# Significance of Facial Bone Thickness After Dental Implantations in Healed Ridges: A Literature Review

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Abstract: Literature has suggested that a minimum threshold of bone thickness facial to a dental implant is necessary to ensure successful implantations. The authors, therefore, decided to review the effect of buccal bone thickness on horizontal and vertical bone resorption, recession, and implant survival. Databases were searched, and seven human studies were found that evaluated the effect of facial bone thickness on hard- and soft-tissue outcomes and survival rates related to dental implants. Results revealed that a wide range of buccal bone thickness after implant placement (0.5 mm to ≥2 mm) resulted in a high implant survival rate (97% to 100%). Vertical and horizontal bone loss usually occurs following implant placement, 0.4 mm to 1 mm and 0.08 mm to 0.7 mm, respectively, after restorations are placed. Peri-implant mucosal recession of around 0.5 mm is frequently observed 1 year after implant placement. This literature review concluded that implants have a high survival rate despite a range of facial bone thickness adjacent to implants. It also found that no minimum initial facial bone thickness adjacent to an implant could be verified that would preclude horizontal and vertical bone loss after implant insertions.



Implant-supported restorations are an accepted and proven treatment modality.[1] As a general principle, endosseous implants are placed where there is sufficient bone vertically, buccally, and lingually to support a restoration. An often-debated issue pertains to what minimum buccal bone thickness on the facial aspect of an implant is needed to enhance the success of implants placed in healed ridges. Examples of various buccal bone thicknesses are shown in Figure 1 through Figure 3. Some clinicians have suggested that this bone thickness should be at least 1 mm or 2 mm thick after implant placement, as seen in Figure 3.[2,3] In this regard, buccal bone thickness may affect a variety of issues, including soft-tissue esthetics, recession, subsequent vertical and horizontal bone resorption, and implant survivability.[4]

Having a known minimum threshold for facial bone thickness prior to implant insertion would be advantageous for determining the need for guided bone surgical procedures to augment the alveolar ridge. Interestingly, the desired lingual thickness of the ridge adjacent to an implant has not been addressed in any studies. This may be due to the finding that the lingual bony plate is usually thicker than the buccal osseous plate and, thus, less prone to resorb after an extraction.[5]

This article addresses the importance of buccal bone thickness facial to an implant with respect to various aspects of dental implantations in healed ridges. It provides background information concerning bone physiology and remodeling after an extraction.

## Bone Types and Function

Bone is a dynamic tissue whose main function is to provide mechanical support to the human body.[6] It is a highly specialized form of connective tissue and has an organic and inorganic phase. The organic matrix is strengthened by calcium and predominated by type 1 collagen, whereas the inorganic matrix consists mostly of hydroxyapatite.[7]

There are two morphological types of bone: cortical and cancellous. They have different structural arrangements that provide different functions.[7] Cortical bone supports the body, protects the organs, and stores and releases chemical elements, such as calcium. Cancellous bone is highly vascularized and contains bone marrow where hematopoiesis and production of blood cells occur.[8]

Dental implants are in contact mainly with cancellous bone; this is important for peri-implant bone healing. Cortical bone is mostly involved with implant stability. Both types of bone experience some resorption after dental extractions.[9]

## Buccal Bone Vascularization

Vascularization of the buccal aspect of the ridge in the maxilla originates from the anterior, middle, and posterior branches of the superior alveolar artery and the buccal artery.[10] In the mandible, facial bone is vascularized by the buccal artery. Specifically, bone derives its blood supply from three vascular sources: the periodontal ligament (PDL), periosteum, and endosteal space.[7]

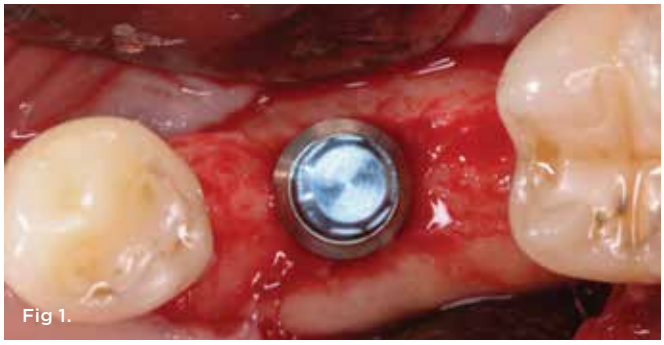




**Fig 1.** Example of thin buccal bone (<1 mm) facial to an implant at site No. 19 (occlusal view). The exact thickness of buccal bone that forecasts successful implantation has yet to have been determined. **Fig 2.** Example of thick buccal bone (≥2 mm) facial to an implant at site No. 4 (occlusal view). Data suggests bone >1.8 mm facial to an implant hinders horizontal and vertical bone loss associated with implant placement. **Fig 3.** Example of 1 mm to 2 mm buccal bone facial to an implant at sites Nos. 19 and 20 (occlusal view). This amount of bone facial to an implant is often encountered during implant placement.

Disruption of blood supply to bone has the potential to induce osseous resorption.[9] For example, after flapless tooth extractions, vascularity derived from the PDL is disturbed, leaving two sources of blood supply remaining. On the other hand, if a flap is elevated during an extraction, it compromises a second vascular source, the periosteum. Subsequently, only one source of blood supply to the buccal bone remains (endosteal marrow), until angiogenesis occurs and the periosteal blood supply is restored.[11]

The bone buccal to dental implants is routinely comprised of cortical and cancellous bone. Thin facial bone, which consists of an increased ratio of cortical bone compared to cancellous, may be more susceptible to resorption due to decreased vascular supply.[12] In contrast, thick bone facial to an implant has a better blood supply and is less prone to bone loss.[12]

## Socket Dimensional Alteration After Tooth Extraction

In humans, dimensional bony changes occur after a tooth extraction with respect to buccolingual width and vertical bone height.[13] The degree of resorption after tooth removal depends on several factors: buccal bone thickness, method of tooth removal (traumatic versus atraumatic, flap versus flapless), inflammatory response, systemic factors, the tooth site in the mouth, socket integrity, presence of pathosis, anatomical variations, blood supply, and genetics.[14]

Shropp et al reported that there was up to a 50% bone width ridge reduction in premolar and molar sites 3 months post extractions using a flap.[15] Most osseous resorption occurred during the first 3 months after tooth removal but continued for an additional 9 months. A systematic review by Tan et al summarized the magnitude of bone loss, horizontally and vertically, 1 year post tooth extraction when using a flap.[16] They reported that the mean width bone loss was 3.79 mm and the vertical height decrease was 1.24 mm. In contrast, flapless extractions resulted in 1 mm resorption of bone height and width.[12]

In summary, a flapless tooth extraction demonstrates a reduced amount of horizontal, but not vertical, bone loss. The similar amount of bone resorption vertically for flapless and flapped extractions is probably caused by disruption of the PDL blood supply.[9] A reduced amount of horizontal bone loss with flapless extractions is due to preserving the periosteal blood supply to bone.[9]

## Buccal Plate Thickness: Anterior Vs Posterior

Buccal plate thickness in the maxilla and mandible has been investigated on natural teeth using cone-beam computed tomography (CBCT). Januário et al defined a thin buccal plate as having a thickness <1 mm and a thick buccal plate as ≥1 mm.[17] Using CBCT technology, they assessed buccal plate thickness in the anterior maxilla and reported that in most cases it was <1 mm thick, and in 50% of cases it was <0.5 mm wide. Fuentes et al also evaluated buccal plate thickness in the anterior maxilla with CBCT and noted that <10% of sites showed a buccal plate thickness ≥2 mm.[18]

Others using CBCT reported that a thicker buccal plate was found adjacent to posterior teeth.[19,20] Zekry et al noted that the mean width of the facial alveolar bone wall in anterior teeth of both arches was around 0.9 mm and increased posteriorly (range 1.23 mm to 2.46 mm).[19]

## Amount of Facial Bone Thickness Related to Implant Success

Table 1 lists characteristics of the studies included in this review.[21-27] Table 2 demonstrates that there is a wide range of facial bone thickness recorded after implant placement (range 0.5 mm to 1.83 mm) and that the survival rate in six of the seven studies was 100%[22-27] and in one study it was 97%.[21] Most of the studies listed in Table 2 were only 1 year long,[22,23,25-27] one spanned 6 months,[21] and one was 3 years long.[24] Based on short-term data, there does not appear to be a relationship between implant success and buccal bone width after implantations. It should be noted that some of the studies assessed facial bone width at different locations (eg, at the level of the implant platform) (Table 2).

### Impact of Implant Facial Bone Thickness on Horizontal Bone Loss

Several investigations assessed the relationship between initial buccal bone thickness on the facial aspect of an implant and the amount of horizontal bone resorption that occurs after implant insertion (Table 2). In a large, prospective, multicenter study, Spray et al evaluated the association between facial bone thickness and horizontal bone loss.[21] The authors reported that an initial buccal bone thickness of 1.8 mm to 2 mm could maintain ridge thickness after a dental implantation. Others reported that initial facial bone thicknesses of 1.2 mm,[22] 1.25 mm,[26] and 0.5 mm[27] after implant placement were associated with horizontal buccal bone resorption of, respectively, 0.4 mm,[22] 0.54 mm,[26] and 0.3 mm.[27] These last three studies indicate that initial buccal bone thickness ranging from 0.5 mm to 1.25 mm resulted in a residual facial bone thickness of <1 mm. Another study concluded that there was no statistically significant difference in horizontal bone loss between thin (<1 mm) and thick (≥1 mm) buccal bone on the facial aspect of an implant.[23]

From another perspective, Kaminaka et al assessed the decrease in buccal bone thickness related to initial buccal bone width after the use of different types of implant connections: external, internal, and conical.[25] Their results demonstrated that the amount of horizontal bone loss was minimal (0.08 mm to 0.18 mm) and did not appear related to the initial buccal bone thickness. Similarly, Omori et al evaluated facial bone alterations adjacent to 32 screw-shaped devices installed in posterior edentulous ridges when there was a buccal bone width of 1 mm or 2 mm.[28] After 3 months the horizontal bone resorption was 0.3 mm when the facial bone was initially 1 mm thick and 1 mm when it was initially 2 mm thick.

In summary, initial horizontal bone width on the facial aspect of implants is usually reduced several months after dental implant insertion. The magnitude of this horizontal width reduction is normally ≤1 mm. When patients are evaluated several months after implantation the residual horizontal bone buccal to an implant

TABLE 1

**Characteristics of Included Studies**

| Author | Type of Study | No. of Patients | No. of Implants | Implant Site(s) | Implant Brand | Type of Prosthesis | Healing Time (Months) | One- Vs Two-Stage | Measurement Type |
|---|---|---|---|---|---|---|---|---|---|
| Spray et al[21] | P | Not stated | 2,685 | Mixed | Mixed | Not stated | 3–4 (mandible), 6–8 (maxilla) | Two | Caliper |
| Cardaropoli et al[22] | P | 11 | 11 | Incisors | Nobel Biocare | Single crown | 6 | Two | Caliper |
| Merheb et al[23] | P | 24 | 47 | Mixed | Astra Tech | Not stated | 6 | Two | Caliper |
| Temmerman et al[24] | P | 28 | 100 | Mixed | Astra Tech | Removable and fixed | 3.6 | Two | CBCT |
| Kaminaka et al[25] | P | 32 | 34 | Incisors and premolars | Nobel Biocare | Metal-ceramic | 2–3 (mandible), 4–6 (maxilla) | Two | CBCT |
| Vera et al[26] | CS | 8 | 8 | Anterior and premolars | Astra Tech | Single crown | 4 | One | CBCT |
| Takuma et al[27] | P | 30 | 66 | Posterior | Biomet 3i | Single crown | 3–4 | One | Mechanical device |

*CBCT = cone-beam computed tomography, CS = case series, P = prospective*

frequently appears to be <1 mm. Spray et al correlated initial bone width and future horizontal bone loss and reported that initial width of 1.8 mm to 2 mm precluded horizontal bone loss.[21] However, their study has drawbacks. The authors did not specify if the assessment of buccal bone thickness was done on implants that were placed anteriorly or posteriorly intraorally, there was no indication of whether the implants were inserted crestally or subcrestally, and their data only applies to implants placed in healed ridges. Furthermore, the kind of connection, implant design, and surface texture used in the study are not employed anymore. Additional prospective studies are needed to corroborate that a buccal bone thickness facial to an implant of 1.8 mm to 2 mm is necessary to prevent a reduction of horizontal bone width after dental implantation.

## Initial Bone Dimensions Facial to an Implant: Effect on Vertical Bone Loss

Only five of the seven studies in this review reported the effect of bone thickness facial to an implant on vertical bone loss (Table 3).[21,22,25-27] Spray et al, for instance, noted that if the buccal bone

TABLE 2

### Influence of Initial Bone Thickness Facial to an Implant on Horizontal Bone Resorption and Implant Survival

| Author | | Initial BBT at T1 Mean (SD) | BBR at T2 Mean (SD) | Survival Rate | Measurement Location | Follow-up |
|---|---|---|---|---|---|---|
| Spray et al[21] | | 1.7 mm ± (1.1 mm)<br>1.83 mm ± (1.1 mm) | 0.7 mm ± (1.7 mm)<br>0.0 mm | 97% | 0.5 mm below the crest | 6 months |
| Cardaropoli et al[22] | | 1.2 mm ± (1 mm) | 0.4 mm | 100% | At implant level | 1 year |
| Merheb et al[23] | | 1.1 mm ± (0.77 mm) | 0.85 mm ± (0.71 mm) | 100% | At platform level | 1 year |
| Temmerman et al[24] | | <1 mm | n/a | 100% | n/a | 3 years |
| Kaminaka et al[25] | EC | 0.18 mm ± (0.22 mm) | 0.18 mm ± (0.22 mm) | 100% | At platform level | 1 year |
| | IC | 0.87 mm ± (0.97 mm) | 0.14 mm ± (0.21 mm) | | | |
| | CC | 0.53 mm ± (0.71 mm) | 0.08 mm ± (0.11 mm) | | | |
| Vera et al[26] | | 1.25 mm | 0.54 mm | 100% | 1 mm apical | 1 year |
| Takuma et al[27] | | 0.5 mm | 0.3 mm | 100% | At platform level | 1 year |

*BBR = buccal bone resorption, BBT = buccal bone thickness, CC = conical connection, EC = external connection, IC = internal connection, T1 = initial bone thickness, T2 = buccal bone resorption at second surgery/CBCT*



TABLE 3

### Influence of Initial Bone Thickness Facial to an Implant on Vertical Bone Resorption

| Author | | Initial BBT at T1 Mean (SD) | VBR at T2 Mean (SD) |
|---|---|---|---|
| Spray et al[21] | | 1.7 mm ± (1.1 mm)<br>1.83 mm ± (1.1 mm) | 0.7 mm ± (1.7 mm)<br>0.0 mm |
| Cardaropoli et al[22] | | 1.2 mm ± (1 mm) | 0.7 mm |
| Merheb et al[23] | | 1.1 mm ± (0.77 mm) | n/a |
| Temmerman et al[24] | | <1 mm | n/a |
| Kaminaka et al[25] | EC | 0.18 mm ± (0.22 mm) | 1.85 mm ± (0.90 mm) |
| | IC | 0.87 mm ± (0.97 mm) | 1 mm ± (1.08 mm) |
| | CC | 0.53 mm ± (0.71 mm) | 0.21 mm ± (0.28 mm) |
| Vera et al[26] | | 1.25 mm | 0.49 mm |
| Takuma et al[27] | | 0.5 mm | 1 mm |

*BBT =buccal bone thickness, CC = conical connection, EC = external connection, IC = internal connection, T1 = initial bone thickness, T2 = vertical bone resorption at second surgery/CBCT, VBR = vertical bone resorption*

thickness after implantation into a healed ridge was ≥1.8 mm, there was no decrease of vertical buccal bone height.[21] However, if there was <1.8 mm of buccal bone adjacent to an implant the average vertical bone loss was 0.7 mm. The final data were recorded when abutment connections were inserted after 6 months. In that study, when there was increased thickness of buccal bone, vertical bone resorption was significantly decreased. (Shortcomings of the study were addressed in the previous section of this article.)

Some studies reported that after implant placement vertical bone loss occurred, but it was not possible to specifically correlate initial buccal plate thicknesses to the amounts of vertical bone resorption.[21,25-27] Rather, the authors reported initial average buccal plate thickness and the mean amount of vertical bone loss that occurred. For example, initial facial bone thickness to implants and subsequent vertical height bone loss after implantations were provided as follows: Cardaropoli et al, 1.2 mm thickness, loss 0.7 mm[22]; Vera et al, 1.25 mm thickness, loss 0.49 mm[26]; and Takuma et al, 0.5 mm thickness, loss 1 mm.[27]

Some researchers provided a different perspective. Omori et al evaluated 32 sites that received a screw device when there was a buccal bone width of 1 mm or 2 mm.[28] After 3 months there were no statistically significant differences in loss of vertical bone related to the initial bone thickness, as bone loss was 0.9 mm and 0.8 mm, respectively, in the two groups of patients. Kaminaka et al observed mean vertical bone loss associated with the three aforementioned types of implant connection (external, internal, and conical) groups: respectively, 1.85 mm, 1 mm, and 0.21 mm.[25] The respective initial buccal bone thicknesses were 0.18 mm, 0.87 mm, and 0.53 mm. In this latter study, it was obvious that a thin buccal bone resulted in a considerable amount of vertical bone loss.

To summarize, vertical bone resorption is a common finding after dental implantations. A vertical bone loss of 0.4 mm to 1 mm should be anticipated. This can be attributed to biologic width formation after prosthetic abutment connections. Additionally, differences in the magnitudes of vertical bone diminishment can be caused by different implant systems with varying connections (platform versus non-platform switch), the position of the implant relative to the alveolar crest, surgical trauma, and possibly the initial thickness of the buccal bony plate after implantation. No study except for Spray et al[21] correlated different initial buccal bone thicknesses to the subsequent vertical bone loss adjacent to implants. Drawbacks of that study have been previously noted; furthermore, that investigation was done on healed ridges, therefore the data does not apply to immediate dental implants.

## Buccal Ridge Thickness Facial to an Implant: Effect on Recession

Peri-implant mucosal tissue recession after implantations needs to be evaluated to determine if buccal bone thickness is a critical determinant for esthetic implant placement. None of the studies in Table 3 clearly addressed whether facial bone thickness influences the final esthetic outcome after insertion of a prosthesis.

Three studies reported soft-tissue recession after prosthetic loading and provided data regarding the initial thickness of the bone facial to the inserted implants.[22,25,27] (See Table 2 for the initial thicknesses of bone.) Cardaropoli et al found mucosal recession of 0.6 mm,[22] and Takuma et al noted 0.4 mm recession at the 1-year recall.[27] Kaminaka et al recorded an average 0.35 mm gingival recession associated with three types of implant connections.[25] The recession noted in these three studies may have been caused by the horizontal and vertical bone loss that occurred post implantation.

In summary, a peri-implant mucosal recession of around 0.5 mm can be anticipated at 1 year after implant insertion.[22,25,27] However, a number of confounding factors could affect the amount of recession, including crown contour, buccolingual implant placement, and type of abutment connection. Therefore, the precise amount of buccal bone thickness to ensure limited recession cannot be determined based on the published articles addressing this issue.

## Assessment of Buccal Thickness of Bone

In most of the studies reviewed, a dental caliper and CBCT scans were used to quantify the amount of buccal plate present after implant placement. Sixty percent of the studies in this review used a digital caliper to assess buccal bone thickness and 40% employed CBCT scans (Table 1).

## Shortcomings of Radiographic Assessments

The use of x-ray imaging, including CBCT scans and periapical radiographs, helps evaluate bone prior to implantations. A radiograph provides a 2-dimensional image but offers no information with respect to alveolar ridge width, while a CBCT scan can provide information concerning ridge width. Nevertheless, CBCT scans may not provide precise information regarding the amount of bone buccal to a tooth. In this regard, Vanderstuyft et al reported that the presence of metal objects leads to blooming artifacts resulting in underestimation of buccal plate thickness.[29] Also, Peterson et al evaluated the accuracy of CBCT scans for assessing facial bone height and detecting dehiscence and fenestration defects around teeth. They concluded that CBCT scans may underestimate facial bone height and overestimate the presence of dehiscence and fenestration defects.[30] Therefore, while CBCT scans are useful in treatment planning, they should be interpreted carefully.



## Conclusions

The literature does not provide enough evidence to facilitate defining a threshold with respect to the thickness of buccal bone facial to an implant that precludes vertical or horizontal bone loss. Spray et al provided the only study that demarcated a facial bone thickness benchmark to prevent vertical and horizontal bone resorption.[21] However, no other studies corroborate this finding. Successful implantations have been reported with less buccal bone thickness than previously considered necessary, but long-term investigations assessing these results are lacking. Most articles that suggest a minimum amount of buccal bone thickness facial to an implant that is needed to attain a successful result (eg, 1 mm or 2 mm), except Spray et al, are opinions.

Based on the reported data in this review, the authors draw the following conclusions:

- Implants placed when there is 0.5 mm to 1.83 mm of bone facial to an implant have high survival rates (97% to 100%). However, long-term follow-up is lacking.
- The initial facial bone thickness adjacent to implants may have a direct influence on both vertical and horizontal bone loss. However, no minimum threshold of facial bone thickness to an implant could be defined to prevent additional bone loss. Only one study addressed this issue,[21] but no other investigations could be identified to corroborate its findings.
- Soft-tissue changes were noted after implantations (around 0.5 mm). No threshold for minimum buccal bone thickness could be established to avoid soft-tissue recession.
- Caution should be exercised when interpreting CBCT imaging, because often a thin buccal plate thickness may not be accurately recorded.
- Determining the minimum amount of bone that is needed on the buccal of dental implants to enhance results would be advantageous, because it could help guide the need to perform guided bone regeneration prior to implantations.
- Additional prospective studies are needed to help establish whether there is a minimum buccal bone thickness facial to an implant that can enhance implant results with respect to reducing horizontal and vertical bone loss and avoiding recession.

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