

# Biologic Interfaces in Esthetic Dentistry. Part I: The Perio/ Restorative Interface\*

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## The scientific chairman's prologue

by Prof. Aris Petros Tripodakis

In witnessing esthetics within the human body, the issues of beauty, health, and integrity work in continuous synergy. The pursuit of dental esthetics should embrace equally all three in serving the patient as a person. During the clinical practice of esthetic dentistry, the critical issues that differentiate an excellent end result from a failure lie mostly within the crucial areas where these items come into contact: the interfaces.

Biologic and material interfaces in restoring the mutilated dentition can compose a clinical intervention of harmony. But which are the attainable limits of clinical achievements? Evidence-based in-

formation, along with outstanding clinical skills and the contemporary advances of technology and dental materials can conduct the realization of the ultimate biologic response of an esthetic outcome. However a clear documentation, definition, and demonstration of the limits through an interdisciplinary official communication, is still academically missing.

One of the major scopes of the EAED is "to provide leadership in the profession by defining the highest ethical standards and to foster interdisciplinary communication and research through publications and educational presentations." It is for this reason that the 2010 Active Members' Meeting has been structured as a workshop aiming to give a documented clinical interpretation of the existing scientific evidence concerning specific biologic interfaces in



esthetic dentistry. The meeting aims to be a thorough and well-structured discussion that will generate conclusions. For this reason the discussion will be founded on presented essays addressing specific issues divided in two parts as follows:

- Part I: the perio/restorative interface
- Part II: the peri-implant /restorative interface.

At this point, it is more than appropriate for the Scientific Chairman of this meeting to extend genuine gratitude to the two essayists, Dr Gerd Körner and Dr Arndt Happe and to the two moderators, Dr Giano Ricci and Prof. Jörg Strub for their willingness to invest their hard work and time toward the success of such a demanding workshop. Also, a warm invitation is extended to all the Life and Active Members of the Academy to respond to this opportunity by actively participating in the workshop, as proposed in the guidelines.

## Moderator's introduction

*by Dr Giano Ricci*

The times when people wanted just to save the natural dentition without concern for esthetics have long gone. Today's periodontal treatment requires great consideration for good esthetic results at the end of therapy. In most cases, to completely solve the functional and esthetic problems of periodontal disease or periodontal therapy, there is the need to utilize a combined surgical and prosthetic approach, especially when it is necessary to recapture the

shape and size of teeth to improve the smile, which in turn should fit perfectly in the general esthetic appearance of the patient. However when there is the need to use prosthetic therapy, especially in periodontally susceptible patients, many questions arise.

Surgical and prosthetic crown length modifications, surgical and orthodontic leveling of gingival margins, improving quality and quantity of attached gingiva, periodontal plastic surgery procedures such as root coverage, ridge augmentation, recapture of papilla height are all problems which the clinician is confronted with, every day. Hard and soft tissues need to be mastered in the proper way. Stability of the gingival margins, absence of pocket depth, functionality and esthetic long-term results are keywords for the sophisticated operator.

Location of the prosthetic finish line is a fundamental aspect of the esthetic outcome. A good long-term result will depend on many different considerations, such as tooth position, periodontal biotype, susceptibility to periodontal disease, control of inflammation, and good oral physiotherapy. In order to maintain marginal soft tissue stability, all of these parameters must be kept under control along with proper prosthetic manipulation. It is imperative not to violate the biologic width. The influence of the type of restorative material, provided it is precise, smooth, polished and doesn't allow plaque accumulation, has yet to be scientifically demonstrated.

In patients who have undergone periodontal surgery for treatment of the attachment apparatus, for periodontal plastic surgery or for crown lengthening procedures, it is mandatory to wait

a long period of time, much longer than usually believed especially in esthetic cases. This precaution is fundamental in order to allow proper maturation of the tissues, which present a wide range of patient-related responses.

The most demanding esthetic challenge is the recapture of papilla height both around natural teeth or implants. Different surgical techniques have been proposed but the results seem questionable and very technically sensitive. It is in this area that surgical and prosthetic procedures may be really complementary and must act together to obtain the ultimate result. This will be accomplished and maintained in the long term only if the oral hygiene of the patient is excellent and a strict protocol of supportive periodontal therapy is followed.

The planned discussion regarding most of the above issues will be founded on presented essays addressing the specific items as follows:

- esthetics and stability of the marginal interface as influenced by its location and the restorative material
- long-term stability of marginal surgical intervention: crown lengthening, guided tissue regeneration and soft tissue grafting
- predictability and long-term stability of reconstructing the interproximal papilla in abutment teeth and in pontic areas.

## The essays

“There is no doubt that at present no man-made restorative can match the biologic acceptance of a hygienic nat-

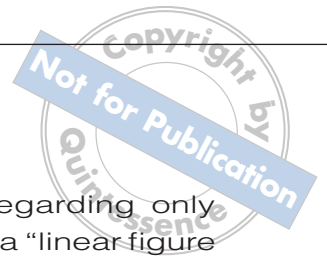
ural tooth surface.” This statement by Wunderlich and Cafesse (1985)<sup>1</sup> will stay true even in the future. Ideally no restoration should approach the gingival apparatus. However, as case demands often dictate violating this ideal, the intention of this article is to clarify different factors influencing the relationships between the periodontal surroundings and the restorative situation on the interface.

## Essay 1: Esthetics and stability of the marginal interface as influenced by its location and the restorative material

### The periodontal soft tissue

The tooth is secured in the alveolar bone by a combination of connective tissue and epithelial attachment.<sup>2</sup> Connective tissue attaches to a tooth in two distinct areas: below the alveolar crest and above the alveolar crest. With this, maxillary gingival fiber bundles provide additional attachment to secure the tooth in the alveolus, but they also serve to immobilize the gingival tissues in relation to the supra-alveolar portion of the root cementum. This tissue immobility, along with resistance to bacterial and mechanical challenges, contributes to the maintenance of a permucosal seal. The outer part of this seal is constituted by three types of epithelium.

The junctional epithelium attaches to the tooth and occupies the area between the most coronal attachment of the supra-alveolar connective tissue and the base of the gingival crevice. The thin,



non-keratinized sulcular epithelium lines the entire gingival sulcus and provides the first line of defence against bacterial ingress or toxin penetration into the underlying tissue. The oral epithelium lines the external gingival surface from the crest of the free gingiva to the mucogingival junction.<sup>3</sup> This relatively thick keratinized epithelium which is firmly attached to the underlying connective tissue provides resistance to the forces of mastication and oral hygiene.

### The biologic width

The term “biologic width” derives from histometric measurements of some of the above-mentioned structures. In 1961, Gargiulo, Wentz and Orban<sup>4</sup> conducted a landmark study of the dimension of the dental gingival junction in humans, and re-evaluated and added to the original data by Orban and Kohler in 1924.<sup>5</sup> The biologic width is defined as the combined dimensions of the supra-alveolar connective tissue attachment and junctional epithelial attachment with a mean value of 2.04 mm. It represents a dimension of 1.07 mm for connective tissue attachment and 0.97 mm for epithelial attachment, the mean of raw data with a very large range. Additionally, the tooth type and the dimension of the sulcus were not considered. Few studies<sup>6–7</sup> have offered more information on the magnitude of the supra-alveolar tissues. Basically they confirmed the above-mentioned data and found a mean value of 1.34 mm for sulcus depth, but revealed dissimilarities between different tooth types, with molars at statistically significantly higher mean values than anterior teeth. In

a clinical observation<sup>7</sup> regarding only maxillary central incisors, a “linear figure of 3 mm” was reported, determined by probing through the sulcus to the bone crest. However, this dimension varied depending on whether it was measured at the interproximal papilla or the mid-facial aspect.

In a recent study, Perez et al<sup>8</sup> concluded that variations exist within patients for similar and different tooth types, arches, and surfaces. Sclar<sup>9</sup> summarizes that nevertheless, although the exact dimension of biologic width for a particular clinical situation cannot be determined to date, the concepts derived from these studies can serve as important guidelines in the clinical restorative and surgical practice.

### Location of the margin

Following Maynard and Wilson,<sup>10</sup> a distance of 0.5 to 1.0 mm between the restorative margin and the base of the sulcus is generally considered to be safe.

To ensure an esthetic and physiologic intra-crevicular restoration, they suggested a minimum depth of 1.5 to 2.0 mm from the free gingival margin to the base of the sulcus prior to intra-sulcular margin preparation. Furthermore the claim has been made that approximately 5 mm of keratinized gingiva, composed of 2 mm of free gingiva and 3 mm of attached gingiva, is necessary to maintain health when the margins of the restorations are extended into the sulcus.

The placement of restoration margins subgingivally is generally discriminated as an invasion of the biologic width,<sup>9</sup> and may not only create a direct operative trauma to the tissues<sup>11</sup> but may also fa-





cilitate subgingival plaque accumulation with resultant inflammatory alterations in the adjacent gingiva.<sup>12–15</sup> All investigations are supporting the landmark study by Valderhaug 1980<sup>16</sup> regarding the negative impact of subgingival restoration margins followed by 40% showing supragingival exposure already after 1 year. At the 10-year examination, as many as 71% of the restorations had become supragingivally positioned due to unesthetic recession of the soft tissue margin.

Stetler and Bissada<sup>17</sup> could demonstrate that teeth with subgingival restoration margins and a narrow (< 2 mm) band of keratinized gingiva in the apico-coronal direction showed more pronounced clinical signs of inflammation than restored teeth with a wide gingival zone. But there was no difference in loss of probing attachment. However, if subgingivally placed restorations facilitate plaque accumulation and the adjacent so-called “gingival biotype”<sup>18–19</sup> is “thin-scalloped,” there may be a potential risk for the development of soft tissue recession. This conclusion can be drawn from findings in an animal model<sup>20</sup> and from clinical observation.<sup>21</sup>

### Influence of material

Subgingival restoration margins neither prevent recurrence of decay,<sup>22–23</sup> nor do they stop the onset of gingivitis, periodontal attachment loss, or gingival recession.<sup>23–24</sup> Nevertheless there is a tendency to hide them, in the sulcus or even subgingivally, out of esthetic and functional reasons.<sup>25</sup> In those situations, dental restoration materials are coming into intimate contact with the adjacent tissues.

Considering that there has been an increasing demand for esthetic restorations in recent years, the type of restorative material and the subgingival microflora features after the placement of well-finished subgingival restorations were of interest for Paolantonio et al.<sup>15</sup> In a short-term clinical and microbiological investigation over a 1-year observation period, amalgam, glass-ionomer cement, and composite resin subgingival restorations did not significantly effect the clinical parameters recorded. However, composite resin restorations may have some negative effects on the quantity and the quality of the subgingival plaque. Compared to other investigations<sup>26–29</sup> the effects were not as detrimental to gingival health. The dissimilarity was explained by the small number of subjects highly motivated towards oral hygiene and by the accurate contouring, finishing, and polishing of subgingival restorations.<sup>30–31</sup> These findings are supported by a review from Quirynen and Bollen<sup>32</sup> explaining the influence of surface roughness and surface-free energy on supra- and subgingival plaque formation in man.

Rough surfaces will promote plaque formation and maturation, high-energy surfaces are known to collect more plaque. Although both variables interact with each other, the influence of surface roughness overrules that of the surface free energy. In accordance to these findings, different investigations are ranking several materials in respect to plaque accumulation and biocompatibility:<sup>33–39,122</sup>

- glass-ceramics
- zirconium oxide
- titanium
- dental porcelain



**Fig 1-1** Situation after periodontal treatment, before restorative correction.



**Fig 1-2** Minimally invasive preparation after adhesive filling of cervical erosions with composite.

- metal alloys
- composite resin.

#### Clinical interpretation

- Prefer crevicular or supragingival margins by minimally to non-invasive techniques and adhesive ceramics (Figs 1-1 and 1-2).
- If subgingival margins are inevitable, then choose the best biocompatible materials with optimal biologic response with regard to plaque accumulation, to ensure esthetic outcome and stability in the long run (Figs 1-3 and 1-4). Make sure that the overflow of fixation materials can be reached and properly detached.
- Go for gingival augmentation to stabilize the marginal interface for changing the periodontal biotype<sup>7</sup> and the dimension of the keratinized gingiva.<sup>17</sup>
- Downshift the biologic width by resective techniques (surgical crown lengthening) to avoid violation of the biologic width.

## Essay 2: Effectiveness and long-term stability of marginal surgical intervention

### Surgical crown lengthening

The surgical crown lengthening procedure is often necessary to provide adequate retention and resistance form by gaining supra-crestal tooth length<sup>40</sup> as well as to prevent impingement of restoration margins on the attachment apparatus by re-establishing a logical biologic width,<sup>41-42</sup> especially in cases of increased esthetic demands. Therefore crown lengthening involves the surgical removal of hard and soft periodontal tissues.

There are only a few controlled studies<sup>43-46</sup> and interestingly they all report that crown lengthening is possible but the desired amount of crown lengthening is either not predictably attained or is subject to change over time. The data suggests that there is a significant tissue rebound that has not fully stabilized by



**Fig 1-3** Glass ceramic veneers for best biologic response and esthetic outcome.



**Fig 1-4** Clinical situation after cementation of veneers 12 to 22.

6 months. This pattern of coronal displacement of the gingival margin was more pronounced in patients with “thick gingival biotype” and also appeared to be influenced by individual variations in the healing response, not related to gender or age.

### Root coverage

The treatment of gingival recession in the area of the perio-restorative interface is a common requirement due to patient-centered concerns including root sensitivity, difficulty in plaque control, increased potential for root caries, restorative failure, and compromised esthetics.<sup>47</sup>

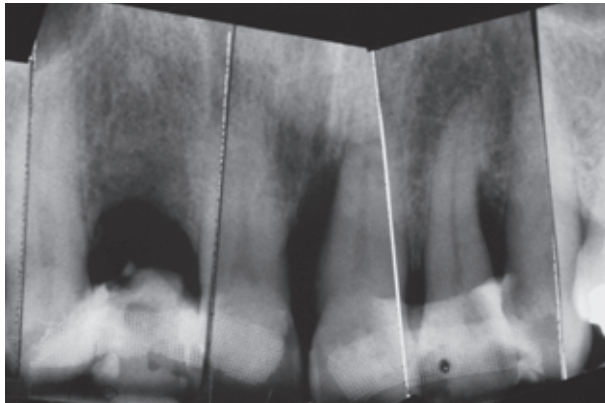
The ultimate goal of a root coverage procedure is the complete coverage of the recession defect with stable and good appearance related to adjacent soft tissues and minimal probing depth (PD).<sup>48-50</sup>

A large variety of different procedures may be indicated<sup>51-52</sup> even though for some, very limited data are available.

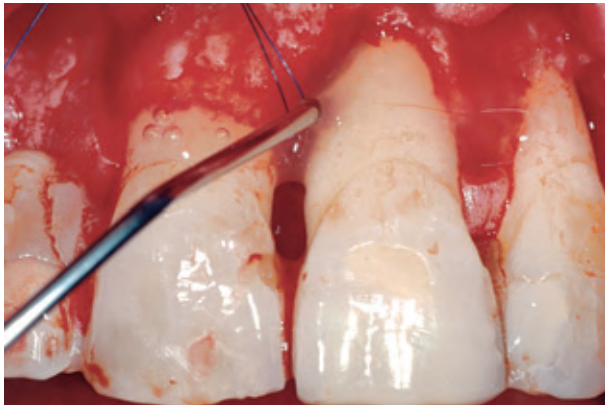
The best research data available is for the coronally advanced flap (CAF) procedure. It is based on the coronal shift of the soft tissues on the exposed root surface.<sup>52-53</sup> This approach may be used alone or in combination with soft tissue grafts,<sup>54</sup> barrier membranes (BM),<sup>55</sup> enamel matrix derivative (EMD),<sup>56</sup> acellular dermal matrix (ADM),<sup>57</sup> platelet plasma (RPP),<sup>58</sup> and living tissue-engineered human fibroblast-derived dermal substitute (HF- DDS).<sup>59</sup>

Cairo et al<sup>60</sup> conducted a systematic review where only randomized-controlled clinical trials (RCTs), including a split-mouth model of at least 6 months duration, were considered to measure and compare clinically relevant outcomes for Miller Class I or II localized gingival recession defects. Determining complete root coverage (CRC) as the primary outcome variable revealed the most decisive result: only two combinations (CAF + CTG and CAF + EMD) provided better results than CAF alone. And no other therapy showed better results than CAF + CTG.

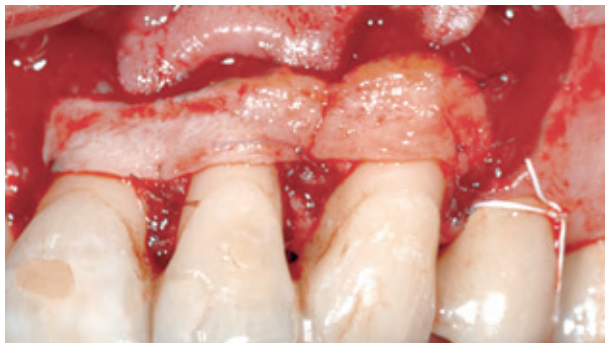




**Fig 2-1** Initial perio-compromised situation.



**Fig 2-2** Periodontal regeneration with Emdogain (EMD) and papilla preservation technique (Cortellini 1995).



**Fig 2-3** Root coverage of situation Fig 2-1 with an autologous connective tissue graft.

The decision on whether to select CTG or EMD in conjunction with CAF could be influenced by the positive impact of sufficient keratinized tissue (KT)<sup>17</sup> following restorative treatment. This systematic review showed that CAF + CTG were associated with the best clinical outcome in terms of KT gain among the compared combinations. On the other side, CAF + EMD appears to be an easier procedure than CAF + CTG and does not require a donor area for CTG harvest.<sup>52</sup> But the unfavorable cost-benefit ratio of CAF + EMD, the suboptimal keratinization, and missing data should be evaluated.

Also in recent years ADM was proposed as a promising alternative to CTG,<sup>61,66</sup> but long-term data are rare or rather disappointing. Harris<sup>62</sup> reported a study to evaluate the short-term and long-term coverage results obtained with ADM and CAF + CTG. He concluded that the mean results with CAF + CTG stood the test of time better than ADM.

On the other hand the long-term stability of the “gold-standard procedure”<sup>63</sup> CAF + CTG could be demonstrated by Dorfman et al 1982<sup>64</sup> in a classic split-mouth study over 4 years. Different authors<sup>65,66</sup> confirmed similar positive results in favor of grafted sites with respect to KT, attached gingiva, and recession. Recent long-term studies by Agudio et al<sup>67,68</sup> with follow-ups (10–27 years) underlined a sustained stability of the gingival margin following gingival augmentation surgery. The contralateral untreated sites showed a tendency for apical displacement of the gingival margin with an increase in the existing recessions. Findings by Wennström and Lindhe<sup>69,70</sup> in dog studies, which concluded that “soft tissue

grafting was found to be an effective and predictable means to increase the width of keratinized tissue but did not otherwise improve the condition of the periodontium,” could not be verified.

### Clinical interpretation

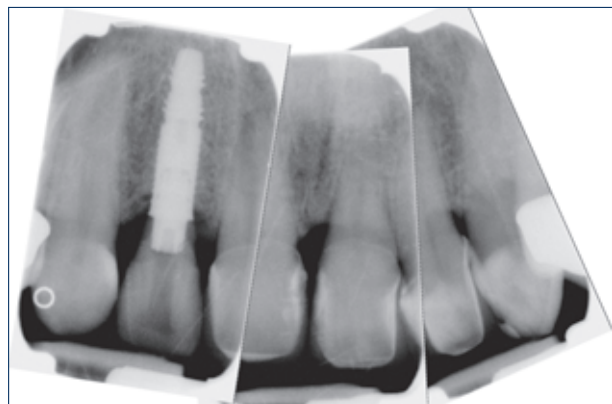
- Surgical crown lengthening and root coverage are effective treatment modalities,<sup>43–46, 60</sup> and long-term stability is reported for the “gold standard procedure” – coronally advanced flap in combination with autologous connective tissue grafts – and with restrictions the use of EMD<sup>63–70</sup> (Figs 2-1–2-6).
- The impact of biotype and tissue maturation on the effect of surgical crown lengthening needs to be taken into account. Both parameters, accorded as thick biotypes and less than 6 months after surgery, can lead to a marked rebound of tissues and encroaching of restorative margins<sup>7</sup> (Figs 2-7–2-9).
- Raising flaps for crown lengthening, or coronally advancing the pedicle flap during root coverage via vertical incisions, is more often now replaced by incision-less procedures including micro-surgical tunnel-techniques and new suturing methods.<sup>119,120</sup> The aim of these up-and-coming procedures is to minimise trauma to tissues, avoiding scarring, and reducing mortality.<sup>121</sup>
- The question of whether eroded areas of the denuded root should be restored before root coverage or after a sufficient period of healing cannot be answered definitively because of missing data.<sup>123</sup> But clinical



**Fig 2-4** After regeneration and root coverage with connective tissue, implant placement at tooth 12.



**Fig 2-5** Clinical situation 5 years after restoration: full ceramic crown on implant 12, ceramic veneers of teeth 13, 11, and 21 to 23.



**Fig 2-6** Radiograph situation 5 years after initial situation.



**Fig 2-7** Situation after conventional periodontal treatment with persisting violation of biologic width caused by the old unesthetic restoration.



**Fig 2-8** Final preparation 6 months after surgery (maxillary front left).



**Fig 2-9** Final situation 1 year later.

evidence advocates an approach considering connective tissue as natural filler at least for moderate cervical eroded defects.

### Essay 3: Predictability and long-term stability of reconstructing the interproximal papilla next to restorative situations

#### Preserving and reconstructing the interproximal papilla

The interproximal papilla first described by Cohen in 1959<sup>71</sup> is the gingival portion, which occupies the space between two adjacent teeth or adequate clinical restorations supported by natural teeth and implants or pontic designs.

The interproximal papilla, playing a critical role for esthetics and phonetics, may accordingly appear in different constellations. In any case the foundation for the structured support is the underlying contour of the osseous crest. However the mere existence of the biologic width<sup>4,6</sup> with more or less constant value of 2 mm supra-crestal gingival tissue fails to explain by itself the 5 mm height<sup>72,73</sup> of the interdental papilla.

It became obvious that other key factors, besides the bone level, may be involved in the papillary presence/absence like the presence of the adjacent tooth attachment and the volume of the gingival embrasure.<sup>74,75</sup> Following Tarnow et al,<sup>73</sup> the vertical height from the base of the interproximal contact to the bone crest is one determining factor in maintaining a papilla. But there are other factors in a more

**Table 1** Tissue height needed from the contact point to the crestal bone level in order to maintain papillae in different clinical situations. From Zetu and Wang.<sup>78</sup>

Contact point alveolar bone crest	100% papillae appearance (mm)	Author
Interdental papillae	≤ 5	Tarnow et al (1992)
	< 4.5	Kois (2001)
Implant–tooth papillae	< 4.5	Salama et al (1998, 2002), Salama (2001)
Implant–implant	< 3.5	Tarnow et al (2003)
Implant–pontic	< 5.5	Salama et al (2004)
Tooth–pontic	< 6.5	Salama et al (2004)
Pontic–pontic	< 6	Salama et al (2004)

three-dimensional direction like form and volume of the embrasure, size, shape of the contact area, lateral bone dimension, root proximity, and biotype playing a major role.<sup>76,77</sup> Hence, there are different options for therapeutic impact:<sup>78</sup>

- preserving and reconstructing the interproximal bony support
- proper soft tissue management
- beneficial selection of abutment constellations
- restorative interproximal design.

Socket preservation techniques<sup>79-91</sup> have been developed to preserve or reconstruct the interproximal space even in combination with forced orthodontic extrusions<sup>92</sup> while maintaining or rebuilding the soft tissue surroundings.

Different bone augmentation techniques have been advocated for supporting the papilla appearance including but not limited to GBR,<sup>93</sup> onlay grafting,<sup>94</sup> distraction osteogenesis<sup>95</sup> and combinations of soft and hard tissue grafting.<sup>96</sup> The aim of reconstructing the bony support is to match ideally

the needed dimensions among the possible abutment constellations (Table 1).

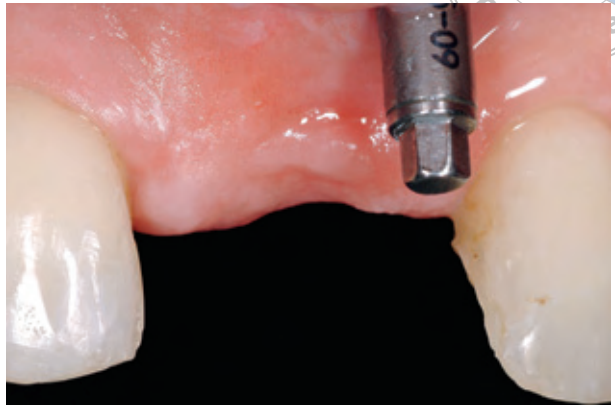
The proper soft tissue management is directed to recreate the papillae.<sup>97-99</sup> Different techniques for papilla preservation<sup>100-105</sup> have been described for beneficial impact on papilla reconstruction. Especially in regard to implant uncovering techniques in combination with optional soft tissue grafting, a large variety of techniques were introduced recently.<sup>106-110</sup>

The predictability of all these techniques remains to be determined. Since soft tissue collapse can occur following bone resorption, additional steps can be taken for the impact on interproximal tissue height. Immediate tooth replacement using an ovate pontic to support the papilla for a natural-appearing emergence profile,<sup>111</sup> for example in combination with strategic abutment selection (Table 1) can be an advantage. Last but not least, there are different options for having synergetic impacts in terms of backing and reinforcing the interproximal papilla by a longer term provisional restoration,<sup>112</sup>

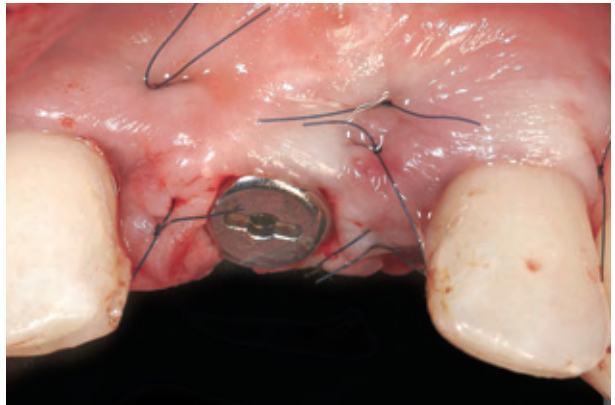
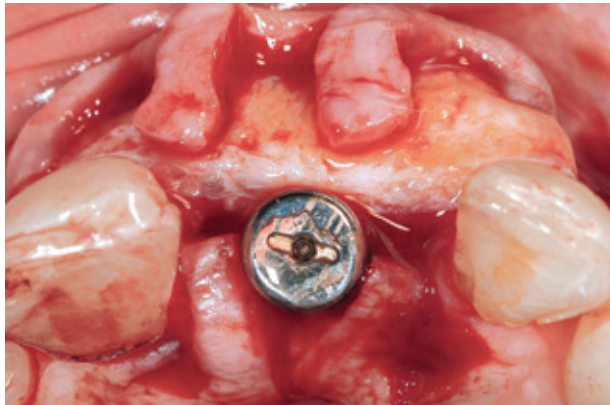




**Fig 3-1** Periodontally compromised tooth 21 can not be preserved.



**Fig 3-2** Vertical correction of the defect via osseodistraction.



**Figs 3-3 and 3-4** Implant 21 uncovering in combination with root coverage of tooth 11 and 22 interproximally and labially at implant site by a connective tissue graft, before and after suturing.





**Fig 3-5** Final restoration: veneers of tooth 11 and 22 and zirconia-based ceramic restoration of implant 21.



**Fig 3-6** Final restorative situation 1 year postoperatively.

the interproximal restorative reshaping,<sup>113</sup> and ceramic veneering for altering the interproximal space.

### Clinical interpretation

The three-dimensional structure of the interproximal papilla is influenced by numerous factors and different constellations.

Reconstructing a missing papilla is a prestigious and bench-marking goal of modern treatment concepts. But predictability is low and efforts in that field should be first focused on preserving and then reconstructing. Therefore promising approaches deriving from recent studies of papilla preservation are available.<sup>99–104</sup>

In reconstructing this area, the bony support should be enhanced by GTR procedures and/or bone augmentation including bone grafting or distraction osteogenesis. Additional soft tissue management for tuning the final outline should be considered (Figs 3-1–3-6).

Synergistic effects can be obtained by strategic selection of abutment constellations, interproximal restorative design, and orthodontic impacts.

Provisionalisation is a key element for conditioning the interproximal papilla. The thereby created individual emergence profile should be cautiously transferred into the final restorative situation.

Long-term stability has to be seen against this background. Only a few articles<sup>114–118</sup> have reported a long-term increase of papilla height, at least around single implants, even in compromised situations. But it is evident that there is not sufficient scientific data.

### Acknowledgement

The authors would like to express their sincere appreciation for the very ambitious contributions of Aris Tripodakis. He was the one who set the focus on the topic of biologic interfaces in esthetic dentistry. He formulated the aims of the literature review and gave advice for the final conclusions.

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