 1.5 mm from the alveolar crest, partially covering the underlying supracrestal CT. The supracrestal CT includes an avascular area of dense circular fibers near the implant surface. Peri-implant CT is characterized by a low density of cells and blood vessels but is rich with collagen fibers and fibroblasts,<sup>16</sup> which explain its usually whitish color (Fig 3). Human and dog studies have described how implant collar and abutment surface modifications can allow a direct CT attachment<sup>21,22</sup> to implant and abutment surfaces.

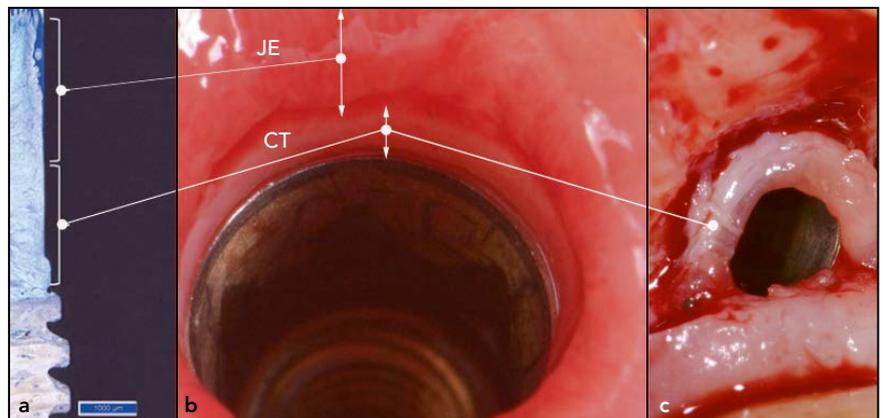
### Materials and Methods

Implant-supported rehabilitations can be managed with a wide variety of materials and restorative approaches. It is worth discerning the submucosal material, which will be in contact with peri-implant soft

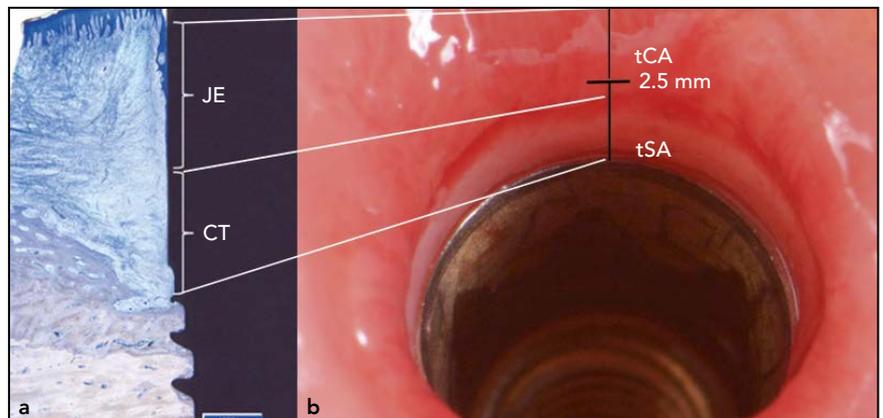
**Fig 2** The funneling effect of the junctional epithelium (JE) can be identified in the most coronal part of the JE. It is characterized by rapid desquamation of cells and effective removal of bacteria adhering to JE, representing the first antimicrobial defense mechanism. CT = connective tissue. Histologic image courtesy of Dr P. Schupbach.



**Fig 3** (a and b) Peri-implant connective tissue (CT) around an implant with a conical connection and platform switching. It is characterized by low density of cells and vessels but is rich with collagen circumferential fibers and fibroblasts. The portion in contact with the abutment and/or the implant is avascular, showing a whitish color. JE = junctional epithelium. (c) Clinically, it appears like a supracrestal "ring" constituted by circumferential fibers with a thickness of about 1.0 mm. Its role is to protect the underlying bone. Histologic image courtesy of Dr P. Schupbach.



tissues and will contribute to their seal and adherence, from the supra-mucosal material, which is used for the anatomical reconstruction.<sup>23–25</sup> In the subcritical area of the emergence profile, where the prosthetic components interact with CT and the hemidesmosomes of the apical third of the JE, it is mandatory to use materials with the highest biocompatibility in order to promote integration of adhering cells (Fig 4). To date, the only two materials showing these features are titanium and zirconia,<sup>24,25</sup> and they should be used in the submucosal area, thoroughly polished, and without any layer of glaze, ceramic, or stains. It has been shown that soft tissue



**Fig 4** The submucosal running room of an implant can be divided into the critical (tCA) and the subcritical (tSA) areas. The tCA is more coronal, starting at the sulcus and ending about 2 to 2.5 mm apically. The tSA is more apical, starting immediately after the critical zone and ending at the implant neck. The tCA zone involves the sulcus and the coronal portion of the junctional epithelium (JE), while the tSA zone includes the deepest portion of the JE and the connective tissue (CT). Histologic image courtesy of Dr P. Schupbach.

cells interact differently on smooth and rough surfaces; proper balance between minimal roughness and complete smoothness represents the ideal condition to achieve good cell adhesion and maintain good cleanability at the same time. The ideal roughness for both titanium and zirconia in the subcritical area should range between 0.1 and 0.2  $\mu\text{m}$ <sup>26</sup> in order to promote cell adhesion; in the critical area, a thoroughly polished surface with a mirror-like appearance is necessary to reduce the risk of plaque accumulation and contamination. Tissue integration also depends on the surface properties of the materials in contact with peri-implant tissues, such as decontamination, sterilization, and surface energy. In vitro results suggest that decontamination of the abutment surface is important for early fibroblast adherence and may improve the biologic seal of peri-implant soft tissues.<sup>27</sup> Evidence suggests that steaming does not achieve complete surface cleaning, and more sophisticated decontamination and sterilization techniques should be considered.<sup>28,29</sup> However, the influence of decontamination systems on surface chemistry and properties should be evaluated; in fact, abutments should ideally have a surface that is completely decontaminated and sterilized to allow for tight soft tissue adherence and integration in the subcritical and critical zones to support peri-implant tissues and to create a tight soft tissue seal against bacterial microorganisms.<sup>30</sup> Surface chemistry, nanostructure, topography, charge, and wettability are key parameters that

modulate the body's response and the subsequent tissue integration.<sup>29</sup> This biologic performance depends on keeping the abutment surface properties pristine from atmospheric damage and during storage. Consequently, industrial packaging strategies, such as wet storage or dry storage using a soluble protective layer, have been developed.<sup>31,32</sup>

### *Morphology*

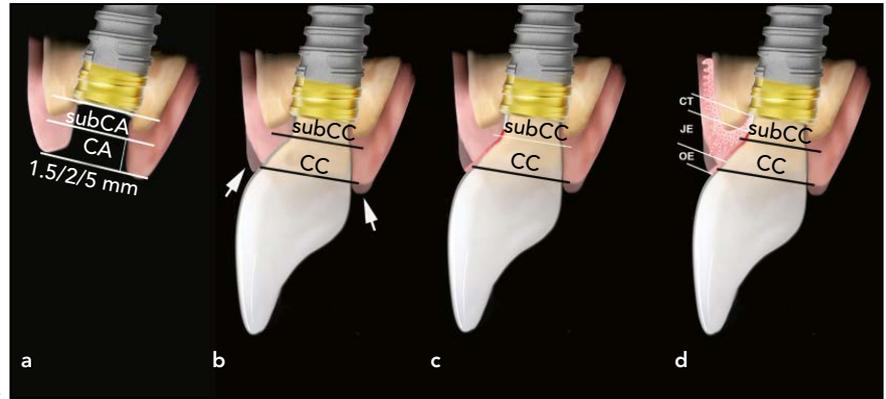
Abutment morphology represents another important factor for stability of bone and soft tissues. The morphology in the critical area is designed in relation to each specific clinical situation in order to obtain the best esthetic outcomes. The goal of the critical contour is to correctly support the soft tissues, conditioning and scalloping the pink esthetics. The height of this portion should range from 2 to 2.5 mm as needed to meet the esthetic demands of each clinical case. In this area, particularly in the most coronal portion, cleanability is a crucial factor in reducing the risk of contamination, and therefore a thoroughly polished surface with mirror-like appearance is necessary, particularly in patients with unideal oral hygiene, with history of periodontal disease, and in smokers. The morphology in the subcritical area does not significantly influence the esthetic outcomes; therefore, its design should be focused on preserving as much bone and as many soft tissues as possible and on achieving an ideal soft tissue seal. The height of this portion, the subcritical area, extends

from the apical portion of the critical area to the implant platform, ranging from 1.5 to 2.5 mm; however, this height could vary greatly in relation to (1) the position of implants in the coronal direction and (2) the crestal soft tissue thickness. In the subcritical area, the abutment should maintain a slim and vertical profile to provide enough room for soft tissues, maintaining a greater distance from the bone crest, bone peaks, and adjacent structures (Fig 5).

### *Abutment Placement Protocol*

A vertical distance of at least 3 to 3.5 mm (ie, 2-mm-high epithelial apparatus and a 1- to 1.5-mm-high supracrestal CT<sup>16-22</sup>) should be considered from the implant-abutment interface to the free mucosal margin to accommodate biologic width (BW) in the soft tissue thickness.<sup>4,8</sup> Biopsy samples taken from functionally and esthetically well-integrated implant-supported restorations showed a mean supracrestal soft tissues thickness of 3.6 mm; therefore, a clinical range of 3.5 to 4 mm could be considered optimal to achieve an ideal prosthetic integration and emergence profile.<sup>33</sup> This height, in fact, should allow an ideal morphology of the emergence profile, avoiding morphologies with excessively angled and steep horizontal components that could compromise oral hygiene maintenance. In order to obtain a gradual emergence profile in esthetic areas, such vertical distance could be increased (up to 4 to 4.5 mm), particularly when the implants are placed slightly palatally.

**Fig 5** Ideal design of the emergence profile of an implant-supported restoration. (a) The running room is divided into critical (CA) and subcritical (subCA) areas. (b) In the subcritical contour (subCC), the profile should be kept straight, and the morphology could flare out, with a divergent profile supporting and conditioning the soft tissues only in the CA; this concept should be considered for the entire periphery of the abutment. The morphology of the critical contour (CC) scallops the soft tissues, creating a new position of the free mucosal margins (arrows). (c and d) The subCC includes connective tissue (CT) and the apical portion of junctional epithelium (JE). In this area, it is important not to compromise the bone crystals and to preserve room for soft tissues. OE = oral epithelium.



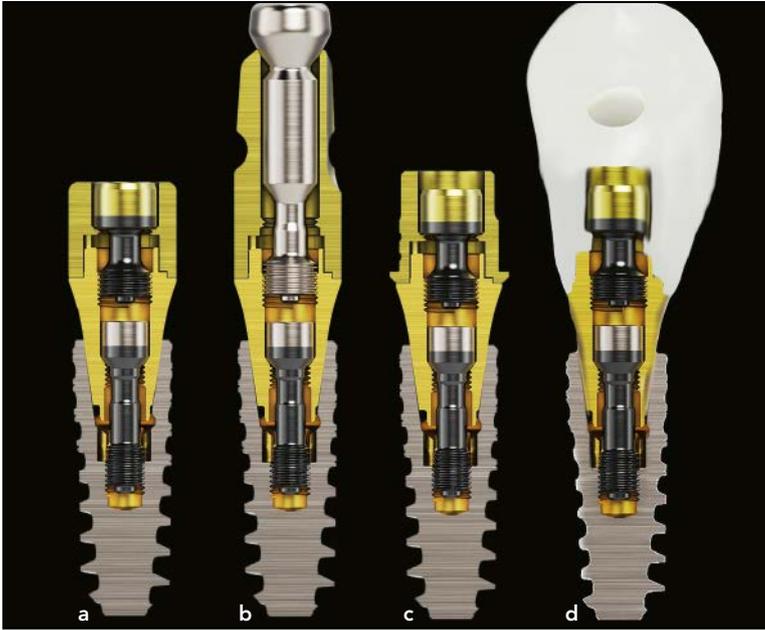
If the soft tissues thickness is not adequate, it must be increased surgically (specifically in the frontal area) or by modifying the vertical position of the implant. Many studies have reported that adapting the vertical position of implants in relation to soft tissue thickness can prevent early implant surface exposure<sup>4,5,8</sup>; however, this approach can only be recommended using implant systems with a conical connection and platform switching.<sup>6,34</sup>

The “one abutment/one time” approach represents the technique most friendly to bone and soft tissues, avoiding multiple connections and disconnections at the bone interface and favoring undisturbed bone and soft tissue healing.<sup>9,15</sup> Such a prosthetic approach is based on the use of an immediate definitive abutment placed at implant insertion and never removed, used with a cement-retained restoration. The main clinical limitation of this technique is the difficulty in previewing the final soft tissue contour and therefore the morphology and the margin line of the immediate final abutment; this is associated with

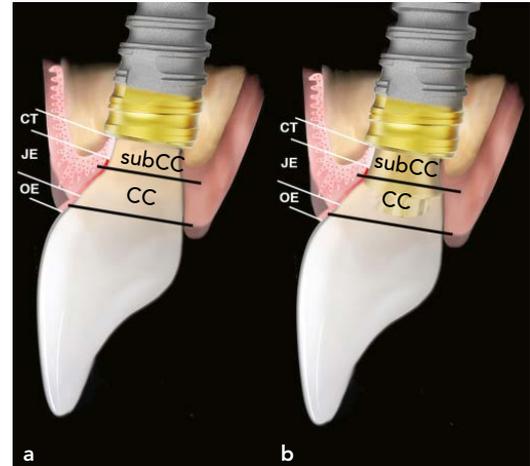
limitations in designing the subcritical contour and, in particular, the critical contour. Moreover, this technique implies the use of only cement-retained prostheses, including all of the drawbacks associated with this clinical approach.

A viable alternative is offered by intermediate transmucosal final abutments that can be screwed in with the final torque at the time of implant insertion or reentry (in two-stage surgical approach cases) and then finally restored with a screw-retained restoration at the new prosthetic interface (Figs 6 and 7). This approach can be performed using intermediate final stock abutments produced industrially, with ideal decontamination, sterilization, and surface chemistry kept pristine up to intraoral placement. These intermediate final abutments mainly need to fill the subcritical zone, allowing customization of the ideal morphology in the critical area using CAD/CAM technologies; in this way, the subcritical area that interfaces with the most critical parts of the BW (ie, the CT and the deepest portion of the JE) could be managed

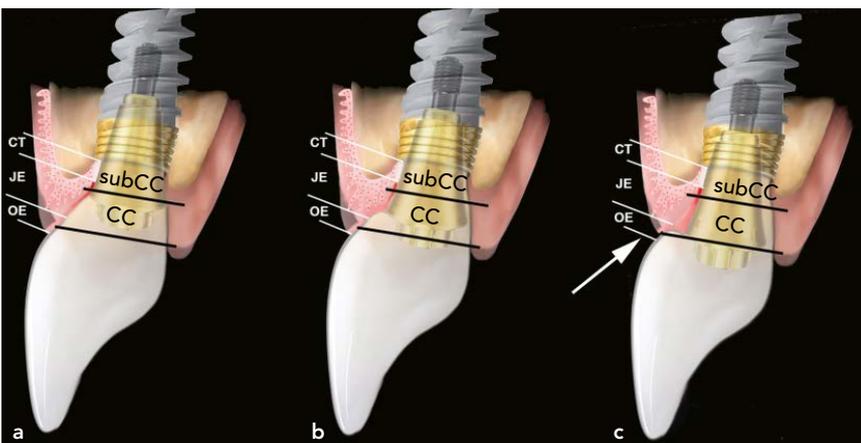
with a prosthetic component that is perfectly decontaminated and sterilized and has an ideal surface chemistry. The size and height of the prosthetic components should be evaluated correctly in order to achieve the best profile that favors an esthetic outcome, good hygiene maintenance, and a gradual emergence profile (Fig 8). This concept is characterized by simplified retrievability, as restorations can be easily removed if necessary, without any kind of soft tissue contamination, alteration, or irritation in the subcritical area. A viable option is to take a digital impression on the day of surgery with implant placement, allowing the possibility of producing the final abutment and restoration immediately and avoiding or reducing abutment disconnections. It is advisable to use screw-retained restorations to avoid possible submucosal cement remnants. However, if a cemented approach cannot be avoided, the clear visibility of prosthetic margins plays a fundamental role in cement removal. Although healthy and stable peri-implant soft tissues can be obtained with



**Fig 6** Clinical role of intermediate abutments in the restorative complex. On the day of surgery, the final abutment is placed onto the implant with final torque. (a) A healing abutment is then placed at the new prosthetic level. In this way, the prosthetic platform is moved coronally and all the clinical procedures will be performed at this level, such as (b) impression-taking and placement of the final restorations, which could use (c) conventional universal titanium abutments or (d) zirconia-based restorations.



**Fig 7** A final prefabricated abutment placed on the day of surgery offers the potential to create an ideal and stable seal at the bone interface. (a) Subcritical and critical contour areas (subCC and CC, respectively). (b) The abutment could seal the connective tissue (CT) and the apical portion of the junctional epithelium (JE), where the majority of hemidesmosomes are located, favoring soft tissue adherence. This would maintain an ideal seal at the implant-abutment interface and protect this critical area from prosthetic procedures. OE = oral epithelium.



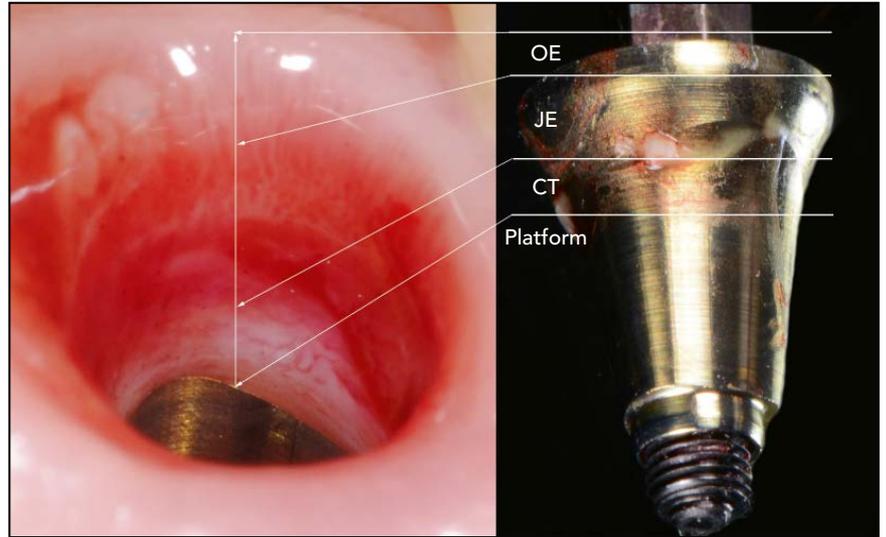
**Fig 8** The height and size of the intermediate abutment will influence the final morphology of the emergence profile. (a and b) An ideal configuration, creating an effective seal at the deepest portion of the running room and achieving ideal soft tissue support and esthetics with soft tissue displacement (arrow). (c) In case of the abutment height being longer than the critical contour (CC), it could be necessary to work with a more angled and steep horizontal profile to achieve the same soft tissue conditioning. If the abutment is too coronal, it would be necessary to work with a 90-degree horizontal profile; in this case, taking advantage of the CC conditioning would be impossible. This situation implicates a final, extreme, angled horizontal profile and a lack of soft tissue support, which could cause an esthetic defect (arrow). subCA = subcritical area; CA = critical area; subCC = subcritical contour; CT = connective tissue; JE = junctional epithelium; OE = oral epithelium.

both cemented and screw-retained restorations if managed correctly, enhanced soft tissue adherence was seen more frequently with the one abutment/one time approach (Figs 9 to 11).

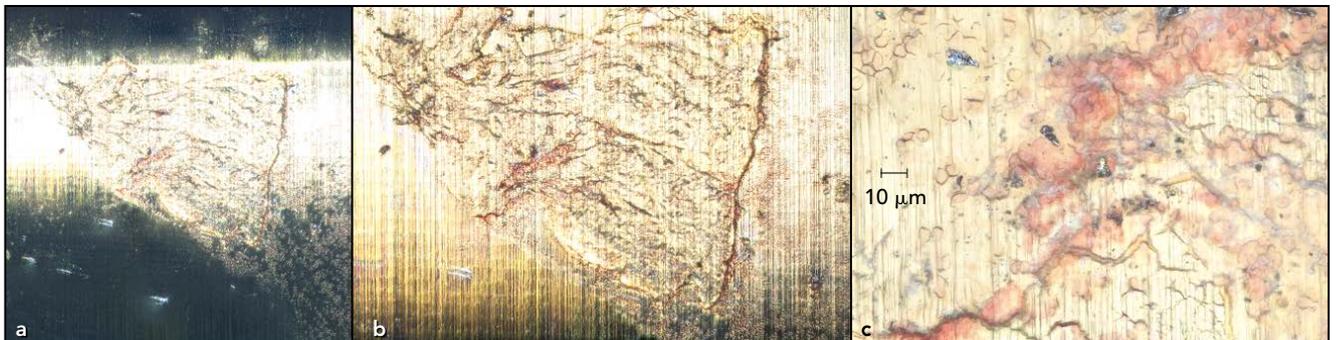
## Discussion

Based on the currently available literature, there is a lack of convincing evidence regarding the ideal emergence profile design. When an implant is placed and restored, soft tissues should adhere onto the abutment and restoration surfaces, preventing the inflow of plaque and bacteria into the sulcus; this adherence represents a seal that protects the bone interface and, therefore,

**Fig 9** A final prefabricated abutment was removed from the oral cavity 10 weeks after placement using the “one abutment/one time” approach. A wide area of soft tissues is seen in the apical portion of the junctional epithelium (JE). The three-layer configuration of the biologic width is admirable. OE = oral epithelium; CT = connective tissue.



**Fig 10** Microscopic evaluation of soft tissue remnants on the surface of an abutment placed with the “one abutment/one time” approach. The abutment (N1 Base Xeal TCC,  $4.8 \times 1.75$  mm, Nobel Biocare) was removed 10 weeks after its placement (placed on the day of surgery). The soft tissue adhered to the abutment surface is shown at three different magnifications: (a)  $\times 5$ , (b)  $\times 10$ , and (c)  $\times 50$ . Even if clinically significant differences and/or scientific evidence were absent, it can be speculated that the presence of a clear, wide area of cell adhesion can be interpreted as a solid, positive variable, indicating a stronger and more stable soft tissue seal. Because industrial processing is necessary to obtain such improved surface properties, it is not possible to customize the morphology of abutments with this approach; therefore, careful evaluation of the clinical situation and a correct treatment plan are mandatory.



**Fig 11** Microscopic evaluation of soft tissue remnants on the surface of an abutment placed with a traditional approach. The abutment (N1 Base Xeal TCC,  $4.8 \times 1.75$  mm, Nobel Biocare) was placed 10 weeks after a one-stage surgery approach, replacing a previous identical implant positioned on the day of surgery; the present implant was then removed 10 weeks after placement for microscopic evaluation. The soft tissue adhered to the abutment surface is shown at three different magnifications: (a)  $\times 5$ , (b)  $\times 10$ , and (c)  $\times 50$ . The amount of adhered soft tissues was reduced compared to those adhered to the surface of an identical abutment placed on the day of surgery.

the osseointegrated implant. Adherence of the epithelial apparatus and CT to the prosthetic components is fundamental in this process and deserves careful analysis and further investigation. Prosthetic factors, such as the restorative emergence profile, can significantly influence soft tissue integration and early bone remodeling caused by establishing the BW. Designing the emergence profile should be planned on the basis of a comprehensive evaluation, assessing the material properties, morphology, and abutment placement protocol. The morphology of the critical and subcritical contours must be planned with the intent to preserve adjacent tissues, especially in the subcritical area when a divergent configuration is used, as the abutment walls are located closer to the marginal bone, inducing bone remodeling.<sup>35</sup> Recently, the influence on marginal bone stability of soft tissue height in contact with titanium base was investigated.<sup>36</sup> The height of titanium abutments should be selected with consideration of both the implant vertical position and soft tissue thickness; in fact, the subcritical zone should be occupied totally with titanium and/or zirconia, particularly in the subcrestal tunnel when deep implant placement is performed. Manually polished zirconia could be used in this area as well, but in case of full zirconia conical connections, the unfavorable biomechanical factors could compromise the predictability of prosthetic outcomes.<sup>37</sup>

## Conclusions

The prosthetic concept presented herein is suggested to be an operative strategy to preserve peri-implant hard and soft tissues and achieve predictable prosthetic outcomes. The emergence profile should be evaluated with a comprehensive planning of all critical factors that can influence the integration, stability, and preservation of bone and soft tissues. Biologic principles should guide clinicians' decision-making process about the configuration of the emergence profile.

## Acknowledgments

The authors declare no conflicts of interest.

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