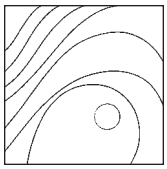
Clinical, Tomographic, and Histologic Evaluation of an Autogenous Bone Graft Harvested from the Maxillary Tuberosity for Guided Bone Regeneration: Case Report with a 4-Year Follow-up



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This report presents a case in which autogenous bone grafts were harvested from the maxillary tuberosity for guided bone regeneration and dental implant placement, with long-term follow-ups and assessment at the clinical, tomographic, and histologic levels. Particulate and block autogenous bone grafts were covered with a resorbable collagen membrane. Advanced bone remodeling and good bone quality, enabling dental implant placement, were observed after a short healing time (3 months). The differences in buccal bone plate thickness in the grafted area between the period immediately after implant placement and 4 years thereafter ranged from +0.879 mm to –0.001 mm. The implants osseointegrated uneventfully, and alveolar bone regeneration remained stable with a satisfactory result after 4 years. Int J Periodontics Restorative Dent 2021;41:e183–e190. doi: 10.11607/prd.4587

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Several intraoral donor sites, primarily the ramus and symphysis, have been used as bone graft sources, but they are associated with limited accessibility, complications, and postoperative morbidity.[1,2] Bone grafts have also been harvested from the maxillary tuberosity in particulate,[1,3,4] block,[5] and both particulate/block form[6,7] to facilitate accessibility of the bone-graft donor area and to reduce morbidity of the donor site and postoperative complications in the treatment of localized bone defects, bone augmentation, and implant placement procedures.

By contrast, the resorption of autologous bone grafts, such as those from the maxillary tuberosity,[6] has been associated with a cancellous and thin cortical structure.[8] Thus, Khojasteh et al[1] added an inorganic particulate bovine bone graft to a maxillary tuberosity graft to increase density and decrease the possibility of resorption. They used either a titanium mesh reinforcement or platelet-rich fibrin and collagen membrane cover to protect the grafts.[1] The use of guided bone regeneration (GBR) in combination with onlay bone grafts has been shown to improve bone retention and increase bone gain with good efficacy and predictability.[9]

GBR with a particulate autogenous bone graft,[10,11] particulate inor-

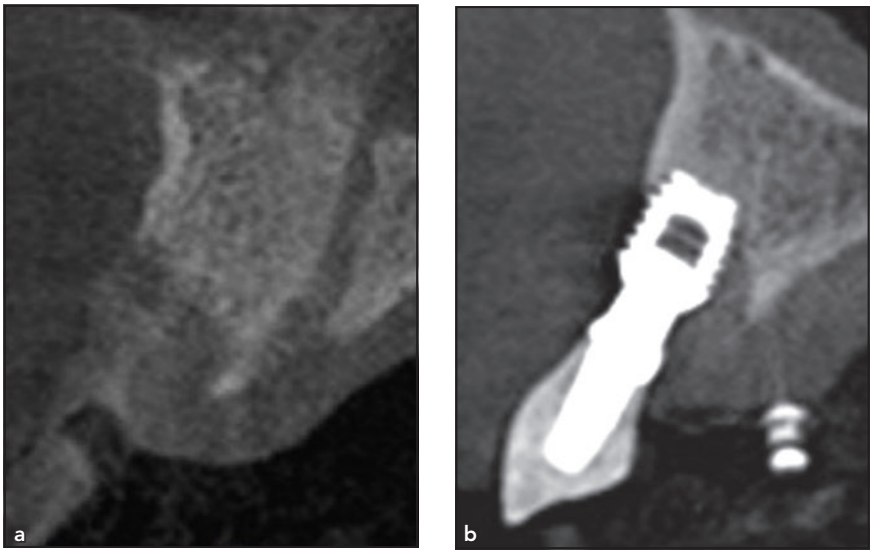

Fig 1 *Preoperative CBCT images of the* (a) *edentulous tooth 11 site (FDI tooth numbering system) and* (b) *the condemned implant at the tooth 12 site. The buccal bone plate was absent in both areas.*

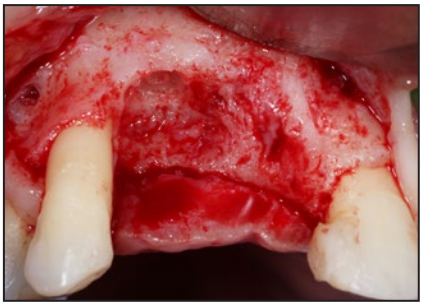

Fig 2 *Clinical view of the horizontal and vertical bone defect.*

ganic bovine bone, alloplastic bone graft,[12] or a 1:1 mixture of particulate inorganic bovine bone and particulate autogenous bone[13–16] has been used for horizontal bone augmentation in the alveolar ridge.[17] It has not yet been extensively investigated whether bone harvested from the maxillary tuberosity as bone graft is efficient to maintain bone augmentation and osseointegration. Previous studies in which the maxillary tuberosity served as the donor site for autogenous bone grafting did not involve a biopsy nor macroscopic or microscopic analysis of the grafts.[1,3–5,7]

This report presents a case in which block and particulate autogenous bone grafts were harvested from the maxillary tuberosity for dental implant placement and shows 4 years of follow-up. The case is examined at the clinical, tomographic, and histologic levels.

Case Report

A 59-year-old, systemically healthy, nonsmoking woman with good oral hygiene and no history of bone-associated disease, cancer, or use of medication affecting bone metabolism was referred to the clinical practice of one of the authors (J.C.M.R.) for vertical and horizontal bone augmentation for the purpose of dental implant placement. Preoperative photographs and radiographs, including CBCT images, were obtained for initial screening and evaluation of the alveolar bone ridge. All images were acquired with an i-CAT device (Imaging Sciences International) using a 0.25-mm voxel size and 7-cm field of view. The lip retractor technique described by Januário et al[18] was applied. The preoperative CBCT examination confirmed the presence of a horizontal and vertical anterior maxillary alveolar ridge bone defect (Fig 1).

Harvesting and Placement of Bone Graft

One author (J.C.M.R.) harvested the bone graft, applying the concepts of GBR, primary wound closure, clot stability, and space maintenance[19] and the use of a double resorbable collagen membrane (Bio-Gide, Geistlich). After administration of local anesthesia, the bone graft recipient site was assessed by raising a full-thickness mucoperiosteal flap over the keratinized tissue and intrasulcular mucosa at the teeth adjacent to the defect, followed by the creation of one vertical releasing incision one tooth distal to the surgical site. A Molt elevator (no. 2/4, Schwert) was then used to raise the full-thickness flap beyond the mucogingival junction and at the palatal aspect. Flap elevation was performed to allow the insertion and stabilization of the collagen membrane with titanium pins (Fig 2). The

Fig 3 *Bone graft blocks were harvested from the maxillary tuberosity.*

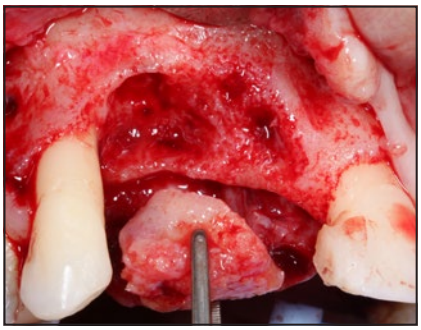

Fig 4 *The shaped corticocancellous block graft was matched to the size and configuration of the bone defect.*

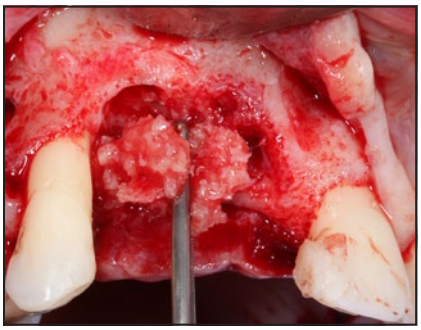

Fig 5 *The corticocancellous particulate graft was placed to fill the bone defect.*

surface irregularities in the recipient bed were smoothed, and the site was prepared with multiple perforations using small-diameter cylindrical burs under copious irrigation with saline solution.[20]

The bone graft was harvested from the maxillary tuberosity as described previously.[20] Briefly, a midcrestal incision was made and extended to the maxillary molar area in combination with a vertical releasing incision, and the full-thickness mucoperiosteal flap was subsequently raised. A block bone graft with dimensions compatible with those of the defect was harvested from the maxillary tuberosity using chisels (IDR Kit, Schwert; Figs 3 and 4). The donor site was then closed with a nylon monofilament 6-0 suture (Resorba) using a single interrupted suturing technique.

The bone graft was divided into particulate and block parts. The particulate part was obtained with the aid of a rongeur and placed on the bone defect (Fig 5). The block part was positioned over the particulate part and fixed to the receptor bed with a bone graft screw (Neodent; Fig 6).

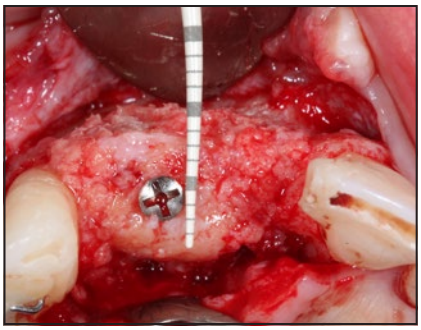

Fig 6 *The corticocancellous block bone graft was screwed over the particulate bone graft.*

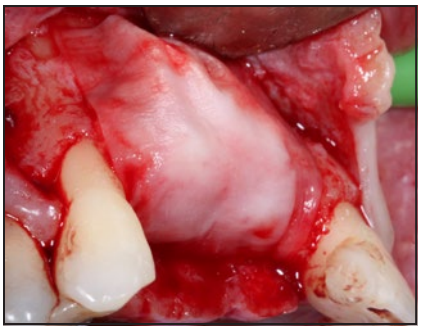

Fig 7 *The resorbable collagen membrane was positioned over the graft.*

Once the collagen membrane had been adapted (Fig 7), a periosteal releasing incision was made until complete tension-free closure of the primary incision was possible. The flap at the graft recipient site was then sutured in two layers. Horizontal mattress sutures were placed from the buccal angle of the flap, and single interrupted sutures were placed over them. Mono-nylon 6.0 (Resorba) was used for all sutures. The sutures were removed 10 days after surgery.

Postoperatively, the patient was prescribed amoxicillin (875 mg) twice a day for 7 days, nimesulide (100 mg) twice a day for 3 days, and acetaminophen (750 mg) every 6 hours on the first day and then as needed. The patient was instructed to rinse her mouth carefully with 0.2% chlorhexidine twice a day for 2 weeks.

Implant Placement and Biopsy Sample Collection

After 3 months of graft healing, CBCT examination demonstrated that the graft was incorporated, and there was sufficient bone augmentation for implant placement (Fig 8a). Two implants (4-mm diameter, 12-mm length; Bone Level Tapered,

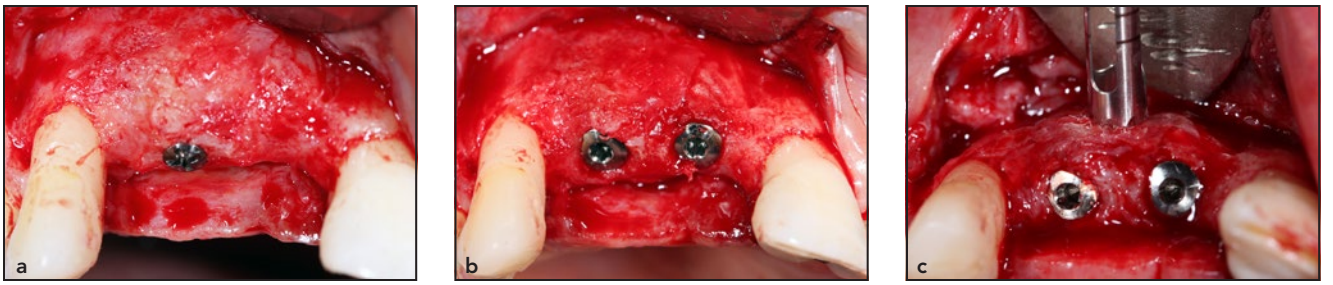

Fig 8 (a) *Buccal view of bone augmentation after 3 months of grafting healing.* (b) *Two implants were placed in the augmented bone.* (c) *A cylindrical biopsy sample was taken from the augmented bone area.*

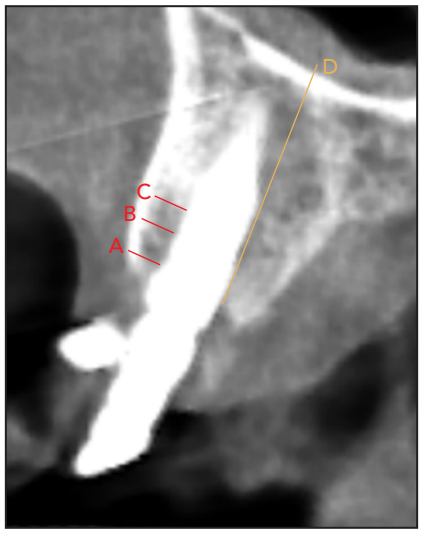

Fig 9 *Measurements taken on CBCT images. Lines A, B, and C were drawn on the buccal bone plate at the platform level and 2 and 4 mm apical of the implant, respectively. Line D was used to determine bone plate height.*

Straumann) were placed in the maxillary right central and lateral incisor positions in the prosthetic 3D position[21] (Fig 8b) with the aid of a surgical guide and 40-Ncm torque.

A biopsy sample was taken at the time of implant placement using a trephine bur with an inner diameter of 3.0 mm, positioned in the vestibular-palatal direction at the alveolar ridge of the grafted area (Fig 8c). The vestibular face of the bone biopsy sample was marked with India ink to allow for spatial orientation during microscopic analysis. The biopsy specimen was fixed in 10% neutral buffered formalin and stored until routine histologic processing.

CBCT Evaluation

CBCT scans were used to determine horizontal and vertical linear dimensions immediately after implant placement and at 2 and 4 years. The i-CAT Vision software (Imaging Sciences International) was used to perform all measurements according to the methodology described by Rosa et al.[7] Sagittal sections (1 mm thick) were obtained by CBCT and assessed by a previously trained examiner (B.S.S.M.). The examiner performed four measurements on the central sagittal section of each implant using Image Tool software. Measurement A was the perpendicular line extending from the outer border of the bone crest to the implant platform. Measurements B and C were parallel apical lines extending 2 mm and 4 mm, respectively, from the outer border of the bone crest to the implant. Measurements A, B, and C were used to determine the degree of buccal bone plate thickness preservation. Measurement D was the line extending from the most cervical point of the bone crest to the lowest point of the concavity of the nasal cavity and was used to determined bone plate height (Fig 9).

Histologic Evaluation

The biopsy sample was decalcified in 7% ethylenediaminetetraacetic acid and processed routinely for light microscopy. A trained examiner (L.A.V.P.) performed the histologic analysis. The following histologic parameters were recorded as described in de Freitas et al,[22] with modifications: vital bone and mature newly formed bone (both scores ranged from 1 [none] to 5 [all]); bone lining cells and osteoblasts, osteoclasts (both scores ranged from 1 [limited presence] to 5 [abundance]); and bone marrow (score ranging from 1 [fibrous] to 5 [typical cellularity and blood vessels]).

Macroscopic analysis of the biopsy sample showed a well-consolidated cylindrical core

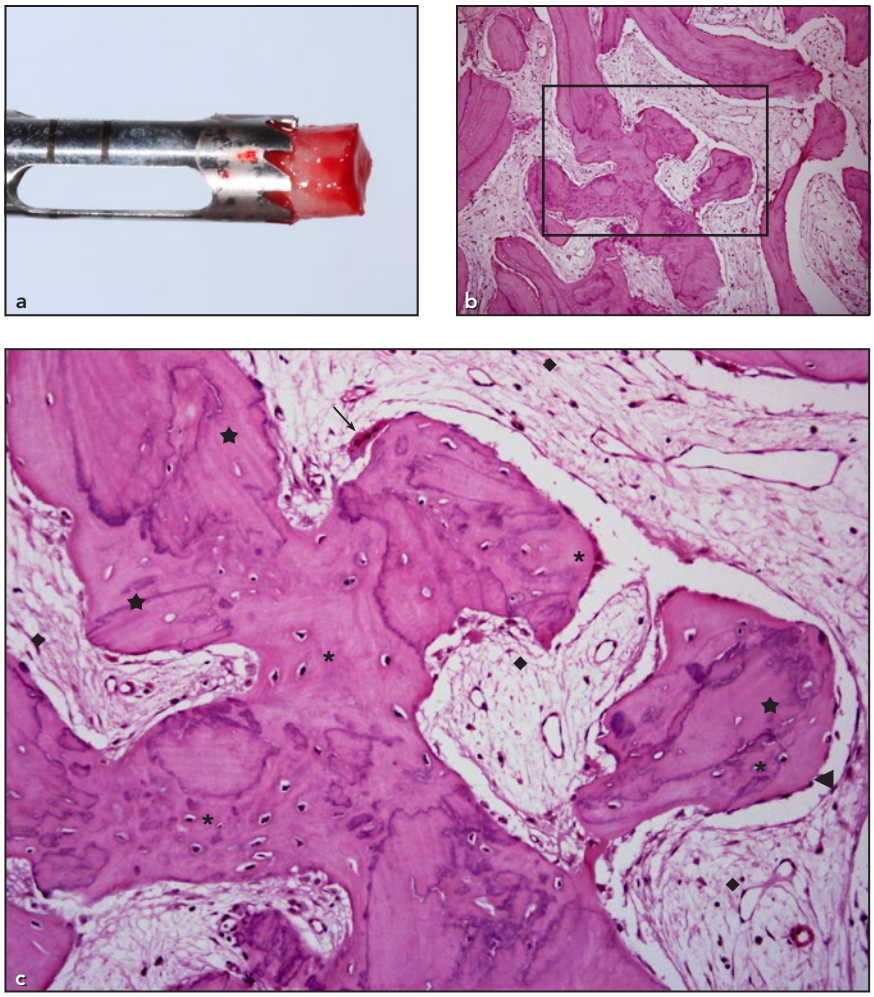

Fig 10 (a) *The cylindrical core biopsy sample.* (b) *Representative section viewed at a low magnification (×10).* (c) *Higher magnification (×20) of the area within the black frame in Fig 11b. Newly formed bone (asterisk), nonvital bone (star), blood marrow (diamond), bone lining cells (arrowhead), and an osteoclast (arrow) are visible.*

(Fig 10a), and histologic analysis showed lines of osteoblast-forming osteoids, the predominance of newly formed bone (lacunae with osteocytes and immature bone), few areas of nonvital grafted bone (empty osteocyte lacunae), and no sign of bone marrow alteration (Figs 10b and 10c). No histologic evidence of the collagen membrane was observed. Scores were 3 for vital bone, 2 for mature newly formed bone, 3 for osteoblasts, 2 for osteoclasts, and 5 for bone marrow.

Long-Term Outcomes

No postoperative or prosthetic complication or graft displacement was observed during the 4-year evaluation period. The differences in buccal bone plate thickness in the grafted area between the period immediately after implant placement and 4 years (Fig 11) thereafter ranged from –0.00 mm to +0.88 mm (Table 1).

Discussion

Autogenous, xenogenous, and allogenous bone grafts and GBR have yielded clinically satisfactory results for subsequently placed implants.[2,12–14,16,17,23,24] In the present case, the use of an autogenous bone graft harvested from the maxillary tuberosity enabled the placement of dental implants after a short (3-month) healing period. Advanced bone remodeling was observed at the time of implant placement, and the thickness of the buccal bone plate was maintained.

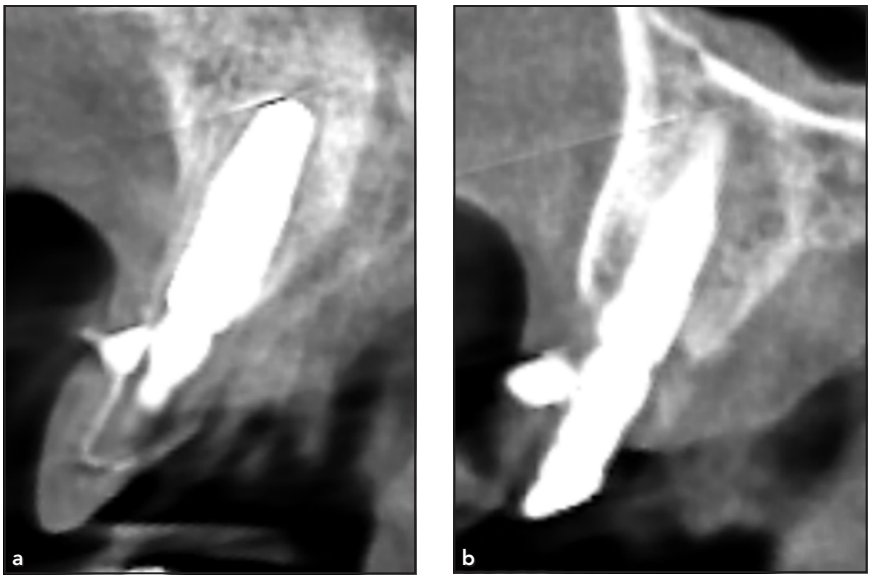

Fig 11 *CBCT images of the augmented buccal bone plate at implant sites* (a) *11 and* (b) *12 after 4 years of follow-up.*

Table 1 Clinical and Tomographic Information and Outcomes

Implant no.	Tooth (FDI), implant size, insertion torque	Grafted area at implant placement, mm	2-y follow-up, mm	Difference from implant placement to 2 y, mm (%)	4-y follow-up, mm	Difference from implant placement to 4 y, mm (%)	Difference from 2 y to 4 y, mm (%)
1	Tooth 11, 4.0 × 12 mm, 40 Ncm	Line A: 0	0	0	0.879	+0.879	+0.879
		Line B: 0.650	0.764	+0.114 (+17.5%)	1.352	+0.702 (+108%)	+0.588 (+77.0%)
		Line C: 1.517	1.496	–0.021 (–1.4%)	1.516	–0.001 (–0.07%)	+0.020 (+1.3%)
		Line D: 15.389	15.830	+0.441 (+2.8%)	15.154	–0.235 (–1.5%)	–0.676 (–4.3%)
2	Tooth 12, 4.0 × 12 mm, 40 Ncm	Line A: 1.759	1.646	–0.113 (–6.4%)	1.986	+0.227 (+12.9%)	+0.340 (+20.7%)
		Line B: 2.490	2.451	–0.039 (–1.6%)	2.754	+0.264 (+10.6%)	+0.303 (+12.4%)
		Line C: 2.548	2.654	+0.106 (+4.2%)	3.089	+0.541 (+21.2%)	+0.435 (+16.4%)
		Line D: 12.863	14.287	+1.424 (+10.0%)	15.040	+2.177 (+16.9%)	+0.0753 (+5.3%)

Line A = the perpendicular line extending from the outer border of the bone crest to the implant platform; Lines B and C = parallel apical lines extending 2 mm and 4 mm, respectively, from the outer border of the bone crest to the implant. Line D = the line extending from the most cervical point of the bone crest to the lowest point of the concavity of the nasal cavity.
Measurements A, B, and C were used to determine the degree of buccal bone plate thickness preservation. Line D was used to determined bone plate height.

The histologic scores for bone parameters at the time of implant placement were high and consistent with the accelerated bone formation observed in grafts containing autogenous bone particles, which leads to more rapid dental implant osseointegration, earlier graft consolidation, and the possibility of earlier implant loading.[10]

The positive results using autogenous bone graft in the present

case can be attributed to the osteogenic, osteoinductive, and osteoconductive[2,25] properties of this material, despite the cancellous and thin cortical structure of the maxillary tuberosity. The cancellous bone of such corticocancellous grafts may be condensed mechanically during graft crushing or screwing, which increases graft bone density while maintaining bone volume during remodeling. In addition, large bone graft particles obtained with rongeurs were used in this case rather than small particles (chips), which may have preserved the total bone volume.[26]

Cicconetti et al[27] described the osteogenic activities of the maxillary tuberosity: Cells from this structure form bone in vivo following a phase of ex vivo expansion. In a cell culture assay, cells derived from graft-like fragments of the maxillary tuberosity showed an increase in the index of proliferation over time and displayed alkaline phosphatase (ALP) activity, extracellular mineralized matrix, and gene expression of bone markers (ALP, RUNX2, bone sialoprotein, osteopontin, osteocalcin, and distal-less homeobox 5), confirming their osteogenic potential.[28] Finally, using the maxillary tuberosity for bone regeneration is ideal because this structure provides a natural scaffold (for osteoconduction) filled with osteoblastic cells and growth factors.[27,28] In autografted bone, osteoblasts in the graft contribute primarily to the early phase of forming new bone, and grafted cells may contribute to the recruitment of mesenchymal cells into the graft bed.[29]

Bone grafts harvested from the maxillary tuberosity have not been used extensively because they were thought to be of poor quality and because the tuberosity is often small[1] and difficult to access, especially in patients with small mouth openings and/or third molars.[30] All of these factors may limit the bone volume available for harvesting. Nevertheless, accurate CBCT evaluation of the maxillary tuberosity provides valuable clinical information that aids surgeons in harvesting bone from the maxillary tuberosity.[6]

Conclusions

Although good results are seen from the clinical, tomographic, and histologic aspects of the block graft associated with the particulate graft harvested from the maxillary tuberosity in the present reported case, more clinical case evaluations and longer observation periods are required to determine the long-term outcomes of such graft procedures.

Acknowledgments

The authors declare no conflicts of interest.

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