



Three-Dimensional Bone and Soft Tissue Requirements for Optimizing Esthetic Results in Compromised Cases with Multiple Implants



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Achieving an esthetic outcome in tooth replacement and implant treatment requires a **proper tooth shape and stable surrounding soft tissue profiles**. Bone augmentation is considered vital to support the esthetic soft tissue profile around definitive restorations. To prevent recession of the peri-implant soft tissue in cases with multiple implants, **buccal bone augmentation of more than 2 mm** from the implant platform is necessary to overcome the normal pattern of bone remodeling. **Drawing an imaginary horizontal line spanning the space between the remaining healthy interproximal bone peaks is the most reliable vertical augmentation target to create esthetic papillae around an implant prosthesis**. Provided that the adjacent bone peaks are at an ideal height and the bone is **augmented vertically up to this line**, the accepted general guideline of **2 to 3 mm of interproximal vertical bone augmentation from ideally placed implant platforms will invariably also be achieved**. In addition, **placing pontics in strategic positions to avoid consecutively placed implants has been suggested to facilitate vertical bone height preservation after bone augmentation**. Even with esthetically successful results, there have been very few long-term studies on compromised cases with multiple implants. This will become more and more critical over time and must be remedied. (Int J Periodontics Restorative Dent 2010;30:503–511.)

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Dental implant treatment should always be performed with esthetics in mind¹; this requires proper tooth shape and stable surrounding soft tissue profiles. In single-tooth implants, interdental papillae are restored predictably by maintaining the health of the adjacent periodontium.² Alternatively, **in cases with multiple implants, the peri-implant soft tissue is guided and shaped by the restoration and supported by the bone foundation**. Restoring soft tissue esthetics in cases with multiple implants remains a great challenge,³ since **bone remodeling and resorption occur at the implant-abutment junction and peri-implant soft tissue does not share the natural tooth's attachment apparatus and blood supply**.⁴ In this article, the concepts behind achieving esthetic and functional implant restorations and the necessary three-dimensional peri-implant hard and soft tissue management required to realize these goals are discussed.



Fig 1 Relationship between the natural morphology and implant position. Midbone crest to interproximal bone crest (blue) = 3 mm; free gingival margin to midbone crest (green) = 3 mm; free gingival margin to implant platform (red) = 2 to 3 mm; implant platform to interproximal bone crest (yellow) = 2 to 3 mm.

Three-dimensional bone augmentation

Horizontal parameters

It has been found that between 1.3 and 1.4 mm of horizontal bone resorption⁵ and 1.5 to 2.0 mm of vertical bone resorption⁶ occur at the implant-abutment junction. This could result in total soft tissue volume loss, gingival recession, and subsequent esthetic problems in the labial and interproximal areas. To maintain esthetic results and prevent future soft tissue recession, Grunder et al⁷ recommended augmenting the labial bone foundation beyond the implant platform by at least 2 to 4 mm to adequately compensate for the natural bone remodeling that occurs following restoration and loading.

The routine procedures involved in implant site osteotomy and placement are traumatic to the hard tissue. In a worst-case scenario, if alveolar bone thickness is not adequate, implant placement could lead to the total loss of bone, especially on the labial aspect of the ridge.⁸ In cases with multiple implants, supporting the ideal crown form and soft tissue profile requires at least 2 mm of labial bone foundation from the implant platform. To support the ideal crown form and soft tissue profile, the implant

platform is usually placed 1 to 2 mm lingual to the future gingival margin.⁹ Therefore, the bone should be more buccal than the future gingival margin (> 2 mm). This should establish maintainable facial bone support for the stability of the labial soft tissue profile.

Additionally, after bone augmentation, the mucogingival junction often moves in a coronal direction, and the soft tissue thickness over the barrier membrane is reduced because of the compromised blood supply to the area.¹⁰

Berglundh and Lindhe¹¹ reported that when peri-implant soft tissue thickness was reduced intentionally to less than 2 mm in dogs, bone resorption occurred around the implant to reestablish a 3-mm peri-implant soft tissue thickness. Kan et al¹² found that a thick biotype maintained better peri-implant soft tissue height at all measuring points on the labial and interproximal surfaces. Jung et al¹³ reported that mucosal thickness is a crucial factor in terms of the discoloration caused by different restorative materials.

It would therefore appear that soft tissue augmentation is advisable after bone augmentation, not only because of the gain in keratinized tissue and soft tissue thickness, but also to maintain the regenerated bone and tissue color for optimal esthetics.

Vertical parameters

In natural teeth, crestal bone height typically follows the cemento-enamel junction, approximately 3 mm apical to the proximal surfaces in relation to the facial.¹⁴ The biologic width at the facial aspect is approximately 3 mm.¹⁵ To allow for adequate prosthetic space, implants should be placed 2 to 3 mm apical to the free gingival margin at the facial aspect.¹⁶ An ideally placed implant platform would then be 2 to 3 mm apical to the interproximal height of bone because of the flat nature of the typical implant platform (Fig 1). Hence, in cases with single and multiple implants, the vertical bone height in the proximal area is suggested to be 2 to 3 mm coronal to the implant platform, which is the ideal position.

For multiple implants, papillae are created by a combination of prosthetic components and adequate vertical bone support. To create esthetic papillae around an implant prosthesis, the most reliable vertical augmentation target is achieved by drawing an imaginary horizontal line spanning the space between the remaining healthy interproximal bone peaks. Provided that the adjacent bone peaks are at an ideal height and the bone is augmented vertically up to this line, the accepted general

Fig 2 (left) The maxillary right central incisor and left central incisor, lateral incisor, and canine were lost because of infection, resulting in significant vertical and horizontal tissue loss.



Fig 3 (right) Periapical radiograph showing the degree of vertical bone loss. Because of limited space, the four lost teeth were to be replaced with three crowns.

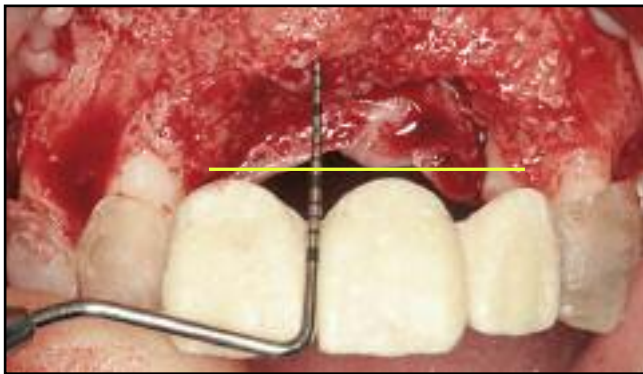


Fig 4 Nine millimeters of bone augmentation was necessary to reconstruct a bone ridge up to the imagined horizontal line connecting the adjacent bone peaks (yellow).



Fig 5 Three implants (Prevail 4/3 x 13 mm, Biomet 3i) were placed in their ideal positions, maintaining interimplant distances of more than 3 mm.

guideline of 2 to 3 mm of interproximal vertical bone augmentation from ideally placed implant platforms will invariably also be achieved.

Unfortunately, some degree of resorption will always be experienced clinically. Dahlin et al¹⁷ found that using a combination of 3-mm abutments, bovine hydroxyapatite, and membranes to augment interproximal bone

and optimize the papillae appearance ultimately preserved an esthetic result at 5 years, even after the unavoidable ridge resorption (Figs 2 to 10).

When there is significant attachment loss present, restoring the bone level on adjacent teeth through orthodontic extrusion may be required prior to vertical bone augmentation.¹⁸

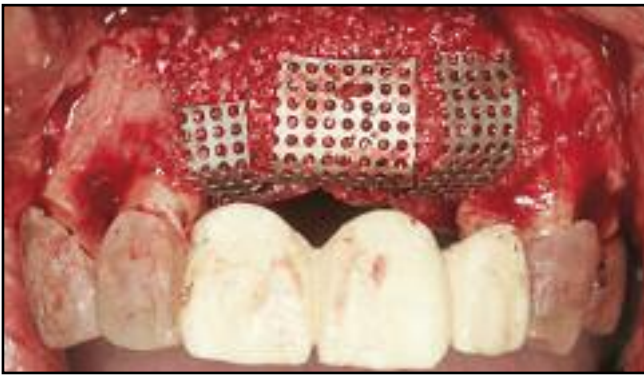


Fig 6 Autogenous bone particles mixed with Bio-Oss (Geistlich) and soaked in recombinant human platelet-derived growth factor were held in place by titanium mesh. The three implants acted as a support for the graft and mesh. A cross-linked collagen membrane was used as a barrier.



Fig 7 The implants were completely covered with regenerated tissue 7 months later. However, an additional 2 to 3 mm of vertical augmentation was necessary to achieve an esthetic outcome.



Fig 8 Vertical augmentation was accompanied by a 4-mm buccal horizontal augmentation and a 3-mm lingual horizontal augmentation.

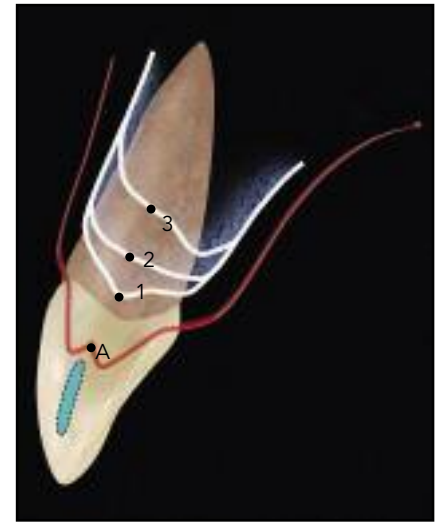


Fig 9 Secondary guided bone regeneration was performed to reconstruct the optimal interproximal height of bone. Three healing abutments were used to support the titanium mesh.



Fig 10 An interpositional subepithelial connective tissue graft was performed to correct the displaced mucogingival junction and to acquire optimal soft tissue thickness.

Fig 11 Classification of the interproximal height of bone. **Class 1:** Optimal prognosis for achieving soft tissue esthetics (2 mm from the cemento-enamel junction [CEJ] in conventional restorative dentistry or 4 to 5 mm from the apical extent of the future contact point [A] in implant therapy). **Class 2:** Guarded prognosis; restorative intervention may be required to position the contact point apically (4 mm from the CEJ in conventional restorative dentistry or 6 to 7 mm from point A in implant therapy). **Class 3:** Poor prognosis (greater than 5 mm from the CEJ in conventional restorative dentistry or greater than 7 mm from point A in implant therapy) (reprinted from Salama et al²⁰ with permission).



Class	Restorative environment	Proximity limitations (mm)	Vertical soft tissue limitations (mm)
1	Tooth-tooth	1.0	5.0
2	Tooth-pontic	NA	6.5
3	Pontic-pontic	NA	6.0
4	Tooth-implant	1.5	4.5
5	Implant-pontic	NA	5.5
6	Implant-implant	3.0	3.5

NA = not applicable.

Strategic pontic placement

If implants are placed at a distance of less than 3 mm, the bone height between them will be reduced as bone remodeling occurs, and the related papilla height between them will also be reduced. Scarano et al¹⁹ measured the distance necessary to diminish bone resorption between implants. They reported that maintaining a 5-mm interimplant distance resulted in no significant bone resorption, but as the interimplant distance decreased, the amount of bone resorption increased accordingly.

Salama et al²⁰ reported the three classifications of interproximal bone support (Fig 11) and the classification of predicting the height of interdental papillae in six different fixed restorative environments (Table 1).²¹ Implant-to-implant papillae showed the lowest vertical height, while implant-to-pontic papillae maintained a comparatively superior vertical height. Salama et al concluded that in multiple tooth replacement, the distance between the interproximal height of bone and the proximal crown contact point may vary from 3.5 to 6.5 mm, depending on the type of restoration selected.



Fig 12 Final treatment outcome. This patient had a **high smile line**, so establishing a truly esthetic soft tissue frame necessitated the creation of natural tissue over the entire restoration area.



Fig 13 A natural-looking keratinized soft tissue frame was achieved using a **subepithelial connective tissue graft**.

Tarnow et al²² measured the height of interimplant papillae and reported the **mean papillae height between two implants was 3.4 mm**, with 3- and 4-mm-high papillae representing 72.8% of the total sites evaluated.

To create adequate papillae form between adjacent implants, **the ideally augmented interproximal bone height should be 3.5 mm from the projected final restorative contact area**, although this is impossible to maintain clinically.

In cases with multiple implants, **it is suggested that placing a pontic in a strategic position is better than placing adjoining implants**, since this would minimize the loss of vertical bone height resulting from crestal bone remodeling and facilitate greater soft tissue height in the proximal area.^{21,23}

Even if papillae heights between varied restorative environments are different, **the clinician can merely aim to achieve the vertical bone augmentation standard of a solid bone frame connecting the two adjacent bone peaks**. Therefore, in a clinical reality, the papillae **must be adjusted** using manipulation of the subgingival contour of the abutment and the crown. The **crown contour can also be modified supragingivally to create acceptable embrasure spaces** (Figs 12 to 14).

Platform switching,²⁴⁻²⁶ Laser-Lok microchannels,²⁷ one-piece implants, and reducing the numbers of abutment try-ins²⁸ has also been postulated to reduce bone resorption at the implant-abutment junction and maintain **long-term soft tissue stability**.

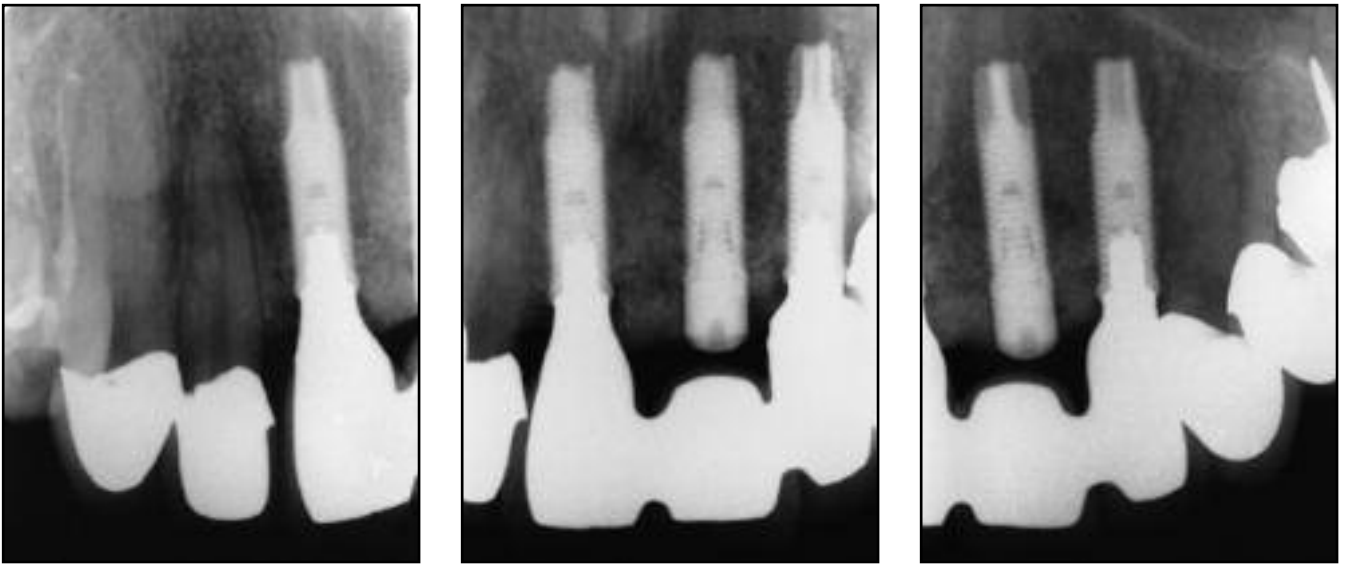


Fig 14 Periapical radiograph taken 2 years after the implants became functional. Regenerated tissue height was preserved by using a strategically placed pontic instead of all three neighboring implants. Platform switching seems to have had a positive effect on the bone preservation around the functioning implants.

Using the same procedures and concept, very similar results have been achieved in multiple patients.²⁹

Conclusion

To achieve an esthetic outcome in cases with multiple implants, augmentation of the vertical and horizontal bone foundation and the gingival tissue is critical to overcome the bone remodeling that occurs at the implant platform level. Selecting better prosthetic environments (avoiding adjacent implants), reducing the number of times that abutments need to be removed and reinserted, as well as using one-piece implants, micro-grooves, and platform switching, may

all eventually provide assistance in maintaining bone and soft tissue height around implants. Soft tissue augmentation is often necessary simultaneous to or after bone augmentation, not only for gaining adequate keratinized tissue and soft tissue thickness, but also in maintaining regenerated bone and esthetic contours of the definitive restoration. Even with successful results, we must keep in mind that there have been very few long-term studies regarding the esthetic results of compromised multiple implants. This is a factor that will become more and more critical over time and must be remedied.

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