Prosthetically driven techniques to compensate peri-implant soft tissue deficiencies

Urs Belser,[1] German Gallucci,[2] Kelvin Afrashtehbar,[3] Daniel Buser[4]

Abstract

Local soft tissue deficits often follow tooth loss and implant therapy. Under these circumstances, future implant reconstructions should aim to completely or at least partially compensate this loss in order to minimize any adverse effects, namely compromising subjective patient comfort. In the main, this encompasses disconcerting food impaction, as well as esthetic and phonetic impairment. The present article reviews the relevant prosthetically driven compensation measures, confining itself to the esthetic zone of partially dentate implant patients and fixed dental prostheses (FDP). In this specific context five objectives are of paramount importance: (I) establishing healthy peri-implant soft tissues, (II) avoiding open embrasures, (III) maintaining or recreating a harmoniously scalloped soft tissue course, (IV) achieving the optical illusion of balanced relative tooth dimensions, and (V) providing ease of access for effective plaque control. Six representative clinical examples featuring various degrees of peri-implant soft tissue deficiencies are addressed in detail, highlighting different design guidelines and pointing out their inherent limitations. In the case of minor-to-moderate soft tissue deficiencies, achieving the goal by implementing only morphological elements of the so-called white crown substrate such as adequate positioning of facial transition line angles and increased interdental contours is recommended. However, when facing major soft tissue deficiencies, the addition of pink ceramics as an integral part of the implant restoration may become unavoidable to achieve a clinically acceptable result. In this context one has also to take into consideration the position of a given patient's individual smile line as an important decision-making parameter.

Keywords: Peri-implant soft tissue, implant esthetics, soft tissue deficit, implant-prosthetic design, pink ceramics

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Introduction and scope

After tooth loss and subsequent implant placement, it is not uncommon for the clinician to face restoration sites featuring a deficit of soft tissue (Araujo & Lindhe 2005; Bidra & Chapokas 2011). The degree and three-dimensional configuration of the resulting peri-implant soft tissue deficiencies depend on both the local preoperative conditions and the surgical protocol used (Buser et al. 2013; Levine et al. 2014; Chappuis et al. 2016). These soft tissue deficiencies concern predominantly the interproximal "papillary" area, followed by mid-facial recessions (Tarnow et al. 2003; Buser et al. 2004). If the new implant-based restoration simply reproduced the originally present anatomical crown volume, it would logically result in open interdental embrasures or so-called "black triangles". This, in turn, may significantly interfere with the patient's subjective comfort. In posterior segments of the jaws, the main consequence of open embrasures is disconcerting food collection. In order to narrow down open embrasure space, restoration volumes are often increased to an unacceptable degree, leading to over-contoured design configurations that contradict the access required for plaque control.

When it comes to the esthetic zone, additional phonetic and esthetic problems arise. The latter is strongly dependent on the height of a given patient's individual smile line and the degree to which the anterior maxillary alveolar process is exposed (Jensen et al. 1999).

In order to comply with the editorial space restrictions of the Forum Implantologicum, the focus of this article will confine itself to peri-implant soft tissue deficiencies located in the esthetically relevant zone of partially dentate implant patients and review their prosthetically driven compensation techniques.

Fig. 1a: Initial frontal view of a 49-year-old female patient presenting with two recently inserted single implant restorations at sites 21 and 22. Her main complaint addresses the marked asymmetry (i.e. altered length-to-width ratio) between the implant crowns and their contralateral control teeth. Furthermore, the peri-implant mucosal line is completely lacking a harmoniously scalloped course otherwise present at the adjacent natural dentition.

Fig. 1b: Final situation after removal of the malpositioned implants 21 and 22, followed by the placement of a new implant at site 21, restored with a 2-unit fixed dental prosthesis (FDP) comprising a distal cantilever unit and some pink ceramics as well as the insertion of a new crown on tooth 11. At the patient's non-forced smile, a significant improvement in terms of symmetry and balanced relative tooth dimensions can be noted.

Fig. 1c: In order to compensate the major vertical soft tissue deficiencies and the resulting esthetic drawbacks, namely in terms of unbalanced relative tooth dimensions, pink ceramics were added to the new restorations. The final adjustments of the latter are performed chair-side to ensure adequate access for Superfloss®.

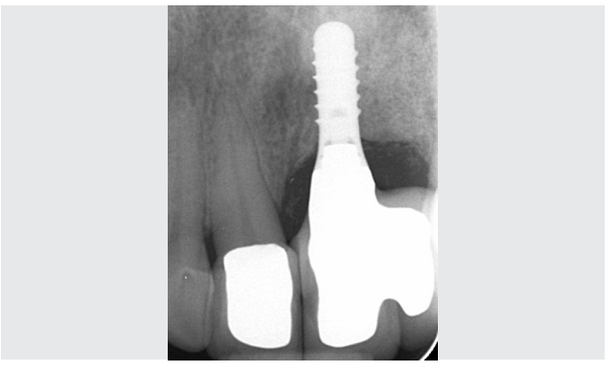


Fig. 1d: The radiographic control at the end of treatment confirms stable peri-implant bony conditions at the site of the screw-type soft tissue level implant.

Figs 1e - f: At normal communication distance, the patient's unforced smile displays a harmonious post-operative result in both the frontal (1e) and the oblique (1f) views.

Main esthetic problems associated with peri-implant soft tissue deficits

Negative visual tension arises mainly if the alveolar mucosa is largely exposed during the patient's unforced smile and one or several of the following conditions are present:

- Irregular course of the mucosal line. This points to an absence or interruption of a continuous and harmoniously scalloped soft tissue course. In fact, abrupt vertical position changes of the mucosal margin between neighboring sites are particularly disturbing.
- Open interdental spaces, also widely termed "black triangles". Such open embrasures not only favor food retention, but they also adversely affect esthetic appearance and frequently cause speech impairment.
- Imbalance of relative tooth dimensions. This describes unnatural length-to-width ratios of clinical crowns, a phenomenon that is often the direct consequence of a lack of peri-implant soft tissue (Sterrett et al. 1999; Magne et al. 2003).

Treatment objectives in the case of peri-implant soft tissue deficits

As previously mentioned, the scope of this article discusses only restoration-driven techniques to compensate peri-implant soft tissue deficiencies as the surgical possibilities are specifically presented in two other articles in this issue of Forum Implantologicum. Although the purely implant-prosthetic measures are clearly limited, it is not infrequent that they can still help to predictably transform an originally quite compromised situation into one that is acceptable to many patients (Garber & Belser 1995; Belser et al. 1996; Belser et al. 1998; Gallucci et al. 2004; Belser et al. 2006; Vailati & Belser 2007; Spear 2008; Belser et al. 2009; Gallucci et al. 2011; Buser et al. 2013; Wittneben et al. 2013; Boardman et al. 2016; Furze et al. 2016; Moraguez et al. 2016; Tettamanti et al. 2016). One should not forget that the restorative approach clearly helps to reduce the time, cost and complexity of the treatment. Furthermore, it avoids the inherent risk and morbidity of sophisticated surgical interventions. A typical clinical example where this strategy has been implemented is presented in Figs 1a - f.

In general, implant-prosthetic compensation techniques contribute to the following fundamental treatment objectives:

- Establishing healthy stable peri-implant tissue conditions and contours
- Avoiding or minimizing open embrasure spaces
- Maintaining or recreating a regular, continuous and harmoniously scalloped mucosal course
- Achieving the optical illusion of balanced relative tooth dimensions
- Providing ease of access for effective daily plaque control

Case presentations

In the following paragraphs, five representative clinical examples featuring various degrees of peri-implant soft tissue deficiency are addressed in detail, highlighting different design guidelines and pointing out their inherent limitations.

Situations treated by crown morphology and volume adaptation alone

In the presence of minor-to-moderate peri-implant soft tissue deficiencies, it is recommended to aim at compensating the missing volume at the level of the soft tissue ("pink compartment") by means of morphological adaptation of the crown design ("white compartment") alone. This strategy is particularly appropriate in the case of a low or intermediate level smile line.

Such favorable pre-prosthetic conditions were present in a 36-year-old female patient eight weeks after insertion of a bone level implant to replace the upper right lateral incisor (Fig. 2a). A minor soft tissue deficit was noted at both the mesial and distal papillary regions as well as on the disto-facial aspect of the adjacent central incisor. The three available parameters that allow the creation of the optical illusion of balanced relative tooth dimensions are schematically presented in Fig. 2b. On the one hand the cervical crown volume needs to be slightly increased in comparison to its original size to avoid open embrasures, while on the other one does not want to trade this off against an unbalanced final appearance, i.e. a clinical crown that appears too wide and therefore also too short. This morphological dilemma can be bypassed by moving the mesial and distal transition line angles slightly towards the center of the facial surface, and by likewise giving the mid-central compartment more relative weight in a corono-apical direction. The 6-year follow-up view confirms that the correctly implemented morphological variables helped to reach and maintain a favorable esthetic result that conveys harmony despite the presence of a minor soft tissue deficit (Fig. 2c) and the patient's gummy smile that completely exposes the site during unforced smiling (Fig. 2e). Furthermore, the corresponding 6-year peri-apical radiograph documents the targeted bony stability (Fig. 2d).

Major vertical soft tissue loss in the papillary area may logically call for more complex compensation techniques. This is particularly true when dealing with high smile line patients. This is illustrated by the clinical view of a 21-year-

Fig. 2a: Close-up view of the maxillary right anterior segment of a 36-year-old female patient, 8 weeks after a bone level implant had been inserted at site 12. Note a slight vertical soft tissue deficiency at the facial and distal aspects of the upper right central incisor.

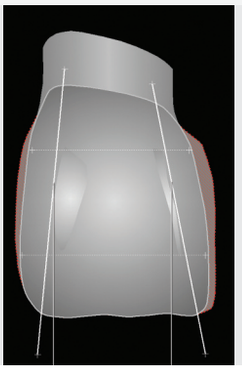


Fig. 2b: Schematic representation of the parameters that can be modified on a maxillary incisor in the case of vertical soft tissue deficiencies to create the optical illusion of balanced relative tooth dimensions (length-to-width ratio): position of the mesial and distal transition line angles, relative weight of the three facial compartments in the corono-apical direction, and palatally located prolonged interproximal contact lines.

Fig. 2c: Clinical close-up view of the maxillary right sextant 6 years after implant surgery. The peri-implant soft tissue deficit has been fully compensated by (1) accentuating the facial transition line angles at their correct anatomical position, and (2) long, palatally located interdental contact lines, including a discreet amount of additional color saturation.

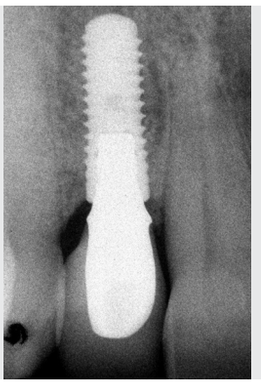


Fig. 2d: The corresponding 6-year peri-apical radiograph documents stable osseointegration and interproximal bone-to-implant contacts located precisely up to the implant shoulder.

Fig. 2e: The patient's unforced smile documents an acceptable degree of esthetic integration of the implant restoration, despite the presence of a so-called "gummy smile".

old female patient photographed immediately after delivery of a directly screw-retained implant provisional at site 21 (Fig. 3a). The symmetrical reproduction of the clinical crown form and volume present at the site of the natural control tooth resulted in a major central black triangle. Furthermore, the distal papillary area of the implant site lacked significant height in comparison with the corresponding region between teeth 11 and 12, where a complete interdental soft tissue fill was noted. At this stage the patient refused a second orthodontic treatment, because she still had mixed feelings about a lengthy previous treatment. As a unilateral increase in coronal volume of the implant restoration would not have allowed complete closure of the central embrasure space

Fig. 3a: Frontal view of a 21-year-old female patient, immediately after inserting a directly screw-retained provisional implant restoration at site 21. A major open embrasure space, termed "black triangle", can be noted at the midline location. In addition, a distinctly short papilla mesial to the upper left lateral incisor creates significant visual tension in comparison to site 12.

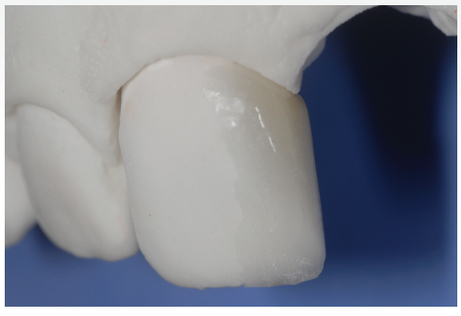


Fig. 3b: In order to restoratively correct the previously described disturbing situation, it was decided to add volume to the mesial aspect of tooth 11. The aim was to reduce the amount of black space and to optically straighten up the slightly inclined long axis of the right central incisor..

Fig. 3c: Without tooth preparation, a mesio-incisal partial veneer consisting of feldspar ceramics was produced on a refractory die.

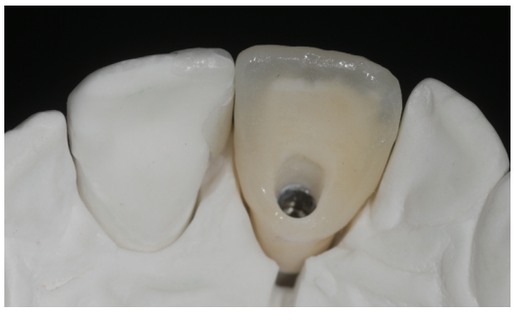


Fig. 3d: The palatal close-up view of the corresponding working model displays the final zirconia-based, directly screw-retained implant crown.

Fig. 3e: The frontal view at the end of treatment documents that the patient's primary concern, i.e. the large "black triangle", could be mostly corrected by the non-invasive adhesive restoration at site 11, in combination with an adequately designed implant crown. However, the problem related to the short papilla between implant crown and tooth 22 could only be minimally improved.

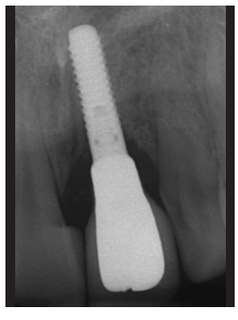


Fig. 3f: The postoperative peri-apical radiograph confirms stable bony conditions adjacent to the NNC soft tissue level implant, including the characteristic remodeling and saucer-like crater formation.

due to the mesial inclination of the natural root, but would have led to a marked asymmetry between the two central incisors (one natural and one implant-borne), it was decided to add half of the required volume to tooth 11 in the form of a bonded feldspar veneer fabricated on a refractory model and requiring no tooth preparation, and the other half integrated in the all-ceramic zirconia-based implant crown (Figs 3b - d). This simple and highly conservative approach permitted the efficient elimination of the black triangle (Figs 3e - f). However, the esthetic problem in the form of a short papilla between sites 21 and 22 persisted, as no restorative technique was available to elegantly intervene. The direct comparison of the clinical views before (Fig. 3g) and after (Fig. 3h) implementing this combined tooth- and implant-borne restorative approach shows a marked overall improvement on the one hand, but also some of the limitations of purely prosthetically driven interventions. The patient's unforced smile, photographed at normal communication distance confirms a predominantly favorable treatment outcome (Fig. 3i).

Situations requiring the addition of pink ceramics

In the case of implant-supported screw-retained fixed dental prostheses (FDPs) comprising two or more splinted units and


Figs 3g – h: The direct comparison before (3g) and after (3h) completion of the combined adhesive and implant-based therapy underlines a marked improvement of a previously – from an esthetic point of view – severely compromised condition, despite the presence of a marked "gummy smile". On the other hand, the clearly limited restorative possibilities when it comes to the correction of marked vertical soft tissue deficiencies have to be underlined.

Fig. 3i: The patient's unforced smile, displayed at normal communication distance, also documents a slightly compromised, yet largely acceptable result when comparing the papillary height at embrasures 12/11 and 21/22.

the presence of significant vertical peri-implant soft tissue deficiencies, the addition of pink ceramics may nowadays be considered not a last resort but a structured integral part of the implant-prosthetic treatment strategy (Vailati & Belser 2011; Belser & Buser 2012). Sometimes the addition of only a minute quantity of pink ceramics can make a major difference in terms of esthetic appearance. The majority of authors who have published design principles for the use of pink agree that it should be reserved for multi-unit implant FDPs and its extension limited to the zone in between the zenith of the units located at each end of the prosthesis (Barzilay & Irena 2003; Capa 2007; Kamalakidis et al. 2007; Cascione et al. 2008; Coachman et al. 2009; Kim et al. 2010; Papadimitriou et al. 2014; Levin et al. 2015; Moraguez et al. 2015; Papaspyridakos et al. 2016). So called embracing of neighboring teeth by extending the pink compartment over and beyond the area of the mesial and distal natural papilla makes access for plaque control virtually impossible and can therefore not be recommended.

A typical clinical example of the elegant use of a small amount of pink ceramics is presented in Figs 4a - f. Two months after placement of a tissue level implant at position 23 in a 46-year-old male patient, a flattened edentulous ridge segment including the missing lateral incisor indicated that the planned 2-unit implant FPD featuring a mesial extension would encounter either the problem of an open embrasure at the transition between implant crown and cantilever unit or end up with altered relative tooth dimensions (Fig. 4a). To provide adequate strength in the connecting area, the metal framework was given the required dimension and was positioned as far to the palate as possible (Fig. 4b). Furthermore, a long interdental contact

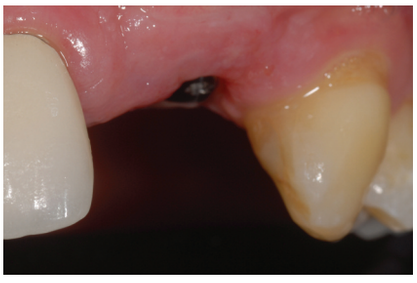


Fig. 4a: Clinical view of the maxillary left sextant of a 46-year-old male patient, taken shortly after the reopening of implant site 23. It was planned to replace the two missing teeth 22 and 23 with an implant-supported 2-unit fixed dental prosthesis (FDP), featuring a mesial cantilever extension.

Fig. 4b: The close-up view of the master model shows the palatal aspect of the directly screw-retained ceramo-metal implant FDP. Note that the metal framework is extended to the lingual surface in order to give maximum strength to the connecting area between the implant crown and the cantilever unit.

Fig. 4c: For esthetic reasons a small amount of pink ceramic has been added in the papillary region of the 2-unit implant FDP. Note the clearly convex profile of the entire cervical aspect of the restoration. This is mandatory to create favorable conditions for adequate daily homecare with the use of Superfloss®.

Fig. 4d: The final clinical view shows the screw-retained, 2-unit implant FDP, featuring a mesial cantilever extension. The determining factors for an optimal esthetic integration consisted of the addition of a minimal amount of pink porcelain, the discreet imitation of a root-like cervical portion at elements 22 and 23 as well as the long interdental contact zone between tooth 21 and the mesial aspect of the cantilever unit.

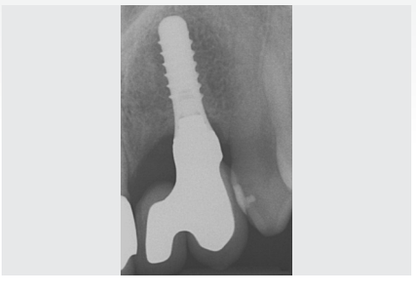


Fig 4e. The corresponding post-operative peri-apical radiograph documents favorable bony conditions associated with the solid screw-type soft tissue level implant. Note also the adequate dimensions of the underlying metal framework, particularly in the connecting area, to provide optimal mechanical resistance.

Fig. 4f: The appearance of the upper left anterior segment during the patient's unforced smile confirms the efficacy of the previously mentioned design elements in terms of natural esthetics.

line provided intimate contact to the neighboring central incisor tooth to avoid an open embrasure. With respect to the design of the integrated pink ceramic, it was limited to the area between 22 and 23, using a discreet pale shade and given a convex profile to harbor the concavity created on the edentulous ridge (Fig. 4c). The clinical close-up view documents the favorable impact of the added pink in terms of esthetic appearance (Fig. 4d), whereas the corresponding peri-apical radiograph highlights the aforementioned design details, namely the dimension of the underlying metal framework (Fig. 4e). Finally, the photograph taken during the patient's unforced smile confirms a satisfactory treatment outcome (Fig. 4f).

A next, more challenging example of how the addition of pink ceramics can be instrumental in re-establishing harmonious conditions is presented in Figs 5a - h. The complaints of this 48-year-old female patient were threefold, addressing a disturbing central black triangle, a marked mid-facial mucosal recession at implant site 11 and a grossly disproportional volume of the two maxillary central implant crowns when compared with the adjacent natural dentition (Figs 5a - c). Based on the analysis derived from a chair-side diagnostic mock-up it was decided to proceed to the fabrication of two new connected implant crowns with integrated pink ceramics to achieve both the elimination of the black triangle and the re-establishment of balanced

Fig. 5a: Initial clinical view of a 48-year-old female patient, complaining about a major esthetic problem in the anterior maxilla. This concerns the volume, form and color of the two implant crowns at sites 11 and 21 as well as the open center embrasure space ("black triangle").

Fig. 5b: The oblique close-up view confirms the aforementioned problems, and additionally highlights the mid-facial exposure of the implant shoulder, including the all-ceramic abutment lying above it.

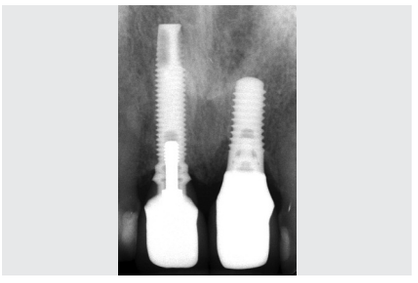


Fig. 5c: The corresponding peri-apical radiograph shows the presence of two implants replacing the missing teeth 11 and 21, featuring inconspicuous bony conditions.

Fig. 5d: In order to achieve a more harmonious and balanced whole, the treatment plan comprised the fabrication of two new implant crowns. To allow the adequate implementation of pink ceramics, the new crowns had to be splinted. After carrying out a clinical "mock-up" trial, it was decided to improve the volume, form and length of the adjacent maxillary anterior teeth with minimally invasive adhesive porcelain restorations.

Fig. 5e: On the clinical view after completion of both the new implant crowns 11 and 21 and the veneers 21 and 13, the insufficient clinical crown length of the as yet unrestored teeth 22 and 23 is noticeable. It became obvious at this stage that a surgical crown lengthening procedure was necessary, because the incisal edge position of the two teeth was adequate.

Fig. 5f: The situation after surgical crown lengthening at sites 22 and 23 now confirms more favorable conditions for the planned adhesive restorations.

Figs 5g – h: The direct comparison before (5g) and after (5h) completion of the combined adhesive and implant-based therapy documents a distinct enhancement of a previously quite compromised situation. It must be said that the patient had an ideal smile line position for this kind of restorative design, allowing optimal benefit from the addition of pink ceramics. This in turn allowed the elimination of the black triangle, as well as the re-establishment of balanced relative-tooth dimensions.

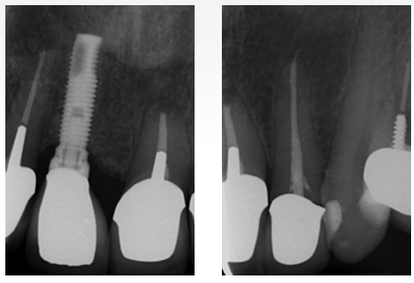
relative tooth dimensions (Fig. 5d). To further diminish the disturbing discrepancy with respect to clinical crown height between the implant restorations and the surrounding natural teeth, it was decided to apply minimally invasive ceramic veneers on the other maxillary anterior teeth. On the patient's right side this was easily possible, as it only required an increase in the incisal edges (Fig. 5e), whereas on the left side a surgical crown lengthening procedure was necessary to accomplish the envisioned treatment objective (Fig. 5f). From an esthetic point of view, the aforementioned primarily restoration-driven measures led to a treatment outcome that was now acceptable to the patient (Fig. 5g) in comparison with the severely compromised preoperative situation (Fig. 5f).

Conclusions

In the case of minor-to-moderate soft tissue deficiencies, it is recommended to achieve the goal by implementing only morphological design elements of the so-called white crown substrate. Among these one should particularly mention adequate positioning of facial transition line angles and increased interdental crown contours including long, orally located contact lines, as well as a discreetly augmented color saturation of the interproximal and cervical regions of the restoration. All these specific aspects are summarized in detail using a representative clinical example (Figs 6a - x).

However, when facing major soft tissue deficiencies, the addition of pink ceramics as an integral part of the implant

Fig. 6a: Initial frontal view of a 45-year-old female patient with a high smile line exposing an irregular soft tissue course, a mid-facial mucosal recession and chronic marginal infection with swelling at implant site 11, a missing central papilla as well as a visible crown margin at tooth 22.



Figs 6b – c: The corresponding radiographs reveal an axis problem of implant 11, endodontically treated and crowned teeth 12, 21 and 22 as well as a peri-apical chronic infection on root 21.

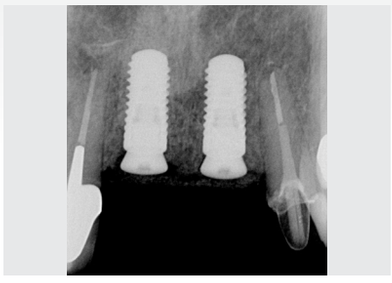


Fig. 6d: This peri-apical radiograph documents the situation after removal of implant 11 and tooth 21, followed by the staged insertion of two bone level implants according to the concept of early implant placement with simultaneous contour augmentation.

Fig. 6e: At the moment of implant impression, using an "open-try" approach, a marked soft tissue deficiency on teeth 12 and 22, primarily involving the papillary area, can be noted.

Fig. 6f: Close-up view of the palatal aspect of the working model, displaying the two directly screw-retained provisional acrylic implant crowns on titanium copings.

Fig. 6g: On the cervical part of provisional implant crowns, a flat smooth emergence profile is recommended to facilitate efficient homecare with dental floss and/or small interdental brushes.

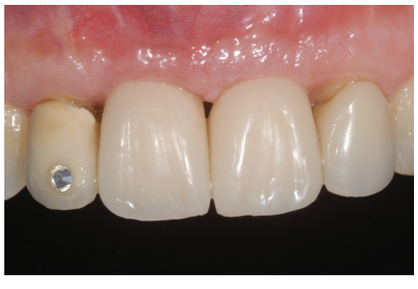


Fig. 6h: After four weeks the provisional implant restorations favorably contributed to peri-implant soft tissue conditioning and tissue maturation. The level achieved of the peri-implant mucosa on the one hand and the gingiva at the adjacent crowned teeth on the other indicates that the final implant crowns will fulfill standard esthetic expectations and that new crowns on teeth 12 and 22 are indicated to assure an acceptable overall integration.

Fig. 6i: Facial close-up view of the four all-ceramic restorations on the master model at their bisque bake stage.

Fig. 6j: The corresponding palatal aspect shows that the adequate three-dimensional implant positioning allowed application of the recommended direct screw-retention design, without interfering with the optimal incisal-edge location or causing a too voluminous cingular area.

Fig. 6k: In order to benefit from both a zirconia-based all-ceramic restoration and a titanium-to-titanium abutment-to-implant connection, a titanium bonding base termed Variobase® was chosen.

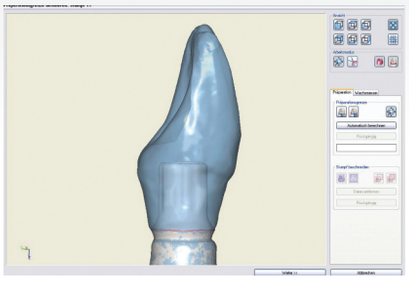


Fig. 6l: The zirconia framework, compatible with the underlying titanium bonding base, and leaving space for minimal final hand layering of cosmetic veneering ceramics, was determined virtually at the computer screen.

Figs 6m – n: Comparison of the two-component titanium-ceramic implant restoration before (6m) and after (6n) provisional assembly. This temporary assembly is necessary to permit a clinical trial at the bisque bake stage.

Fig. 6o: During the clinical bisque bake try-in, the need for minute modifications in color, form and volume can be identified and photographically documented for efficient communication with the dental ceramist.

Figs 6p – q: Facial (6p) and palatal (6q) close-up views of the finalized implant- and tooth-borne all-ceramic restorations. Note in particular the position of the facial transition line angles and the long interdental contact zones.

Fig. 6r: The clinical view of the four final maxillary restorations in maximum intercuspation position confirms a favorable overall integration in terms of form and color.

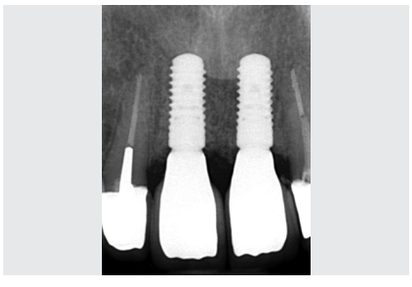


Fig. 6s: The corresponding peri-apical radiograph reveals optimal peri-implant bony conditions as well as minimal uniform support for the veneering ceramic provided by an optimally designed zirconia framework.

Fig. 6t: The oblique close-up view permits the design features that were instrumental in compensating the existing moderate vertical soft tissue deficiencies to be highlighted: (i) position and morphology of the facial transition line angles, (ii) long, palatally located interdental contact zones, and (iii) discreet color saturation of the cervico-interproximal crown surfaces as well as the achievement of (iv) healthy soft tissues.


Figs 6u – v: The direct comparison of the clinical situation before (6u) and after (6v) treatment shows the marked improvement, particularly in terms of a harmoniously scalloped soft tissue course without abrupt changes in vertical position between adjacent teeth and implants, an absence of open embrasures ("black triangles"), and last but not least a favorable degree of balanced relative tooth dimensions.


Figs 6w – x: Similarly, the direct comparison of what is exposed of the anterior maxilla during the patient's unforced smile before (6w) and after (6z) the described combined implant- and tooth-borne restorative treatment documents satisfying overall esthetic integration.

restoration may become unavoidable to achieve a clinically acceptable result. In this context one must also take into consideration the position of the patient's individual smile line as an important decision-making parameter. Finally, one has to ensure that the widely established design rules for the use of pink ceramics such as convex profile and access for plaque control are strictly enforced in order not to jeopardize peri-implant tissue health.

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