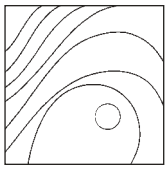
Evaluation of Buccal Plate After Human Bone Allografting: Clinical and CBCT Outcomes of Immediate Anterior Implants in Eight Consecutive Cases



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The aim of this clinical case series was to evaluate buccal bone thickness using cone beam computed tomography and to demonstrate optimal clinical outcomes for implants placed into extraction sockets in the anterior maxilla with a thin biotype, by placing a graft of mineralized and demineralized human bone allograft into the buccal gap. The preliminary outcomes showed good preservation of soft and hard tissue architecture after 1 year in function. In particular, in eight patients, this allograft mixture appeared to minimize the amount of buccal contour change in the extraction site ridge with a thin buccal plate. (Int J Periodontics Restorative Dent 2014;34:e58–e66. doi: 10.11607/prd.1837)

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Implant placement following extraction of a single tooth in the anterior maxilla is a clinical situation often encountered in daily practice. The outcome of placing implants into fresh extraction sockets has been reported to be as predictable as placing implants into healed sites.[1] However, many studies[2–4] reported that recession of the marginal peri-implant mucosa may occur and that this may have an adverse effect on the final esthetic outcome.

Gingival tissue biotype and buccal plate thickness may influence the frequency and extent of marginal gingival recession. Clinical and histologic investigations in dogs[5] and humans[6,7] demonstrated that resorption of alveolar bone after extraction is significantly greater at the buccal side because the buccal socket wall is composed almost entirely of bundle bone. Further, the horizontal and vertical reduction of the maxillary alveolar ridge can lead to facial recession.[8] It was hypothesized that a momentary interruption of blood supply to the buccal plate due to flap elevation may be an important factor.[9,10]

Fig 1 *Initial clinical situation of a 50-year-old woman (patient 2). Preoperative view of the maxillary central incisor: a provisional adhesive prosthesis was cemented on a left central incisor. Discoloration was present on the left lateral incisor, and the canines presented two 4-mm recessions.*

For this reason, some authors recommended positioning implants into extraction sockets with no flap elevation to minimize gingival recession.[11]

It has been proposed that increasing the thickness of the buccal mucosa by using a connective tissue graft beneath the flap may reduce this risk of recession.[12] A bone graft placed into the residual gap between the neck of the implant and the buccal bone wall may also be used.[13] The rationale for the use of regenerative materials is to prevent the migration of cells from the connective and epithelial tissues into this gap, thus supporting the osteoregenerative process. These materials also act as crestal size keepers.[14] Two clinical variables, horizontal gap size and buccal plate thickness, may influence postextractive socket healing. Bone graft materials are proposed when the size of the horizontal gap between the implant surface and the buccal bone wall exceeds 1 to 2 mm.[15] Buccal plate thickness may also significantly influence the amount of new bone fill following immediate implant placement into extraction sockets, as recently suggested.[16,17] For this reason, it is appropriate to use an osteoconductive substance in extraction sockets with a thin buccal plate (≤ 1 mm).[14,18] Nonetheless, these regenerative procedures have reduced but not eliminated buccal bone resorption.[19] At present, there is no optimal bone augmentation technique regarding graft selection during immediate implant placement.[20]

The aim of this clinical case series was to evaluate buccal plate thickness in single-tooth immediate anterior implants placed into fresh extraction sockets without flap elevation, grafting the vestibular gap with a mixture of mineralized and demineralized bone allograft, as described elsewhere, for sinus augmentation procedures.[21]

Method and materials

Eight consecutive patients (four men and four women) with a mean age of 54.7 years (range, 46 to 74 years) were enrolled in this case series. All patients required single-tooth immediate implant placement in maxillary anterior zone extraction sites located from the right lateral incisor to the left lateral incisor and adjacent to natural teeth (Fig 1). A total of eight tapered implants (Tri Dental) were placed into fresh sockets without flap elevation. Inclusion criteria for the study were: patients should be at least 18 years of age, have thin tissue biotype (eg, probe was visible when in place[22]), and have adequate bone volume to support an implant. Exclusion criteria were: poor oral hygiene and motivation, smoking habits, active infection, absence of keratinized mucosa, and lack of occlusal contacts with the opposing dentition. Additional exclusion criteria were the presence of diseases affecting bone metabolism or wound healing; a history of head or neck radiation therapy; regular medicinal consumption of steroids, tetracycline, bisphosphonate, or other medication affecting bone turnover; and patient pregnancy.

Fig 2 *Hopeless root of a left central incisor.*

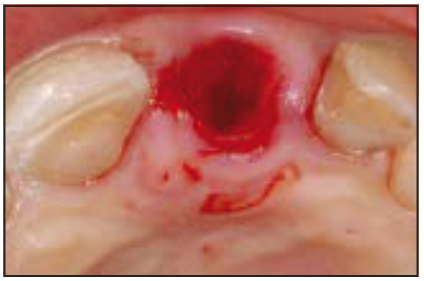

Fig 3 *Alveolar socket after the atraumatic extraction.*

Fig 4 *Occlusal view of the implant showing the buccal gap.*

Fig 5 (left) *The vestibular defect was grafted, and a resorbable collagen wound dressing was applied over the socket and stabilized with a cross suture.*

Fig 6 (right) *The healing abutment was connected.*

Surgical protocol

At the time of implant placement, the surgical area was anesthetized using local anesthesia. As a precaution, the patient received prophylactic antibiotics. The teeth were carefully extracted without flap elevation to maintain the alveolar socket walls and gingival architecture (Figs 2 and 3). The extraction site was cleared of granulation tissue, and osteotomy preparations were performed following the standard surgical protocol recommended by the manufacturer. Prior to immediate implant insertion, all bony walls of the socket existed and remained intact. Buccal plate thickness was measured 3 mm apically from the ridge crest to the center of the mesiodistal aspect of the socket using a sharp caliper (Boley gauge caliper, Hu-Friedy), as described elsewhere.[14]

The implants were placed in the ideal three-dimensional position (Fig 4) using a prefabricated surgical guide.

The horizontal buccal gap between implant and buccal socket wall was measured to the nearest millimeter using a periodontal probe (PW, Hu-Friedy) and grafted with a mixture of 50% cortical mineralized human bone allograft (Oragraft, Lifenet) and 50% demineralized human bone allograft (Readigraft, Lifenet). Following placement of the graft, resorbable collagen wound dressing (Parasorb, Resorba) was applied over the socket and stabilized with a cross suture. The socket was left to heal without primary wound closure (Fig 5).

Immediate loading was not performed for the following reasons: *(1)* adequate wound coverage and protection was sought with collagen dressing to ensure proper graft healing and *(2)* if necessary, an additional increase and/or correction of keratinized tissue could be performed at stage-two surgery.

Provisional adhesive prostheses were cemented. Care was taken to relieve the prostheses to avoid contact with the implants.

Systemic antibiotics were prescribed for an additional 3 days postoperatively with an analgesic to control patient discomfort. The patients were instructed not to brush the surgical site but rinse with 0.12% chlorhexidine gluconate for 10 days. Sutures were removed 10 days postoperatively.

Prosthetic procedures

Four months after placement, implants were reopened and healing abutments were connected (Fig 6). After impressions were made, the

Fig 7 *Definitive crowns; note the resolution of the recessions on the canines using two coronally repositioned flaps performed 4 months earlier.*

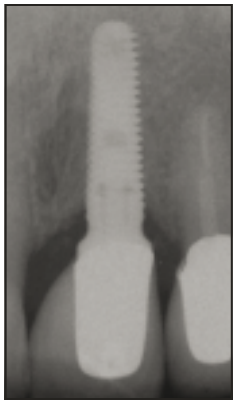

Fig 8 *Radiographic follow-up 1-year after loading.*

Fig 9 *CBCT scan taken 1 year after loading.*

implants were restored with screw-retained provisional resin crowns. The subgingival contour of each provisional crown was concave to promote excellent soft tissue without pushing the facial gingival mucosa apically.

Final impressions were made 5 months after implant placement. Definitive customized abutments with gingival emergence established by the provisional restorations were fabricated and finished abutments were torqued to 35 Ncm. Definitive metal-ceramic or zirconia-ceramic crowns were then cemented (Fig 7).

Clinical and radiographic outcome measurements

The midfacial gingival level was recorded with digital images at rounded 0.5-mm intervals at 1:1 magnification before extraction (baseline) and at the follow-up appointment (after 1 year of loading). The line connecting the midfacial gingival level of the two adjacent teeth was used as the reference. It was ascertained that no gingival recession of the two adjacent teeth had occurred. Changes in marginal level of the implant restoration were measured as its distance from this reference line.

The soft tissue around the implant and neighboring teeth was clinically examined and the following parameters were assessed: Papilla Index Score (PIS)[23] and probing pocket depth (PPD) measured to the nearest millimeter at three sites around the implant (mesiobuccally, distobuccally, and midbuccally).

Buccolingual ridge width at the mesiodistal midpoint between adjacent teeth, 3 mm apically from the gingival margin, was measured using a sharp caliper to calculate the amount of buccal contour change of the extraction site ridge at baseline and follow-up. The points of the caliper were pierced through the soft tissue until they contacted the bone.

Marginal bone loss was analyzed using standardized periapical radiographs obtained with a paralleling device (Rinn Holder) attached to an acrylic jig immediately after definitive crown cementation and 1 year after loading (Fig 8). Periimplant radiographic bone loss was calculated as a mean of mesial and distal bone changes from the baseline values. The implant-abutment junction served as the reference point. The bone level apical or coronal to the above reference point was recorded.

Evaluations of buccal plate thickness and corresponding vertical resorption were performed 1 year after implant loading with a dental cone beam computed tomography (CBCT) scanner[24] (Gendex GX DP-700) (Fig 9). The focal planes of all CBCT scans were directed at the center of the buccolingual aspect of the implant as well as the mesiodistal aspect. Buccal bone thickness was measured to within 1:100 mm using distance measurement tools on the

Fig 10 *Right central incisor with root fracture (patient 8).*

Fig 11 *Provisional restoration after soft tissue healing.*

Fig 12 *Soft tissue tunnel before definitive impression.*

Fig 13 *Subgingival contour of provisional crown.*

Fig 14 *Definitive restoration.*

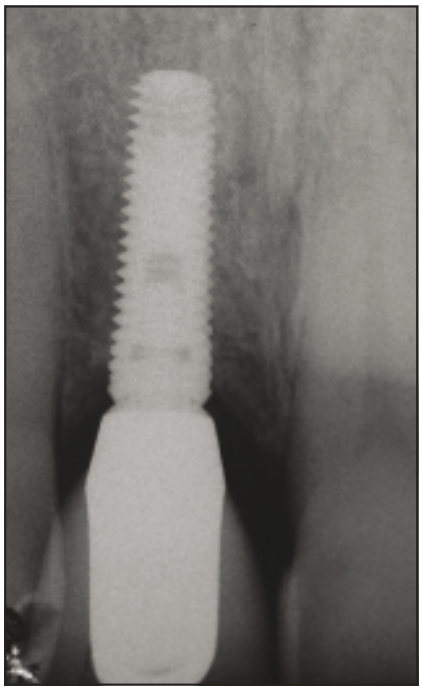

Fig 15 *Radiographic follow-up after 12 months.*

Fig 16 *CBCT follow-up after 12 months.*

CBCT image, perpendicular to the implant surface at 1.5 mm (cervical section thickness) and 5.00 mm (middle section thickness) from the implant platform. Vertical bone resorption was measured from the implant platform to the alveolar crest using distance measurement tools as described elsewhere.[8,25]

All patients signed a specific written informed consent form before undergoing CBCT.

The procedure in patient 8 is shown in Figs 10 to 16.

Results

A total of eight implants were placed in patients with a thin biotype, four in the central incisor position and four in the lateral incisor position (Table 1). The causes of tooth failure were caries (2), endodontic problems (3), advanced periodontitis (2), and trauma (1).

All implants were functioning at the time of the 1-year follow-up examination.

Table 1 Demographic information

Patient	Age (y)	Sex	Smoker	Tooth	Implant diameter (mm)	Implant length (mm)
1	52	Female	No	Right central incisor	3.75	13.0
2	50	Female	No	Left central incisor	3.75	13.0
3	48	Male	No	Left lateral incisor	3.75	11.5
4	46	Male	No	Right central incisor	3.75	13.0
5	53	Male	No	Right lateral incisor	3.75	13.0
6	66	Female	No	Left lateral incisor	3.75	11.5
7	74	Female	No	Right lateral incisor	3.75	13.0
8	49	Male	No	Right central incisor	4.10	13.0

Table 2 Clinical information and outcomes

Patient	BPT (mm)	Gap size (mm)	Gingival recession (mm)	BPT at cervical section 1 y (mm)	BPT at middle section 1 y (mm)	Vertical bone resorption (mm)	Ridge width reduction (mm)
1	≤ 1	3	0	1.98	2.11	0	0
2	≤ 1	1	1	0.68	0.80	1.18	1
3	≤ 1	1	0	0.55	0.84	1.39	1
4	≤ 1	4	0	2.61	2.79	0	0
5	≤ 1	2	0	0.65	1.03	0.89	1
6	≤ 1	2	0	1.21	1.53	0	0
7	≤ 1	1	0	0.84	0.97	1.05	1
8	≤ 1	4	1	1.05	1.17	0.99	1
Mean ± SD		2.25 ± 1.28	0.25 ± 0.46	1.19 ± 0.73	1.40 ± 0.70	0.68 ± 0.58	0.62 ± 0.51

BPT = buccal plate thickness.

Buccal plate thickness before implant placement was ≤ 1mm in each site. Horizontal buccal gap dimension in the eight implant sites was 2.25 ± 1.28 mm (range, 1.0 to 4.0 mm). No gingival recession was present in the facial aspect of six implants. However, 1 mm of gingival recession was present in two implants (patients 2 and 8). Horizontal buccolingual ridge width reduction was 0.62 ± 0.51 mm. The CBCT scans revealed the presence of the buccal alveolar bone in all eight patients after 1 year of loading, and the level of vertical bone loss was 0.68 ± 0.58 mm. The mean thickness of the buccal plate at the cervical level was 1.19 ± 0.73 mm, and the mean thickness at the middle level was 1.40 ± 0.70 mm (Table 2).

The interproximal papillae were present in all implants. Twelve papillae had a PIS of 3 and four distal papillae presented a score of 2.

The PPD around grafted implants was less than 4 mm in all 24 sites examined.

No marginal bone changes greater than 1.5 mm were observed at mesial or distal sites of any of the implants.

Only three complications were observed: three provisional restorations had become loose and were recemented after the first surgical phase.

Discussion

Immediate postextraction implant success depends on several factors, including the ability to obtain primary stability and precise, three-dimensional implant placement.[19] If the extraction has been carried out carefully and the implant has been placed *(1)* 3 mm below the line drawn between the adjacent teeth cementoenamel junction, *(2)* at the center of the predetermined mesiodistal width of the final restoration, and *(3)* slightly lingual to the tooth axis,[20] bone preservation becomes critical for maintaining stability of the gingival buccal margin, which often tends to move apically.[2,4,26] The facial gingival recession found in this case series at the follow-up visit was 1 mm and limited to two patients; specifically, in patients who presented better gingival harmony between the single-tooth implant restoration and neighboring teeth (see Figs 1, 7, 10, and 14). However, the use of a flapless surgery could reduce the stresses to the buccal plate blood supply and minimize bone resorption,[27,28] limiting risk of advanced midfacial recession.[29]

All eight patients presented with an intact buccal bone plate at the follow-up examination. A mean resorption of 0.68 mm was observed regarding the vertical bone height of the buccal bone wall (see Table 2). This limited vertical bone resorption, less than 1.5 mm, is in agreement with other studies,[28,30] and, consequently, the buccal plate was present at the cervical section (measured 1.5 mm from the implant platform) in all eight patients. Nevertheless, Miyamoto et al showed a mean 3.25 mm of vertical bone loss among the seven sites receiving immediate implant placement.[8] This discrepancy can be explained by the placement of an osteoconductive graft with a slow resorption[21,31,32] in the present study, while in Miyamoto's article, only autologous bone graft was used. Another factor that may have preserved crestal bone and ensured more predictable long-term soft tissue levels is the use of platform-switching implants.[33] Grunder et al used the platform-switching technique in the esthetic zone to preserve the buccal plate and reduce cervical cratering.[34]

In this case series, interdental papillae are predictably restored by maintaining the health of the adjacent periodontium. Therefore, an implant may only be prone to papilla loss when the distance from the tip of the papilla to the underlying bone of the adjacent, natural tooth is greater than 4.5 mm.[35] If this distance is ≤ 4.5 mm, papilla growth is extremely predictable. A slight reduction in four distal papillae heights described in this case series was affected by the distance from the bone peak to the contact point and is in agreement with other authors.[36]

The marginal gap that occurs between the implant surface and buccal bone wall in an extraction socket may heal predictably with new bone formation and defect resolution, with[13,15,19] or without[27,30] grafting materials.It has been reported that if the gap is ≥ 1.25 mm, either a bone graft, a membrane, or a combination of the two was performed to facilitate bone healing and regeneration.[37] It is still not well-known whether a thick buccal plate is required or if a thin buccal plate might be sufficient to fill the gap with bone, although some studies have demonstrated significant resorption of the thin buccal plate when no graft was placed.[14,18] On the other hand, a recent clinical and histologic case report showed evidence that immediate implant placement into a fresh extraction socket with a thick buccal plate can result in osseointegration with bone-to-implant contact to the first thread, even in the presence of a 4.2-mm gap.[27]

Only patients with a thin biotype were enrolled in this case series. The facial bone wall of teeth in the anterior maxilla was thin (≤ 1 mm) in all eight patients (see Table 2). For this reason, in accordance with the above studies,[14,18] the residual gap was grafted independent of size in all eight patients, using a mixture of cortical mineralized and demineralized human bone allograft. The cortical allograft is an osteoconductive material with a slow resorption[31,38] and, thus, acts as a crestal size keeper[14] to maintain existing hard and soft tissue architecture. Demineralized bone matrix is considered to have osteoconductive capacity in intraoral edentulous sites[31] and osteoinductive potential, as demonstrated by bone formation when implanted submuscularly in animals.[39,40] This combination should be advantageous in that demineralized bone matrix stimulates

new bone formation and cortical mineralized bone offers a scaffold for bone deposition and remodeling in this crucial area. A healing period of at least 6 to 7 months should allow maturation of newly formed bone tissue, as demonstrated in the sinus elevation procedure.[21] After 1 year of loading, all eight implant sites healed uneventfully with complete bone fill, as revealed by CBCT. In particular, the CBCT scan showed the mean thickness of the buccal plate to be 1.19 mm at the cervical section and 1.40 mm at the middle section. In the three patients with a gap greater than 2.0 mm (patients 1, 4, and 8), a thicker buccal plate was present after 1 year (see Table 2). The mean thickness of the buccal plate of 1.19 mm is in agreement with Degidi el al, who found 0.9 mm at the cervical section after a longer follow-up period[28] and is partially in disagreement with Miyamoto et al, who described only 0.48 mm at the cervical section and 1.19 mm at the middle section,[8] probably due to the different kind of graft used.

This proposed surgical and regenerative protocol appears to reduce unwanted horizontal dimensional alteration of the site, specifically buccal contour reduction of the extraction ridge, to a mean of 0.62 mm; this finding is in agreement with a recent clinical and histologic study that showed 0.55 mm of width reduction in 11 grafted sockets with a thin buccal plate.[14]

Conclusion

This preliminary clinical case series showed good buccal plate preservation of single-tooth immediate anterior implants in fresh extraction sockets with a thin buccal bone, grafting the vestibular gap with a mineralized and demineralized allograft mixture.

A longer observation period, greater sample size, and histologic findings are required to confirm or refute the potentially advantageous properties of this kind of allograft.

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