Critical buccal bone dimensions along implants

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Over time, dental implants have evolved from being merely an anchoring device for dental prostheses to an advanced tooth substitute expected to mimic the role of a tooth root and to provide levels of functionality, esthetics and phonetics that are comparable with those of natural teeth. The scientific literature, when evaluating the outcome of implant therapy, has switched from the analysis of implant survival, in other terms equivalent to the implant still being anchored in the jawbone, to the analysis of implant success, a more elaborate notion that judges implant-therapy outcome on the grounds of several biological, biomechanical, functional and esthetic criteria. Several authors have attempted to fragment evaluation of the esthetic result of rehabilitation with dental implants into a set of objective criteria. Lately, the concepts of the ‘pink esthetic score’, a soft-tissue-related set of criteria (30), and the ‘white esthetic score’, a score based on dental-related criteria (8), have been cited and used in numerous publications related to esthetic implant dentistry. Based on the concept of biological width and on empirical observations and experimental findings, it is suggested that the integrity of the hard-tissue envelope around implants is necessary to provide a stable infrastructure for the overlying soft tissue to ensure satisfactory long-term esthetics and success of implant therapy (9). The peri-implant bone dimensions constitute the base for the supra-crestal soft tissues (13). Because the latter determines the esthetic result and has relatively constant dimensions (36), the bone dimension is one of the key factors that determines the soft-tissue contour. Special attention has been given to the buccal bone, especially in the maxilla, because of its localization in the main esthetic area.

Esthetic success is suggested to be dependent on achieving an optimal three-dimensional implant position within the available bone dimensions (14) and the maintenance of adequate buccal bone over the buccal implant surface (32). Bone remodeling or resorption can be a physiological or a pathological process that occurs as a response to trauma, or to physical, chemical or microbiological events taking place in the vicinity of an implant site. Three bone-remodeling processes determine the bone-dimensional changes at implant recipient sites under normal physiological conditions: remodeling processes that occur after tooth extraction (33); remodeling processes that occur as a result of surgical trauma (31); and bone remodeling processes that occur as a result of saucerization (1). It is the surgeon’s duty to be aware of those dynamics and their extent, as well as their implications on therapy prognosis, in order to offer the most adequate treatment modalities to the patient.

Particular attention needs to be given to the buccal bone because of its extensive remodeling ability (4) as well as its role in supporting the esthetic buccal mucosa. Implant positioning in relation to the buccal-oral dimensions of the alveolar ridge is thought to influence the degree of bone remodeling following implant placement (24). As a general principle, endosseous implants should be installed within the alveolar envelope at implant placement (42). However, bone remodeling after implant installation may, in turn, have a negative influence on the soft-tissue topography and the esthetic outcome of the implant therapy (17). Therefore, when performing surgery on the peri-implant tissues or in the vicinity of an implant site, the surgeon will have to use techniques that inflict a minimal amount of iatrogenic trauma to the tissues (the techniques and instrumentation currently available do not yet allow truly completely atraumatic interventions). Additionally, when faced with partial or total damage and/or the absence of buccal bony tissue, the surgeon needs to be able to make the correct diagnosis and employ suitable methods in order to repair and correct, or at least
reduce, the extent of the damage inflicted on the tissue.

**Anatomical review**

The buccal bone plate is a component of the alveolar process, which is linked to the development and eruption of the teeth. The alveolar process is very responsive to changes occurring in the dental structures it supports. Via constant remodeling (a combination of bone-resorption and bone-apposition processes) it can adapt to physiologic and pathological changes affecting the teeth, such as tooth eruption, natural or forced tooth movement, varying stress intensity and frequency, development of infection foci and surgical trauma. The buccal bone plate is a structure comprised of an external (buccal) lining of cortical bone and an internal (oral) socket wall made of compact bone, also known as alveolar bone proper, and is identified as 'lamina dura' on radiographs. In between those 'plates' lies a core body of cancellous bone. This has been found to be generally thinner than its palatal/lingual counterpart and therefore more prone to osseous dehiscences and fenestrations and subsequent soft-tissue recession (18). Additionally, it tends to be thicker in the posterior regions than in the anterior regions. Its oral component forms part of the tooth socket and is composed of bundle bone, which serves as an anchor for the periodontal Sharpey's fibers. The presence of bundle bone is conditioned by the presence of an adjacent tooth, and tooth loss or removal leads inevitably to the loss of bundle bone and subsequently to partial resorption of the buccal bone plate. The vascularization of the buccal bone plate originates from the superior and inferior alveolar arteries. The nourishing canals of those arteries run through the bony structures within the Haversian canals and the Volkmann canals. Anastomoses are frequent. Although several nerves run through the jaw bones or on its surface, the bone itself does not contain neural terminations.

**Dimensional changes following tooth extraction**

The alveolar ridge in general, and the buccal bone plate in particular, are prone to extensive remodeling. Major bone remodeling occurs following tooth extraction (40, 41, 43) and is mainly a consequence of the disappearance of bundle bone. The bundle bone is considered to be part of the periodontium and its presence is coupled to the presence of a tooth root. This tissue thus resorbs upon tooth extraction or tooth loss (4).

Healing following tooth extraction in the human was meticulously described by Amler et al. (2). Chen et al. (20) summarized extraction socket healing, based on the description by Amler et al., into five stages: (i) formation of the blood clot; (ii) formation of granulation tissue (within 4–5 days); (iii) replacement of granulation tissue with connective tissue (after 14–16 days); (iv) calcification of the immature tissues and bone trabeculae fill (by 6 weeks); and (v) epithelial closure, completion of bone fill and reduction of osteogenic activity (by 16 weeks).

These results were partially confirmed by later studies, but an important variability in the rate of healing was also put forward (48). However, Amler et al. (2) looked solely at intrasocket healing and did not report on changes affecting the remaining buccal and lingual alveolar bone plates.

Bone healing following extraction was followed more closely by Cardaropoli et al. (16) in the mongrel dog model, and histological cuts were made at days 1, 3, 7, 14, 30, 60, 90, 120 and 180 postextraction (Fig.1).

- **Day 1:** the alveole is filled by a coagulum covered with a layer of inflammatory cells.
- **Day 3:** the marginal part of the coagulum is replaced with vascularized granulation tissue.
- **Day 7:** zones of coagulative necrosis are present. Osteoclasts appear in the marrow spaces and in the Volkmann canals.
- **Day 14:** an outer layer of richly vascularized connective tissue appears. The periodontal ligament disappears.
- **Day 30:** a well-organized fibrous connective tissue lined by a keratinized epithelium is present. The socket is now filled almost entirely with newly formed bone.
- **Day 60:** a woven bone bridge, separating the socket from the marginal mucosa, appears.
- **Day 90:** the woven bone is in the process of being replaced with lamellar bone.
- **Day 120:** gradual replacement of the woven bone bridge with lamellar bone.
- **Day 180:** well-organized bone marrow holding a large number of adipocytes and few inflammatory cells is present. The formation of trabeculae of lamellar bone is starting.

Next to intrasocket healing following tooth extraction, marked bone resorption should be expected during this process (Fig.2). Early studies have shown that this resorption is particularly marked in the
horizontal dimension (5–7 mm) but is more limited in the vertical dimension (2–4 mm) (33, 37). Later studies confirmed this extensive remodeling in the horizontal dimension after tooth extraction and quantified this resorption to be around 6.1 mm in the horizontal dimension, or 50% of the ridge width, with two-thirds of the resorption occurring during the first 3 months of healing (43). In contrast to the early studies, Schropp et al. (43) found little or no change in regard to the changes in the vertical dimensions. On average there was a gain of 0.3 mm buccally and a loss of 0.8 mm orally. This discrepancy might be a result of the study of Schropp et al. (43) being limited to single tooth extractions, with the neighboring teeth usually still being present. The presence of neighboring teeth is known to hamper extensive resorption in the vertical dimension (3, 25). Additionally, in a study on beagle dogs (4), it was shown that the buccal bone plate is affected much more than the lingual or palatal bone plates, in which the dimensional changes are discreet. This difference is linked to two factors: first, the thickness of the buccal plate, which is thinner than its palatal or lingual counterparts and thus has a greater tendency to show dimensional changes consequent to bone remodeling; and, second, the importance of bundle bone in the marginal segment of the buccal cortical plate, compared with a much reduced prevalence in the lingual plate. As the fate of bundle bone is directly linked to the presence of the dental element, tooth loss or extraction will systematically

Fig. 1. Mesio-distal sections illustrating the extraction socket after different intervals of healing: (a) 1 day, (b) 3 days, (c) 7 days, (d) 14 days, (e) 30 days, (f) 60 days, (g) 90 days, (h) 120 days, (i) 180 days. Hematoxylin-eosin staining; original magnification ×16. From Cardaropoli et al. (16).

Fig. 2. Bone morphology changes following tooth extraction. The initial contour is drawn in red and the bone contour, 6 months after extraction, is drawn in blue.
lead to the resorption of bundle bone during the remodeling process.

Different strategies of ridge preservation and socket management have been described in an effort to minimize bone resorption after tooth extraction and to optimize the availability of bone volume as well as to reduce the need for additional bone-augmentation procedures. Nevins et al. (38) reported that filling the extraction socket with deproteinized bovine bone mineral and primary closure of the wound leads to an average reduction of vertical crest height of 2.42 mm, whereas this reduction in crest height is 5.24 mm when no filling material was used. It is, however, of relevance that their study does not report on vertical changes but rather on the horizontal dimension because the measurements reported have the following end-points: a constant anatomical structure (e.g. the nasal fossae floor); and the level where the ridge is 6 mm wide, a reference level which is expected to move apically following bone remodeling in the lateral direction. Another socket-management technique, termed the ‘soft-tissue punch technique’, was described by Jung et al. (34). This technique consists of filling the socket with a xenograft consisting of deproteinized bovine bone mineral integrated in a 10% collagen matrix (deproteinized bovine bone mineral + collagen) and closing the wound with a sutured 2- to 3-mm-thick free gingival punch graft harvested from the palate. Alternative techniques were introduced by Fickl et al. (27, 29). These involve, in addition to defect filling with deproteinized bovine bone mineral + collagen and primary closure with a soft-tissue punch, (i) overbuilding of the buccal plate by guided bone regeneration (resorbable collagen membrane and deproteinized bovine bone mineral + collagen), (ii) the insertion of a soft-tissue graft under the buccal mucosa or (iii) forcing the buccal bone plate into a more buccal position using a specifically designed instrument. Volumetric changes at 4 months failed to demonstrate an added value of those techniques in comparison with the standard soft-tissue punch technique. However, the conclusions of this study were based on the analysis of soft-tissue contour and volume, and no information or measurements of the underlying hard-tissue changes were provided. Additionally, ridge preservation seems to have a more important effect when the initial thickness of the buccal plate is limited. When left to heal without any additional manipulation, extraction sites with an initial buccal bone plate thickness of 1 mm show a much higher level of resorption than do sites with an initial thickness of 3 mm. This difference in initial buccal bone-plate thickness seemed irrelevant when a ridge-preservation procedure (deproteinized bovine bone mineral + collagen membrane) was applied (5).

**Dimensional changes following surgical trauma**

It has become clear, from different studies, that any surgical technique by which alveolar bone becomes exposed during flap elevation will result in increased osteoclastic activity and bone resorption (12, 23, 39, 45, 46, 50). Mean crestal bone loss after full-thickness flap elevation has been reported to be between 0.8 and 0.4 mm (26, 28, 46). However, bone exposure is not the only determining factor for bone remodeling after a surgical intervention as split-thickness flap elevation also results in increased osteoclastic activity and bone resorption. This increase in osteoclastic activity following split-thickness flap elevation is, however, lower than in cases of full-thickness flap elevation (26, 39). Consequently, the resulting bone resorption is also lower, but by no means absent (26, 50). It has therefore been concluded that both full- and partial-thickness flaps induce bone remodeling. It might be assumed that the partial-thickness flap technique has the potential to be superior over full-thickness flap elevation regarding the preservation of alveolar bone (26).

**Dimensional changes caused by biological width violation**

As mentioned before, the success of implant therapy is partly judged in terms of soft-tissue volume, position and contour around the implant but is not based on the underlying nonvisible buccal bone plate. The relevance and importance of the buccal bone plate arises from its function as the supporting scaffold of the soft tissues. The concept of biological width has been applied to implants as well as to teeth. It has been put forward to explain how a constant distance has to be maintained between the bottom of the periodontal or peri-implant pocket/sulcus and the marginal bone interface to keep pathological microorganisms and their toxic products at bay. Therefore, it is suggested that whenever this biological width is violated, marginal bone would resorb in order to recreate an adequate safety distance. Equally, it is believed that marginal bone resorption caused by an external insult will lead, in cases of healthy periodontal tissues, to soft-tissue recession in an attempt to
restore an adequate biological width. Additionally, it is believed that soft tissues not supported by an adequate underlying bony structure are much more fragile and much more prone to recession in the event of trauma compared with their supported counterparts. The biological width around implants has been found to be slightly greater than that around teeth and about 3–3.5 mm in length, comprising a 2-mm junctional epithelium and a connective tissue envelope of 1–1.5 mm. Additionally, it was observed that the presence of a thin mucosa, implying an insufficient biological width, would invariably lead to spontaneous bone resorption in order to re-create the minimal epithelial and connective tissue barrier required (9).

**Importance of buccal bone dimensions in relation to implant positioning**

Based on the above-mentioned biological concepts, it should be clear that bone remodeling and dimensional changes of the buccal bone can be expected after implant placement (Fig. 3). Cardaropoli et al. (17) recorded the alterations in the bucco-oral dimensions of 11 single-tooth replacements with implant-supported restorations in the maxillary incisor region. After the initial extraction sockets had healed for a period of at least 6 months, a two-stage implant procedure was used with a 6-month submerged healing period. All implants belonged to the same implant system (Nobel Biocare, Göteborg, Sweden). After preparing the osteotomy, the implants were placed with the top of the cover screw positioned even with the buccal bone crest. This means that the implant shoulder was approximately 1.1 mm below the buccal bony crest. Buccal bone thickness was measured, using a specially designed device, at the level of the implant shoulder (1.1 mm below the buccal bone crest), and 2 and 4 mm more apically. Bone crest levels were measured, using a periodontal probe, from the implant shoulder. The measurements were performed at implant placement and at abutment connection. The buccal bone thickness at implant placement was 1.2, 1.3 and 0.9 mm at the three different depth levels. At the two most marginal measurement points, a nonsignificant mean reduction of 0.4 mm in buccal bone thickness was observed at the second-stage surgery. At that time, a loss of bone height, averaging 0.7 mm, had taken place at the buccal aspect of the implant.

Implant positioning in relation to the bucco-oral dimensions of the alveolar ridge is thought to influence the degree of bone remodeling following implant placement (24). Such bone remodeling may, in turn, have a negative influence on the soft-tissue topography and on the esthetic outcome of the implant therapy (17). Taking into account the above-mentioned biological concepts, several clinical guidelines describing the correct implant position in relation to the bucco-oral bone dimension (14, 32). Regarding the optimal buccal bone dimension required, it has been suggested that it is crucial to have a buccal bone plate of at least 1 mm (7) or 2 mm (15, 32). This degree of buccal bone thickness was advocated to ensure proper soft-tissue support, avoid resorption of the facial bone wall following restoration and thus minimize the risk for peri-implant soft-tissue recession. The latter is an important factor when it comes to esthetics. In order to fulfill these criteria, bone-augmentation procedures, orthodontics, enameloplasty or restorative materials are often recommended (14). Although these criteria might be correctly deduced from the biological concepts of bone remodeling, the impact at the patient level should not be underestimated.

Surprisingly, until now, no clinical studies were available that underlined the necessity of a buccal bone thickness of 1–2 mm. Because supracrestal soft tissues around implants seem to have relatively constant dimensions, which corresponds to the biological width (36), one could eventually hypothesize that a vertical buccal bone resorption will result in a marginal soft-tissue recession. In turn, this will have a negative influence on the esthetic outcome. Several studies have addressed the question of whether residual horizontal buccal bone thickness after implant installation influences vertical buccal bone resorp-

![Fig. 3. Bone morphology changes occurring between the moment of implant placement (red contour) and 12 months after implant placement (green contour).](image-url)
tion. Most of the claims in regard to a minimal buccal bone thickness refer to the large-scale, prospective and multicenter study of the Dental Implant Clinical Research Group. In this study, Spray et al. (44) measured the thickness and height of the buccal bone at the time of implant placement and compared these values with the buccal bone height at the time of abutment connection. Data were obtained from 2667 implants with different surfaces and designs and from original implants as well as replacement implants. There was no discrimination between intra-oral regions (anterior, posterior, maxilla and mandible). Following preparation of the osteotomy site, the thickness of the buccal bone wall was measured to the nearest 0.5 mm, approximately 0.5 mm below the crest. The distance between the buccal bone crest and the top of the implant was measured, using a periodontal probe, to the nearest 1 mm. The initial bone level could be above or below the top of the implants. After implant placement, submerged healing of at least 3 months was allowed. When the healing abutment was placed, the distance from the bone crest to the top of the implant was remeasured. The group of implants that showed no loss of facial bone height had an ‘average’ bone thickness, after preparation of the osteotomy site, of ≥1.8 mm, whereas for implant groups showing loss of facial bone height, the average bone thickness was <1.8 mm. The greater the loss of bone height, the lower the average thickness of the buccal bone at implant placement. Therefore, the authors suggested that a buccal bone thickness of around 2 mm would reduce the incidence and amount of vertical bone loss. However, some remarks are necessary. This study focused on vertical bone resorption and not on esthetics. There are no data indicating that resorption of the buccal bone will lead to soft-tissue retraction. Moreover, it should be noted that the data were grouped and analyzed according to the amount of facial bone loss/gain and not according to the initial facial bone thickness. The authors observed that the initial mean facial bone thickness was smaller for implants that showed more facial bone resorption at the time of abutment placement. With respect to these interesting findings, one needs to consider the large standard deviations for mean facial bone thickness, even for implants that did not show facial bone loss. For the ‘no facial bone loss’ group, with an average buccal bone thickness of 1.8 mm, a standard deviation of 1.1 mm was reported. This means that approximately 95% of the buccal bone thicknesses were located between 0 mm (1.8 – [2 × 1.1]) and 4 mm (1.8 + [2 × 1.1]). Therefore, these data do not allow the extrapolation or reverse calculation that no facial bone resorption will occur when the initial buccal bone thickness is >1.8 mm.

Moreover, if reverse calculations, based on the study of Spray et al., (44) are used, the mean vertical facial bone resorption in the study of Cardaropoli et al. (17) (which did not consider a correlation between buccal bone thickness and loss in vertical height) should have been around 3 mm. However, Cardaropoli et al. (17) only reported an average of 0.7 mm vertical bone resorption at the time of abutment placement. This discrepancy might be related to the different implant systems used in both studies. Additionally, in the study of Spray et al., (44) buccal bone thickness data from different intra-oral regions were mixed, whereas in the study of Cardaropoli et al., (17) only implants in the maxillary incisor region were considered. It should also be noted that Cardaropoli et al. (17) positioned the implant shoulder approximately 1.1 mm below the buccal bone crest. This information is not provided in the study by Spray et al., (44) or perhaps the large standard deviation values in the study of Spray et al. (44) explain this discrepancy.

Much enthusiasm has been shown for the immediate implant-placement protocols (type 1) because they allow a drastic reduction of the length of the treatment as well as a reduction in the number of surgical interventions (6, 35). Early reports have claimed that immediate implant placement could prevent the inevitable bone resorption following tooth extraction. However, those claims have been dismissed. Vertical bone changes in relation to buccal bone thickness after immediate implant placement can be derived from a case series published by Botticelli et al. (11). Twenty-one extraction sockets in 18 healthy patients, located in the anterior region (maxilla and mandible), received a solid screw implant with an sandblasted and acid-etched-modified surface (Straumann AG, Waldenburg, Switzerland) immediately after extraction. The vertical distance between the implant shoulder and the sandblasted and acid-etched portion was 2.8 mm in the type of implant used. The implant was placed so that the marginal level of the sandblasted and acid-etched portion was placed apical to the marginal level of the buccal or the oral wall of the socket. Before implant installation, the thickness of the buccal wall was measured using a caliper, 1 mm below the bone crest. After implant placement, the vertical distance between the implant shoulder and the bone crest, and the horizontal distance between the implant surface and the outer side of the bone crest, were assessed. All implants experienced
a 4-month semisubmerged healing period before healing caps were placed and bone dimensions were reassessed. Because Botticelli et al. (11) provided the measurements for each patient in the case series, the following data could be derived. No statistical analysis was performed owing to the limited number of patients available for analysis. Implants placed in sites with an initial buccal bone thickness of 1 mm \((n = 8)\), 1.5 mm \((n = 8)\) or 2 mm \((n = 5)\) exhibited a change in vertical bone height of, respectively, \(0.1 \pm 0.8\), \(-0.6 \pm 0.4\) and \(-0.3 \pm 0.4\) mm. For implants in which the horizontal distance between the implant surface and the outer side of the bone crest was \(\leq 2.5\) mm \((n = 5)\), average: \(2.4 \pm 0.2\) mm), \(3–3.5\) mm \((n = 7)\), average: \(3.3 \pm 0.3\) mm) or 4 mm \((n = 8)\), the corresponding change in vertical bone height was, respectively, \(0 \pm 0.8\), \(-0.3 \pm 0.4\) and \(-0.4 \pm 0.8\) mm. There was no obvious relationship between buccal bone thickness or the horizontal distance between the implant surface and the outer side of the bone crest at implant placement and the amount of vertical bone resorption at abutment placement.

These, albeit limited, data are in contrast to the observations of Chen et al. (19) and Qahash et al. (42). In an animal study on 12 mongrel dogs, implants were placed in extraction sockets where critical-size supra-alveolar peri-implant defects had been created. A significant correlation was found between the initial width of the buccal ridge and crestal bone resorption. According to the authors, histometric analysis showed more pronounced resorption when the ridge width was thinner than 2 mm. However, no statistical analysis to support that claim was presented. Several modifications to the standard protocol were introduced to enhance the final results and limit the extent of bone resorption after immediate implant placement. Primarily, the use of autologous bone or bone substitutes to fill in the peri-implant space in the extraction alveole is advocated. Alternatively, it is advised to isolate the implant and surrounding bone from the soft tissues using resorbable or nonresorbable membranes. However, some results do suggest that this procedure has no added benefit when the distance from the implant surface to the bony wall is around 1–1.25 mm (10). Some authors also recommended the combined use of isolating membranes and filling material (21). Chen et al. (19) also recently suggested that the initial thickness of the buccal bone crest may be a factor in determining the extent of crestal resorption during the healing phase of immediately placed implants. This study is, however, not directly comparable because the buccal bone-thickness data for immediately placed implants that healed without grafts and membranes were mixed with data from implants that healed with grafts or a membrane. With this in mind, it is still interesting to note that, in the study of Chen et al., (19) for sites showing a buccal bone dehiscence after 6 months of semisubmerged healing, the average initial buccal bone thickness was approximately 50% of the average initial buccal bone thickness of sites that healed without a dehiscence. The vertical resorption in the former sites was up to three times greater than that in the latter sites. This made the authors conclude that the initial buccal bone thickness influences vertical bone resorption but not horizontal resorption. Despite the limited amount of data available, this appears to be in contrast to what could be calculated from the study of Boticelli et al., (11) in which no correlation could be seen between buccal bone thickness and vertical bone resorption.

All studies reporting on buccal bone remodeling after implant placement have relied on direct measurements to assess the evolution of buccal bone. As a result of this restriction, no measurements were possible after the stage of abutment surgery. The only long-term study available is a retrospective radiographic follow up of 11 implants, 7 years postoperatively, which demonstrated an average loss of 0.3 mm in buccal bone thickness and a 0.6 mm average loss in the vertical dimension (22). However, the inherent lack of precision of radiographic measurements and the presence of a strong radiopaque object (the implant) could have had an influence on the measurements. Moreover, one has to bear in mind that the resolution and quality of three-dimensional images, as well as the scattering-reduction abilities of their software algorithms, were much less efficient 7 years ago, when the initial images were produced.

Most studies that investigated buccal bone fate and critical dimensions were performed on traditional implant systems. Those implants exhibited a very particular bone-remodeling feature consisting of the formation of a circumferential shallow angular defect around the implant shoulder, also known as saucervation. The evolution of implant designs and surfaces has resulted in the fact that most of the actual implant systems do not show this particular remodeling and do seem to conserve marginal bone more efficiently. Therefore, this feature should be borne in mind when looking at older data and it is a legitimate to question whether the dimensions considered as critical in the past hold any value now.
Conclusions

An understanding of buccal bone evolution after tooth extraction and after implant placement is of utmost importance, particularly in the highly demanding esthetic zone. Both animal and human studies have shown a considerable amount of bone remodeling following tooth extraction. This remodeling is predominant in the horizontal dimension and more limited in the vertical dimension. Moreover, the extent of resorption seems to be a function of the presence or absence of neighboring teeth, which act as a buffer against extensive resorption. These elements need to be taken into account by the surgeon when opting for immediate implant placement. Therefore, most authors recommend that implants should be positioned in fresh extraction sockets slightly palatal and 1–2 mm subcrestal.

Implants placed in the healed site are subject to much less bone spatial change. In the initial phase following placement, modest buccal bone resorption, of about 0.5 mm, is to be expected. Most authors consider this as a consequence of bone remodeling following surgical trauma (49). The long-term data, presently very scarce (47), seem to suggest that minimal to no bone remodeling is to be expected at later stages. An initial critical buccal bone thickness of 2 mm has been recommended to prevent vertical resorption. However, the literature currently available does not fully back this claim.

References

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