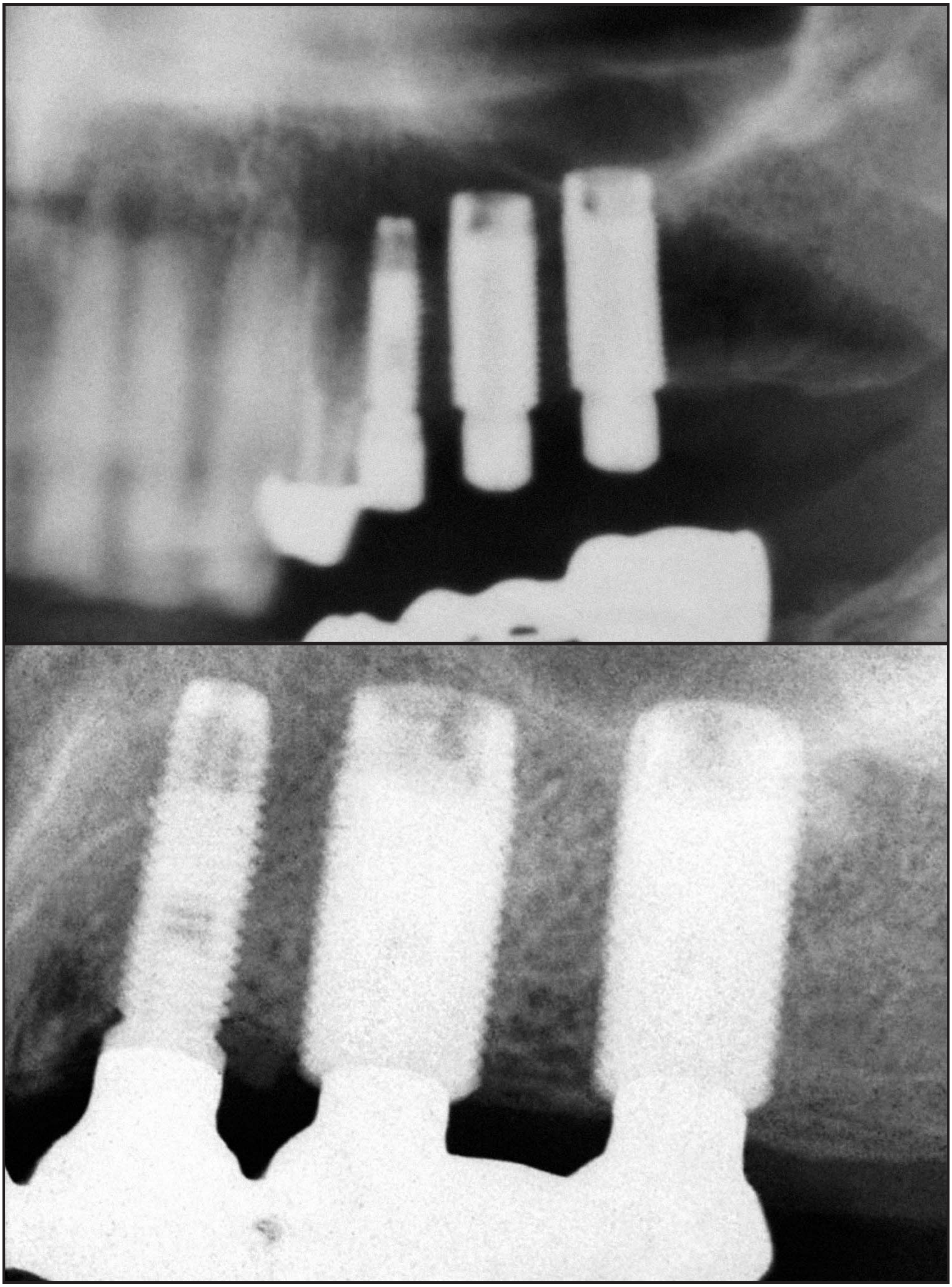

Platform Switching: A New Concept in Implant Dentistry for Controlling Postrestorative Crestal Bone Levels

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Histologic and radiographic observations suggest that a biologic dimension of hard and soft tissues exists around dental implants and extends apically from the implant-abutment interface. Radiographic evidence of the development of the biologic dimension can be demonstrated by the vertical repositioning of crestal bone and the subsequent soft tissue attachment to the implant that occurs when an implant is uncovered and exposed to the oral environment and matching-diameter restorative components are attached. Historically, two-piece dental implant systems have been restored with prosthetic components that locate the interface between the implant and the attached component element at the outer edge of the implant platform. In 1991, Implant Innovations introduced wide-diameter implants with matching wide-diameter platforms. When introduced, however, matching-diameter prosthetic components were not available, and many of the early 5.0- and 6.0-mm-wide implants received "standard"-diameter (4.1-mm) healing abutments and were restored with "standard"-diameter (4.1-mm) prosthetic components. Long-term radiographic follow-up of these "platform-switched" restored wide-diameter dental implants has demonstrated a smaller than expected vertical change in the crestal bone height around these implants than is typically observed around implants restored conventionally with prosthetic components of matching diameters. This radiographic observation suggests that the resulting postrestorative biologic process resulting in the loss of crestal bone height is altered when the outer edge of the implant-abutment interface is horizontally repositioned inwardly and away from the outer edge of the implant platform. This article introduces the concept of platform switching and provides a foundation for future development of the biologic understanding of the observed radiographic findings and clinical rationale for this technique. (Int J Periodontics Restorative Dent 2006;26:9–17.)

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The resulting crestal bone levels around dental implants following restoration has been a topic of discussion and used as a reference for evaluating implant success for many years.[1] Small changes in crestal bone height following implant restoration, however, have not negatively affected long-term implant success in most cases. The implant literature contains numerous articles describing the 1-year postrestorative bone levels around threaded dental implants. These articles report that crestal bone levels are typically located approximately 1.5 to 2.0 mm below the implant-abutment junction (IAJ) at 1 year following implant restoration[1] but are dependent upon the location of the IAJ relative to the bony crest.[2,3]

Several theories exist as to the reason for the observed changes in crestal bone height following implant restoration. The radiographic observation that postrestorative "remodeled" crestal bone generally coincides with the level of the first thread on most standard 3.75- and 4.0-mm implants has led some authors to suggest that when dental implants are placed into function, crestal bone remodels as a result

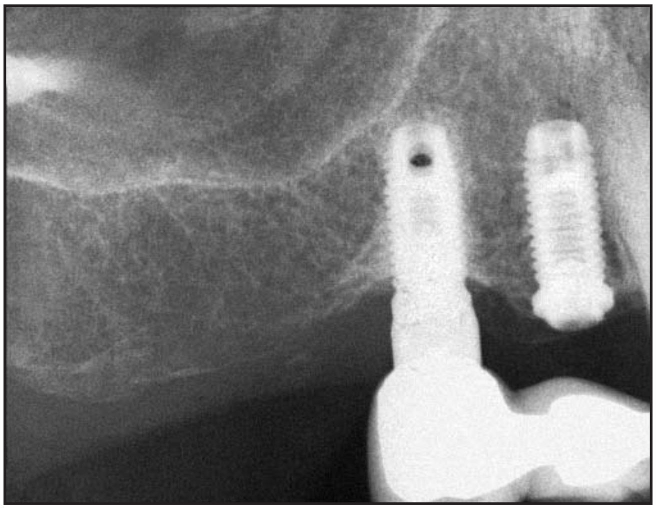


Fig 1 *Eleven-year follow-up demonstrates crestal bone remodeling to approximately the first thread on the restored and functioning implant, with no radiographic crestal bone change observed around the mesial implant, which is still covered with soft tissue.*

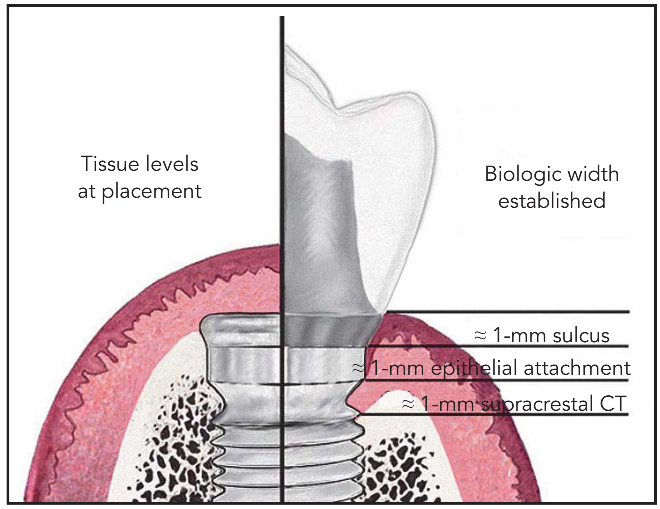


Fig 2 *Crestal bone level around a nonrestored, covered, two-stage implant placed subcrestally* (left)*; and the postrestorative crestal bone level located at the first thread on a threaded dental implant approximately 1.5 mm apical to the implant-abutment junction* (right). *CT = connective tissue.*

of stress concentration at the coronal region of the implant.[4] Other authors have suggested that postrestorative crestal bone remodeling is a result of localized inflammation within the soft tissue located at the implant-abutment interface[5,6] and is a consequence of the soft tissue's attempt to establish a mucosal barrier, ie, biologic width (seal) around the top of the dental implant.

Historically, the standard surgical protocol that is recommended for placing two-stage, threaded, straight-walled, external-hex implants requires positioning the implant platform approximately 1.0 mm below the bony crest to allow for the top of the cover screw to be level with the bone crest during the healing period. With this protocol, it can be observed radiographically that as long as the soft tissue covering the implant remains closed (sealed) during healing, crestal bone remodeling does not typically occur around the top of the submerged implant, and the height of the surrounding crestal bone remains at presurgical levels. However, when second-stage surgery is performed or if the implant becomes prematurely exposed to the oral environment and bacteria, crestal bone changes occur at the coronal aspect of the implant. To create adequate space for the biologic soft tissue seal and attachment of the soft tissue to the stable implant top, crestal bone remodeling occurs to approximately the first thread, 1.5 to 2.0 mm apical to the IAJ. The image in Fig 1 illustrates the radiographic appearance of crestal bone remodeling to approximately the first thread following implant uncovering and restoration.

The same biologic bone remodeling process that occurs around a two-stage dental implant beginning when the implant is uncovered can also be observed radiographically when a one-stage surgical procedure is used with a two-stage implant system, ie, when a healing abutment or prosthetic component is attached to the implant immediately after implant placement. However, unlike the delayed formation of the biologic width that is observed following exposure of an implant in a two-stage surgical approach (Fig 2), the one-stage surgical technique exposes the IAJ to the oral environment immediately following implant placement and abutment connection. As a result, crestal bone remodeling begins immediately.

In a series of studies using a dog model, Hermann et al[2,3,7,8] described the biologic response of crestal bone around the top of a two-piece dental implant following abutment connection and demonstrated that crestal bone remodels to a level approximately 2.0 mm apical to the IAJ. The authors reported that following implant exposure and abutment connection, the distance between the IAJ and the resulting remodeled crestal bone position along the surface of the implant remained relatively constant, regardless of the original vertical position of the IAJ in relation to the original level of the bony crest. Hermann et al,[8] Todescan et al,[9] and Piattelli et al[10] have demonstrated that when the IAJ is positioned deeper within bone, the resulting loss of vertical crestal bone height increases; however, the newly formed crestal bone position remains approximately 2.0 mm apical to the IAJ. Of particular significance is that Hermann et al[8] demonstrated that the formation of the approximate 2.0-mm distance between the IAJ and the newly formed crestal bone location remained constant even when a bone-loading surface that had been sandblasted and acid etched extended coronally to within 0.5 mm of the IAJ. This observation provides direct evidence that the biologic process resulting in the formation of the biologic dimension and position of hard and soft tissues around a dental implant has a greater capacity to influence and direct the bone remodeling process than does the ability of a bone-loading implant surface to resist the resorptive process of crestal bone remodeling that results from the biologic attempt to create adequate space for soft tissue attachment to the implant.

Berglundh and Lindhe,[11] after investigating the dimension of the peri-implant mucosa in a beagle dog model, concluded that a certain minimum width (approximately 3 mm) of peri-implant mucosa was required to create a mucosal barrier around a dental implant and that crestal bone resorption occurred to allow for the formation of a minimum dimension of soft tissue attachment to the implant. Abrahamsson et al[12] reported that, following repeated removal and reconnection of an abutment, the most coronal portion of the peri-implant soft tissue attachment was located slightly apical to the IAJ. The authors explained that the repeated removal and reconnection of the abutment may have created a wound within the soft tissue and that the crestal bone resorption that they observed may have been a consequence of the soft tissue's attempt to establish a proper biologic dimension of mucosal barrier attachment to a stable implant surface. In addition, Berglundh and Lindhe[11] reported that when the soft tissue surrounding an implant is intentionally made thin (ie, 2 mm or less), more crestal bone loss is observed. This observation supports the theory that peri-implant mucosa has a minimum thickness (approximately 3 mm) and that the body attempts to re-establish this minimum soft tissue dimension. The loss of crestal bone height following tissue thinning and crown-lengthening procedures around teeth has also been reported and suggests that the crestal bone remodeling process is a biologic response to create space

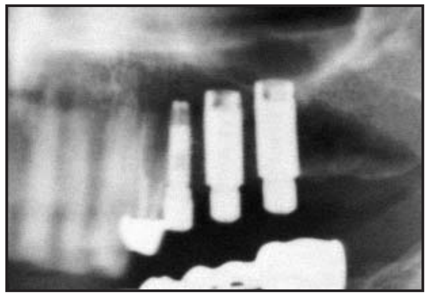
Fig 3 *Platform switching is demonstrated. A 0.95-mm circumferential horizontal mismatch in dimension is created when a 4.1-mm-diameter prosthetic UCLA abutment is placed on a 6.0-mm-diameter implant with matching 6.0-mm-diameter platform.*

for new attachment of supracrestal fibers to the tooth.[13,14] Thus the bone remodeling process around the coronal aspect of a two-stage dental implant and the subsequent development of a biologic width and soft tissue attachment to the implant appear to have a similar barrier function as the soft tissue attachment around teeth, as described by Waerhaug,[15] who reported similar dimensions.

Ericsson et al[5] described histologically the peri-implant tissues around a two-piece dental implant system in the dog model. The authors quantified the dimension and location of the gingival sulcus, the epithelial attachment, and the connective tissue above the bone-implant connection. Two types of inflammatory lesions were observed in the peri-implant soft tissues. One was associated with the gingival sulcus, which they termed the "plaque-associated" inflammatory cell infiltrate (P/ICT), and the second lesion was a 1.0- to 1.5-mm (apicocoronal) zone of inflammatory cell infiltrate associated with the IAJ, which they termed the "abutment" inflammatory cell infiltrate (abutment ICT). The authors report that the peri-implant bone crest was consistently located 1.0 to 1.5 mm apical to the IAJ and that the apical border of the abutment ICT was always separated from the bone crest by approximately 1.0 mm of healthy connective tissue. This indicates that once the biologic dimension is established, the soft tissue seal and attachment to the dental implant provides a protective function to isolate crestal bone from the oral environment. Of interest is that the 0.94-mm dimension of P/ICT at the base of the subgingival plaque front around extracted teeth, as reported by Waerhaug,[15] is of a similar dimension to the overall 0.5- to 0.75-mm coronal and 0.5- to 0.75-mm apical extension of the abutment ICT, as reported by Ericsson et al.[5]

Historically, the resulting 1-year postrestorative repositioned crestal bone level (approximately 1.5 mm apical to the IAJ or at the first thread) has been used as one of the criteria for success of a dental implant.[1,16] Importantly, the literature describing postrestorative crestal bone positions is based on a vertically coordinated implant-abutment relationship (ie, the abutment component and implant seating surface have matching diameters). This matching implant-abutment diameter positions the abutment ICT, as described by Ericsson et al[5] and Abrahamsson et al,[6,12] at the outer edge of the IAJ and in direct approximation to the crestal bone at the time of abutment connection surgery. The close proximity of the abutment ICT to bone may explain in part the biologic and radiographic observation of crestal bone loss around exposed and restored two-piece dental implants.

The following is a description of radiographic observations made over a 13-year period resulting from the placement of smaller-diameter healing and prosthetic components on wider-diameter implants. The authors have termed the inward horizontal repositioning of the IAJ "platform switching" (Fig 3). A description and hypothesis supporting the radiographic observation that little or no crestal bone loss occurs with platform switching is presented.



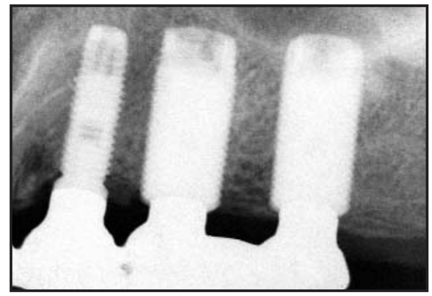
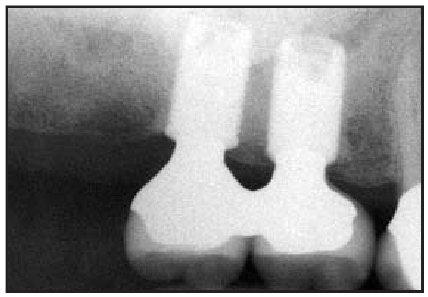


Fig 4a (left) *A 4.0-mm-diameter implant and two 6.0-mm-diameter implants with 4.1-mm-diameter healing abutments attached.*

Fig 4b (right) *Ten-year follow-up illustrating platform switching on the two 6.0-mm-diameter implants with the use of 4.1-mm-diameter prosthetic components. Note that the level of crestal bone around the 6.0-mm-diameter implants approximates the level of the implant platform; compare to the anterior implant, where the bone level is at the expected first thread.*



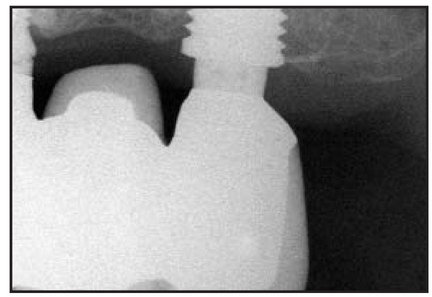


Fig 5 (left) *Ten-year follow-up of two 6.0-mm-diameter implants that were platform switched with 4.1-mm-diameter prosthetic components. Note that the level of crestal bone around both implants approximates the level of the implant platform.*

Fig 6 (right) *Five-year follow-up of a 5.0-mm-diameter implant* (right) *that was platform switched with a 4.1-mm prosthetic abutment. Note that the level of crestal bone on the distal aspect of the implant is at approximately the level of the implant seating surface, while the mesial crestal bone level has remodeled to slightly above the first implant thread as a result of reduced (< 3 mm) soft tissue height.*

Summary of radiographic observations

Altering the horizontal relationship between the outer edge of the implant and the attached, smaller-diameter component seems to reduce or eliminate the expected postrestoration crestal bone remodeling that is typically observed around a two-piece implant. The reduced vertical crestal loss of bone was first noticed, coincidently, on the Implant Innovations (3i) wide-diameter implants. Introduced in 1991, the 3i wide-diameter 5.0- and 6.0-mm implants were designed with a matching 5.0- and 6.0-mm-diameter seating surface. These wide-diameter implants were used mainly as replacement implants when standard-diameter (3.75-mm) implants failed to integrate or in areas of poor quality bone in an attempt to achieve improved primary stability. However, when introduced, there were no matching wide-diameter prosthetic components available, and as a result, most of the initially placed wide-diameter implants were restored with standard 4.1-mm-diameter components. The dimensional mismatch between the implant seating surface diameter and the diameter of the prosthetic component creates either a 0.45-mm (4.1-mm prosthetics/5.0-mm implant platform) or a 0.95-mm (4.1-mm prosthetics/6.0-mm implant platform) circumferential horizontal difference in dimension between the implant seating surface and the attached component. The radiographs in Figs 4a, 4b, 5, and 6 show implant-supported prostheses restored with reduced-diameter prosthetic components, resulting in circumferential horizontal dimensional variances of 0.45 mm and 0.95 mm.

Upon reviewing radiographs of patients in whom platform switching has been used, after an initial 5-year period, it is observed that the crestal bone lateral to implants with the circumferential dimensional difference appears to respond differently than what is typically observed when implants are restored with matching-diameter components. What is typically observed, but with some vari-

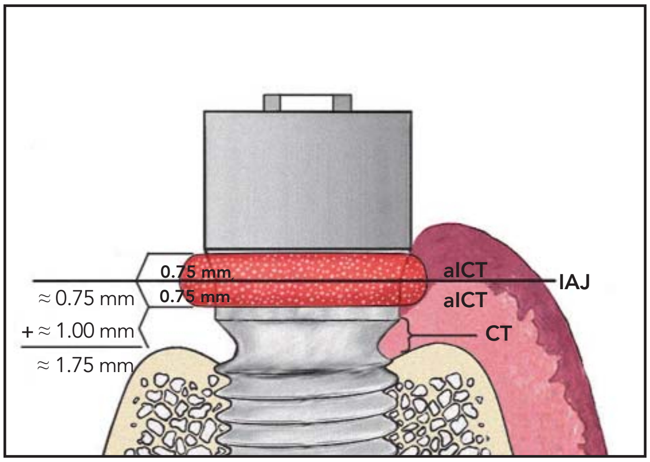


Fig 7 *Composite approximation of soft tissue interface dimensions according to Ericsson et al[5] and Abrahamsson et al.[6,12] IAJ = implant-abutment interface; aICT = 1.5-mm abutment inflammatory cell infiltrate (0.75 mm above IAJ to 0.75 mm below IAJ); CT = zone (approximately 1.0 mm) of healthy connective tissue between the base of aICT and bone.*

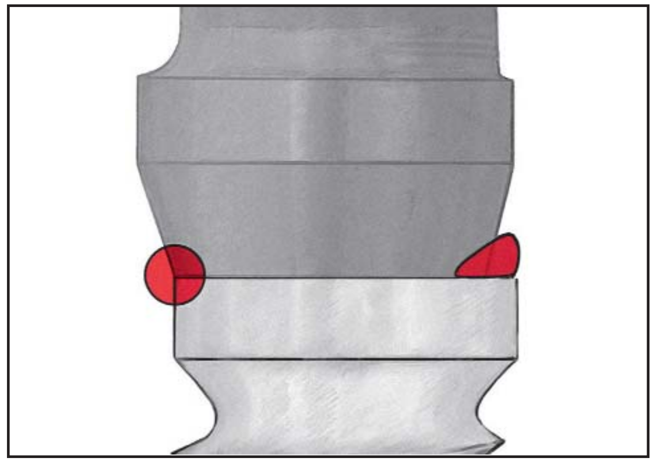
ance, is that when matching-diameter implant and restorative components are used in the fabrication of the definitive restoration, the crestal bone contacting the implant normally remodels 1.5 to 2.0 mm apically, to approximately the first implant thread. The same result is observed radiographically when an implant is uncovered and a matching-diameter healing abutment is attached and remains in place for several months. This observation indicates that the crestal bone remodeling process is not dependent upon an implant being placed into function, but rather its exposure to the oral environment. In contrast, when smaller-diameter components are placed on wider-diameter implant platforms, the amount of crestal bone remodeling is noticeably reduced, with many platform-switched restored implants exhibiting no vertical loss in crestal bone height.

Biologic rationale for platform-switching observation

A partial explanation as to why there appears to be little or no crestal bone remodeling following platform switching is as follows.

Studies have demonstrated that a minimum thickness of approximately 3 mm of soft tissue is necessary to allow for the formation of a biologic seal around the top of a two-stage dental implant and that crestal bone will resorb in an attempt to create the space necessary for soft tissue attachment. Additionally, Berglundh and Linde[11] and Ericsson et al[5] observed in histologic sections of crestal bone and soft tissue that crestal bone is always separated from the base of the abutment ICT by an approximate 1-mm-wide zone of healthy connective tissue, as depicted in Fig 7.

Fig 8 *Amount of exposure the abutment ICT will have with the surrounding bone and soft tissue when positioned at the outer edge of the implant* (left). *In contrast, the inward, horizontal repositioning of the abutment ICT* (right) *will move the abutment ICT away from the crestal bone and into a more confined area.*



There appear to be two results of the horizontal inward repositioning of the implant-abutment interface. First, with the increased surface area created by the exposed implant seating surface, there is a reduction in the amount of crestal bone resorption necessary to expose a minimum amount of implant surface to which the soft tissue can attach. Second, and perhaps more important, by repositioning the IAJ inward and away from the outer edge of the implant and adjacent bone, the overall effect of the abutment ICT on the surrounding tissue as described by Ericsson et al[5] and Abrahamsson et al[6,12] may be reduced, thus decreasing the resorptive effect of the abutment ICT on crestal bone. It is further suggested that platform switching repositions the abutment ICT further away from crestal bone and locates the inflammatory infiltrate within an approximate ≤ 90-degree confined area of exposure instead of a ≤ 180-degree area of direct exposure to the surrounding hard and soft tissues, as depicted in Fig 8. As a consequence, the reduced exposure and confinement of the platform-switched abutment ICT may result in a reduced inflammatory effect within the surrounding soft tissue and crestal bone.

It is theorized by the authors that these related mechanical and biologic concepts may explain in part the 13-year radiographic observation of reduced or no bone loss around implants that have used the platform-switching technique. However, it is important to note that to benefit from the platform-switching bone preservation technique, reduced-diameter components, beginning with the healing abutment, must be used from the moment that the implant is exposed to the oral environment, because the process of biologic width formation begins immediately following exposure to the oral environment. Thus, whether an implant is placed using a one- or two-stage surgical procedure, the first component placed on the implant must be of a smaller diameter if a horizontally repositioned biologic width is to be accomplished. This is important because after crestal bone has remodeled to a postrestorative resting position around the top of an implant, it will not return to its presurgical level if platform-switching principles are implemented at a later time.

Discussion

Much discussion has occurred regarding postrestorative radiographic crestal bone levels and the reasons for the observed changes. After an implant is exposed to the oral environment, bone remodels downward along the implant body and then stops at some predefined position. Such changes in crestal bone height have been attributed to implant loading and concentration of forces, the countersinking procedure during implant placement procedures, and localized soft tissue inflammation, among other reasons. The distance between the IAJ and the remodeled crestal bone following second-stage surgery has been shown to be consistent in several animal and human clinical studies, regardless of the original position of the IAJ in relation to the bone crest. This observation is so consistent, in fact, that it became a part of the accepted implant success criteria, reported by Albrektsson et al[1] and Smith and Zarb.[16] There is evidence that the IAJ is one of the primary controllers of postrestoration crestal bone position; however, soft tissue thickness (minimum of 3 mm), the position of the abutment ICT, and the implant surface itself also seem to play roles in determining the final postrestorative crestal bone position. It is suggested, therefore, that the factors controlling crestal bone levels around dental implants, in order of importance, are as follows:

1. A minimum of 3 mm of soft tissue, which is necessary for the formation of a biologic seal without an increased loss of crestal bone height
2. The position of the abutment ICT and its proximity to crestal bone
3. The implant surface topography

Conclusions

Platform switching is a method for preserving crestal bone around the top of wide-diameter implants and seemingly alters the starting point from which crestal bone remodeling occurs. Platform switching provides the clinician with additional surgical and prosthetic treatment options for use with wide-diameter implants. During a 13-year observation period, greater crestal bone loss has never been observed with platform-switched restorations than would be expected with two-piece dental implants restored conventionally with matching-diameter components. The clinical benefits of platform switching will be discussed in a subsequent article. The technique of platform switching as illustrated by the authors requires additional studies to establish the biologic process(es) responsible for the observed positive radiographic findings.

References

1. Albrektsson T, Zarb G, Worthington P, Eriksson AR. The long-term efficacy of currently used dental implants: A review and proposed criteria for success. Int J Oral Maxillofac Implants 1986;1:11–25.
2. Hermann JS, Cochran DL, Nummikoski PV, Buser D. Crestal bone changes around titanium implants. A radiographic evaluation of unloaded nonsubmerged and submerged implants in the canine mandible. J Periodontol 1997;68:1117–1130.
3. Hermann J, Buser D, Schenk RK, Schoolfield JD, Cochran DL. Biologic width around one- and two-piece titanium implants. A histometric evaluation of unloaded nonsubmerged and submerged implants in the canine mandible. Clin Oral Implants Res 2001;12:559–571.
4. Pillar RM, Deporter DA, Watson PA, Valiquette N. Dental implant design: Effect on bone remodeling. J Biomed Mater Res 1991;25:467–483.
5. Ericsson I, Persson LG, Berglundh T, Marinello CP, Lindhe J, Klinge B. Different types of inflammatory reactions in peri-implant soft tissues. J Clin Periodontol 1995;22:255–261.
6. Abrahamsson I, Berglundh T, Linde J. Soft tissue response to plaque formation at different implant systems. A comparative study in the dog. Clin Oral Implants Res 1998;9:73–79.
7. Hermann JS, Schoolfield JD, Schenk RK, Buser D, Cochran DL. Influence of the size of the microgap on crestal bone changes around titanium implants. A histometric evaluation of unloaded non-submerged implants in the canine mandible. J Periodontol 2001;72:1372–1383.
8. Hermann JS, Schoolfield JD, Nummikoski PV, Buser D, Schenk RK, Cochran DL. Crestal bone changes around titanium implants: A methodologic study comparing linear radiographic with histometric measurements. Int J Oral Maxillofac Implants 2001;16:475–485.
9. Todescan F, Pustiglioni F, Imbronito A, Albrektsson T, Gioso M. Influence of the microgap in the peri-implant hard and soft tissues: A histomorphometric study in dogs. Int J Oral Maxillofac Implants 2002;17:467–472.
10. Piattelli A, Vrespa G, Petrone G, Lezzi G, Annibali S, Scarano A. Role of the microgap between implant and abutment: A retrospective histologic evaluation in monkeys. J Periodontol 2003;74:346–352.
11. Berglundh T, Lindhe J. Dimension of the periimplant mucosa. Biologic width revisited. J Clin Periodontol 1996;23:971–973.
12. Abrahamsson I, Berglundh T, Lindhe J. The mucosal barrier following abutment dis/reconnection. An experimental study in dogs. J Clin Periodontol 1997;8:568–572.
13. Oakley E, Rhyu IC, Karatzas S, Gandini-Santiago L, Nevins M, Canton J. Formation of the biologic width following crown lengthening in nonhuman primates. Int J Periodontics Restorative Dent 1999;19:529–541.
14. Canton J, Nyman S. Histometric evaluation of periodontal surgery. III. The effect of bone resection on the connective tissue attachment level. J Periodontol 1981;52:405–409.
15. Waerhaug J. Subgingival plaque and loss of attachment in periodontosis as evaluated on extracted teeth. J Periodontol 1977;48:125–130.
16. Smith DE, Zarb GA. Criteria for success of osseointegrated endosseous implants. J Prosthet Dent 1989;62:567–572.