Efficacy of Cancellous Block Allograft Augmentation Prior to Implant Placement in the Posterior Atrophic Mandible

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ABSTRACT

Background: The present study evaluated the outcome of ridge augmentation with cancellous freeze-dried block bone allografts in the posterior atrophic mandible followed by placement of dental implants.

Materials and Methods: A bony deficiency of at least 3 mm, horizontally, vertically, or both, according to computerized tomography (CT) para-axial reconstruction served as inclusion criteria. Implants were inserted after a healing period of 6 months. Bone measurements were taken prior to bone augmentation, during implant placement, and at second-stage surgery. Marginal bone loss and crown-to-implant ratio were also measured.

Results: Twenty-nine cancellous allogeneic bone blocks were placed in 21 patients. The mean follow-up was 37 months. Bone block survival rate was 79.3%. Mean horizontal and vertical bone gains were 5.6 and 4.3 mm, respectively. Mean buccal bone resorption was 0.5 mm at implant placement and 0.2 mm at second-stage surgery. A total of 85 implants were placed. Mean bone thickness buccal to the implant neck was 2.5 mm at implant placement and 2.3 mm at second-stage surgery. There was no evidence of vertical bone loss between implant placement and second-stage surgery. Implant survival rate was 95.3%. All patients received a fixed implant-supported prosthesis. At the last follow-up, the mean marginal bone loss was 0.5 mm. The mean crown-to-implant ratio was 0.96.

Conclusion: Implant placement in the posterior atrophic mandible following augmentation with cancellous freeze-dried bone block allografts may be regarded as a viable treatment alternative.

KEY WORDS: augmentation, cancellous block allograft, crown-to-implant ratio, implant, posterior mandible

INTRODUCTION

Tooth loss in the posterior mandible is followed by a reduction of alveolar bone, leading to knife-edge ridges in the severely atrophic cases.^{1–4} Moreover, a deficiency

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of alveolar height may preclude implant placement.⁵ A biomechanically stable bone implant foundation is indispensable for the long-term success of fixed implant-supported prosthesis in the posterior mandible.^{5,6}

The increased biting forces in the posterior mandible result in a variety of stress elements.^{7–9} The opposing arch and crown-to-implant ratio require additional considerations.^{10,11} Biomechanical complications in the posterior mandible, such as crestal bone loss, screw loosening, occlusal material fracture, prosthesis wear, and fracture and implant failure, are often the result of excessive stresses caused by the increased biting forces.^{10–12} Treatment planning in the posterior mandible must therefore include solutions to reduce excessive stresses: eliminating lateral interferences during excursive movements; reducing the occlusal table

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Key findings – cancellous bone block allografts are aviable treatment alternative for alveolar ridge augmentation in the posterior mandible

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relative to the implant diameter, or maximizing the diameter of implants to minimize off-axis forces; shortening or removing cantilevers; and increasing the number of implants.^{6,10,11}

Ridge augmentation enables the use of longer and wider implants, increasing the surface area over which the stresses of occlusal forces are distributed.^{5,6} Several treatment options have been suggested to address these challenges.^{13–15} These include subperiosteal tunneling technique, guided bone regeneration, block grafts, interpositional grafts, and distraction osteogenesis.

An exhaustive search of the most effective augmentation technique for specific clinical indications did not reach conclusive answers.¹⁶ The conclusion of the review was that major bone grafting procedures may not be justified in extremely resorbed mandibles.¹⁶

Preliminary reports^{17–24} suggest that block allografts may be an acceptable alternative to the autogenous block grafts in the treatment of compromised alveolar ridges. The hypothesis of the present study was that augmentation with cancellous bone block allograft prior to implant placement is a valid treatment approach for the atrophic posterior mandible.

MATERIALS AND METHODS

The study comprised of 21 consecutive patients in whom 29 cancellous block grafts (ReadiGraft, Canblock 1.5, LifeNet, Virginia Beach, VA, USA) and 85 dental implants (59-Seven MIS Implant Technologies, Shlomi, Israel) and 26-Osseotite[®] (3i/Implant Innovations, Biomet, Palm Beach Gardens, FL) were placed. The patient group comprised 18 women and 3 men, with an age range from 40 to 65 years at the date of implant surgery (mean age was 55.7 ± 7.6 years).

The systemic health and status of all remaining teeth were comprehensively evaluated. The patients were determined to be in good health, and the medical history review suggested no contraindications to implant therapy. Patients with a mandibular alveolar ridge requiring a vertical and/or lateral augmentation increase >3 mm were included in this study.

Oral examination focused on intra-arch relationship, the buccolingual width and the intermaxillary relationship (Figure 1A). Panoramic radiographs (OPT) and computed tomography (CT) scans were considered mandatory to provide adequate diagnostic information about ridge width and height deficiency. The ridge



Figure 1 *A*, Missing mandibular right first and second bicuspid, first and second molars. *B*, Preoperative computed tomography indicating relative narrow crestal bone.

dimensions could be assessed accurately in the paraaxial reconstructions (see Figure 1B).

A staged approach was planned to reduce potential complications that have been associated with simultaneous grafting and implant placement.¹⁷ All procedures were fully explained to the patients, and the Ethics Committee of the Tel Aviv University approved the study protocol.

One hour preoperatively, oral antibiotics of 1,000 mg amoxicillin (Moxypen Forte, Teva Pharmaceutical, Petach Tikva, Israel) and 600 mg Etodolac (Etopan, Taro Pharmaceutical Industries, Haifa Bay, Israel) were administered. Antiseptic mouthwash, 0.2% chlorohexidine gluconate (Tarodent, Taro Pharmaceutical Industries) was used immediately prior to surgery.

A crestal incision, centered in the keratinized tissue, through the edentulous span and retromolar pad was designed to allow a minimum of 1 to 2 keratinized gingiva on both sides of the flap. In most cases, this was slightly to the lingual side. In cases where sufficient keratinized gingival was available, a midcrestal incision was performed. A distal oblique releasing incision into the buccinator muscle posteriorly and a vertical releasing incision mesial to the most distal tooth were made on the labial aspect. A full-thickness mucoperiosteal lingual flap was initially reflected with extreme caution to prevent tears in the periosteum. The flap was further mobilized lingually away from the mylohyoid line. The



Figure 2 *A*, Block grafts shaped, positioned, and fixated. *B*, Block grafts covered by particles. *C*, Block grafts covered by resorbable collagen membrane.

buccal aspect of the alveolar ridge was then exposed via subperiosteal dissection to allow three-dimensional visualization of the defect. Visualization of the mental neurovascular bundles was mandatory. Periostealreleasing incisions to allow primary closure of the soft tissue were made on the buccal aspect immediately following flap elevation. Multiple perforations through the cortical plate were made with a round bur to ensure communication between the grafted bone and the bone marrow cavity. The allograft was rehydrated with a solution of sterile saline for at least 45 minutes prior to use. A $3 \times 1.5 \times 1.5$ -cm cube of freeze-dried cancellous block graft (ReadiGraft) was refined to fit into the defect. Once the graft was seated and stable, it was fixed with $1.6 \text{ mm} \times 10 \text{-mm}$ bone screws (OsteoMed Corporation, Addison, TX, USA) (Figure 2A). A large, round bur was used to round the sharp edges and shape it to completely conform to the defect site. Deficiencies at the edges of the graft were filled with particulate bone, mineralized freeze-dried bone allograft (OraGraft, Lifenet), or bovine bone mineral (Bio-Oss, Geistlich Pharma, Wolhusen, Switzerland) (see Figure 2B) randomly. Three resorbable membranes (Ossix Plus, OraPharma, Carlsbad, CA, USA; Ossix, 3i/Implant Innovations, Biomet; and Bio-Gide, Geistlich Pharma, Wolhusen, Switzerland) were used randomly (see Figure 2C).

Measurements of the augmented ridge width and height were taken with a UNC periodontal probe (Hu-Friedy, Mfg. Co., Inc., Leimen, Germany). The midcrestal incision was initially closed by using interrupted and horizontal mattress sutures. The vertical incision was secured with interrupted sutures. Amoxicillin (Moxypen Forte, Teva Pharmaceutical) 500 mg tid and 600 mg Etodolac (Etopan, Taro Pharmaceutical Industries) bid were prescribed P.O. for 5 days postoperatively. As an antiseptic solution, 0.2% chlorohexidine gluconate (Tarodent, Taro Pharmaceutical Industries) mouthwash was used for 45 seconds, tid for 2 weeks.

Removable provisional restorations were not used for the entire healing time (6 months). Whenever possible, fixed partial provisional restorations were fitted and delivered to the patient immediately after surgery.

The patients were seen weekly during the first month following surgery and monthly thereafter until second-stage surgery. Periapical radiographs were taken immediately postoperatively and 2 to 3 months after surgery. A thorough search for soft tissue dehiscence and an overall view of the grafted ridge contour were the most important evaluations (Figure 3A).

New panoramic radiographs and CT scans were obtained after 6 months to determine implant width and length (see Figure 3B). Access to the augmented ridge was obtained via a midcrestal incision. The fixation screws were removed. Measurements of additional ridge width and height were taken with a UNC periodontal probe (Hu-Friedy). The implant sites were selected with a diagnostic template (see Figure 3C). The residual buccal thickness following implant placement was measured and repeated at the time of second-stage surgery to further evaluate the bone resorption and determine the horizontal bone dimension.



Figure 3 *A*, Clinical view after 6 months. *B*, Postoperative computed tomography after 6 months. Note bone thickness. *C*, Standard-diameter and standard-length implants in place.

Implants were exposed 3 months later. The soft tissues were allowed to mature for 3 weeks prior to definitive restorative phase (Figure 4A). The implants were restored with cement-retained fixed ceramic prostheses. Temporary cement (Temp Bond, Kerr Italia, Salerno, Italy) was used to enable future maintenance and follow-up. Clinical and radiographic examinations were carried out at the time of restoration, every 6 months follow-up during the first year, and once a year thereafter (see Figure 4B).

All radiographs were made by an experienced radiologist using the long-cone technique and the Rynn system (XCP Instruments, Dentsply Rinn, Rinn Corporation Elgin, IL, USA). The radiographic films were



Figure 4 *A*, Final restoration. *B*, Radiograph of final restoration at 24-month follow-up.

scanned to digital files. The scanned images were studied by using Adobe Photoshop Software (Adobe Systems Inc., San Jose, CA, USA). The landmarks were taken by two examiners. Crestal bone level was calculated as the perpendicular distance from the implant shoulder to the first visible apical bone to implant contact in the mesial and distal aspect of the implant. The crown-to-implant ratio was calculated by direct measurements. Each crown length was measured from the most coronal aspect of the crown to the alveolar crest level. Each implant length was measured from the alveolar crest level to the most apical implant level. The crown-toimplant ratios were calculated by dividing the length of the crown by the length of the implant. Changes in crestal bone level were calculated at second-stage surgery, prosthesis delivery, and last follow-up.

Two-tail Student's *t*-test served for statistical analysis to compare bone gain and resorption.

RESULTS

A total of 21 patients (18 females and 3 males) aged 40 to 65 years (mean 55.7 \pm 7.6 years) were included in the study. Twenty-nine cancellous allogeneic bone blocks were used. Of the blocks, 62% were used to gain width and 38% to gain both height and width. The mean follow-up was 37 \pm 17 months (range: 6–60 months). Six bone blocks failed, resulting in 79.3% survival rate. Bone width at implant placement (7.9 \pm 0.5 mm) was

TABLE 1 Bone Characteristics (mm)					
	N	Range	Mean	SD	SE
Bone gain					
Horizontal	23	3–6	5.6	1	0.2
Vertical	11	3–7	4.3	1.6	0.5
Buccal resorption					
Implant placement	85	0-1	0.5	0.5	0.05
Second stage	79	0-0.5	0.2	0.2	0.02
Buccal thickness					
Implant placement	85	2–3	2.5	0.5	0.05
Second stage	79	2-2.5	2.3	0.2	0.02

significantly (p < .001) higher than initial bone width $(2.3 \pm 0.5 \text{ mm})$. A nonsignificant resorption of 0.4 mm (5%) was noted from graft placement to implant placement (p = .1). Bone gain in horizontal dimension $(3-6 \text{ mm}; \text{ mean: } 5.6 \pm 1 \text{ mm})$ exceeded bone gain in vertical dimension $(3-7 \text{ mm}; \text{mean: } 4.3 \pm 1.6 \text{ mm})$ significantly (p = .047) (Table 1). Buccal bone resorption rate was 0-1 mm (mean: $0.5 \pm 0.5 \text{ mm}$) at implant placement and 0–0.5 mm (mean: 0.2 ± 0.2 mm) at second-stage surgery (see Table 1). Those results were not statistically significant (p = .1). A total of 85 implants were placed. Mean implant diameter was 3.9 ± 0.2 mm (range: 3.7-4.2 mm). Mean implant length was 10.4 ± 0.7 mm (range: 10–11.5 mm). Bone thickness buccal to the implant neck was 2-3 mm (mean: 2.5 ± 0.5 mm) at implant placement and 2-2.5 mm (mean: $2.3 \pm 0.2 \text{ mm}$) at second-stage surgery (Table 1). Those results were not statistically significant (p = .3). There was no evidence of vertical bone loss between implant placement and second-stage surgery.

Four implants (95.2% survival rate) failed 4 to 6 weeks after insertion. After 2 months of waiting, the implants were reinserted and successfully osseointegrated. All patients received a fixed implant–supported prosthesis. No further implants were lost in function. There was no recordable marginal bone loss at secondstage surgery and prosthesis delivery. At the last followup, the mean crestal bone loss was 0.5 ± 0.2 mm (range: 0-1 mm). The mean crown-to-implant ratio was 0.96 ± 0.16 :1 (range: 0.6-1.2).

DISCUSSION

Bone grafting has the potential to increase the number, length, and diameter of implants that can be placed in the posterior mandible. Cancellous block allografts for posterior mandibular reconstruction allowed the placement of several implants with standard length and diameter, enabling a stable long-term prognosis to the implant-supported reconstruction.

The use of allografts prevented donor site morbidity. Autogenous graft morbidity involves impaired tactility and sensitivity of the soft tissues and increased lamina dura and apical pathology in the involved teeth.²⁵ The donor site may show good remineralization, yet a radiologically noticeable concavity may remain in the majority of cases.²⁵ Moreover, existing data suggest that the majority of the osteocytes of the autogenous bone block do not survive grafting. The grafted nonvital bone is progressively remodeled into new vital bone after grafting.²⁶ Therefore, although autogenous bone is considered historically the "gold standard" because of the biologic processes involved, the participation of autogenous grafted cells in osteogenesis can be questioned when bone blocks are used.

Minimal graft resorption $(0.5 \pm 0.5 \text{ mm})$ was noted during the 6-month waiting period between cancellous block grafting and implant placement. The ability of bovine bone to reduce bone resorption of onlay block grafts was previously studied.²⁷ The results indicated that coverage with bovine bone mineral can compensate for the natural bone resorption caused by remodeling. Similar results were obtained when autogenous bone blocks were covered with bovine bone mineral and noncross-linked collagen membrane.28 Similar to the one obtained in the present study, A 10% resorption rate of the initial graft was recorded. It was concluded that the use of bovine bone mineral and collagen membrane coverage allowed such a minimal resorption. In the present study, particulate bone, mineralized freeze-dried bone allograft, or bovine bone mineral was used in conjunction with resorbable membranes. The minimal resorption noted is thus attributable to the coverage with particulate bone and collagen membranes.

A recent study²⁹ evaluated the clinical outcome of standard length implants inserted into alveolar bone sites previously augmented with allograft. The implant survival rate was 97.6%. The results indicated that standard length implants had a high survival and success rate, similar to those reported in previous studies of two-stage procedures in nongrafted bone. The researchers concluded that allograft is a reliable material for alveolar reconstruction and implant insertion. The same group reported 1 year later³⁰ the results of standarddiameter (3.75 mm) implants inserted into allografts. The survival rate was 99.2%. In the present study, bone grafting enabled the use of standard-diameter (range: 3.7–4.2 mm) and standard-length (range: 10–11.5 mm) implants. The survival rate (95.3%) compares well with the above-obtained results.

However, both studies^{29,30} recorded a greater marginal bone loss when fixed prosthetic restorations were used. In the present study, marginal bone loss was minimal (mean: 0.5 ± 0.2). It can be suggested that the use of particulated bone and barrier membranes allowed better ossification, minimizing further marginal bone loss. Moreover, buccal bone thickness at second-stage surgery exceeded 2 mm in the present study. It was previously demonstrated that, as the buccal bone thickness approaches 1.8 to 2 mm, marginal bone loss decreases significantly.³¹ Therefore, the goal of lateral augmentation should be at least 2 mm buccal to the implant to minimize future marginal bone loss.

An unfavorable crown-to-implant ratio has the potential to increase marginal bone loss.³² The use of standard-length implants in the present study resulted in a favorable crown-to-implant ratio (range: 0.6–1.2). The traditional prosthetic concept was that a ratio of 1:1 is the minimum acceptable for a fixed prosthesis abutment. A greater ratio may be applied only if the occlusal forces are decreased.³³ Although the concept of unfavorable crown-to-implant ratios is contradictory, the existing studies are limited.^{32,34–36} Thus, until proven otherwise, although not the primary goal of bone grafting, a favorable crown-to-implant ratio can be considered beneficial for the long-term prognosis.

The overall block graft success rate was 79.3%. Higher success rates were reported for the anterior maxilla (95.6%).²⁴ A lower prognosis (87%) in the posterior mandible was also noted with corticocancellous block allografts. Most of the allograft failures (71%) in this study occurred in the posterior mandible.²¹ It has been suggested, by clinical experience, that mandibular grafting might be less predictable than grafting in the maxilla.⁵ The high failure rate of the block grafts may be attributable to a compromised blood supply in this area,⁵ although this awaits future evidence-based data.

CONCLUSION

Implant placement in the posterior atrophic mandible following augmentation with cancellous freeze-dried bone block allografts may be regarded as a viable treatment alternative.

REFERENCES

- Atwood DA. Some clinical factors related to rate of resorption of residual ridges. J Prosthet Dent 1962; 12:441–450.
- 2. Atwood DA. Reduction of residual ridges: a major disease entity. J Prosthet Dent 1971; 26:266–279.
- Tallgren A. The continuing reduction of the residual alveolar ridges in complete denture wearers: a mixed-longitudinal study covering 25 years. J Prosthet Dent 1972; 27:120–132.
- 4. Worthington P, Rubenstein JE. Problems associated with the atrophic mandible. Dent Clin North Am 1998; 42:129–160.
- Bahat O, Fontanessi RV. Efficacy of implant placement after bone grafting for three-dimensional reconstruction of the posterior jaw. Int J Periodontics Restorative Dent 2001; 21:220–231.
- Pikos MA. Block autografts for localized ridge augmentation. Part II. The posterior mandible. Implant Dent 2000; 9:67–75.
- 7. Devlin H, Wastell D. The mechanical advantage of biting with the posterior teeth. J Oral Rehabil 1986; 13:607–610.
- Gibbs CH, Mahan PE, Lundeen HC, Brehnan K, Walsh EK, Holbrook WB. Occlusal forces during chewing and swallowing as measured by sound transmission. J Prosthet Dent 1981; 46:443–449.
- Mericske-Stern R, Assal P, Mericske E, Bürgin W. Occlusal force and oral tactile sensibility measured in partially edentulous patients with ITI implants. Int J Oral Maxillofac Implants 1995; 10:345–353.
- Misch CE, Goodacre CJ, Finley JM, et al. Consensus conference panel report: crown-height space guidelines for implant dentistry-part 1. Implant Dent 2005; 14:312–318.
- Misch CE, Goodacre CJ, Finley JM, et al. Consensus conference panel report: crown-height space guidelines for implant dentistry-part 2. Implant Dent 2006; 15:113–121.
- 12. Goodacre CJ, Bernal G, Rungcharassaeng K, Kan JY. Clinical complications with implants and implant prostheses. J Prosthet Dent 2003; 90:121–132.
- McAllister BS, Haghighat K. Bone augmentation techniques. J Periodontol 2007; 78:377–396.
- Chiapasco M, Abati S, Romeo E, Vogel G. Clinical outcome of autogenous bone blocks or guided bone regeneration with e-PTFE membranes for the reconstruction of narrow edentulous ridges. Clin Oral Implants Res 1999; 10:278–288.
- Aghaloo TL, Moy PK. Which hard tissue augmentation techniques are the most successful in furnishing bony support for implant placement? Int J Oral Maxillofac Implants 2007; 22(Suppl): 49–70.

- Esposito M, Grusovin MG, Coulthard P, Worthington HV. The efficacy of various bone augmentation procedures for dental implants: a Cochrane systematic review of randomized controlled clinical trials. Int J Oral Maxillofac Implants 2006; 21:696–710.
- 17. Leonetti JA, Koup R. Localized maxillary ridge augmentation with a block allograft for dental implant placement: case reports. Implant Dent 2003; 12:217–226.
- Lyford RH, Mills MP, Knapp CI, Scheyer ET, Mellonig JT. Clinical evaluation of freeze-dried block allografts for alveolar ridge augmentation: a case series. Int J Periodontics Restorative Dent 2003; 23:417–425.
- Keith Jr JD. Localized ridge augmentation with a block allograft followed by secondary implant placement: a case report. Int J Periodontics Restorative Dent 2004; 24:11– 17.
- 20. Petrungaro PS, Amar S. Localized ridge augmentation with allogeneic block grafts prior to implant placement: case reports and histologic evaluations. Implant Dent 2005; 14:139–148.
- 21. Keith JD Jr, Petrungaro P, Leonetti JA, et al. Clinical and histologic evaluation of a mineralized block allograft: results from the developmental period (2001–2004). Int J Periodontics Restorative Dent 2006; 26:321–327.
- 22. Nissan J, Romanos GE, Mardinger O, Chaushu G. Immediate nonfunctional loading of single-tooth implants in the anterior maxilla following augmentation with cancellous freeze-dried block allograft: a case series. Int J Oral Maxillofac Implants 2008; 23:709–716.
- Chaushu G, Mardinger O, Calderon S, Moses O, Nissan J. The use of cancellous block-allograft for sinus floor augmentation with simultaneous implant placement in the posterior atrophic maxilla. J Periodontol 2009; 80:422– 428.
- Nissan J, Mardinger O, Calderon S, Romanos GE, Chaushu G. Cancellous bone block-allografts for the augmentation of the anterior atrophic maxilla. Clin Implant Dent Relat Res (in press).
- Weibull L, Widmark G, Ivanoff CJ, Borg E, Rasmusson L. Morbidity after chin bone harvesting – a retrospective longterm follow-up study. Clin Implant Dent Relat Res 2009; 11:149–157.

- Zerbo IR, de Lange GL, Joldersma M, Bronckers AL, Burger EH. Fate of monocortical bone blocks grafted in the human maxilla: a histological and histomorphometric study. Clin Oral Implants Res 2003; 14:759–766.
- Maiorana C, Beretta M, Salina S, Santoro F. Reduction of autogenous bone graft resorption by means of bio-oss coverage: a prospective study. Int J Periodontics Restorative Dent 2005; 25:19–25.
- von Arx T, Buser D. Horizontal ridge augmentation using autogenous block grafts and the guided bone regeneration technique with collagen membranes: a clinical study with 42 patients. Clin Oral Implants Res 2006; 17:359–366.
- 29. Franco M, Tropina E, De Santis B, et al. A 2-year follow-up study on standard length implants inserted into alveolar bone sites augmented with homografts. Stomatologija 2008; 10:127–132.
- Viscioni A, Franco M, Rigo L, Guidi R, Spinelli G, Carinci F. Retrospective study of standard-diameter implants inserted into allografts. J Oral Maxillofac Surg 2009; 67:387–393.
- Spray JR, Black CG, Morris HF, Ochi S. The influence of bone thickness on facial marginal bone response: stage 1 placement through stage 2 uncovering. Ann Periodontol 2000; 5:119–128.
- 32. Blanes RJ, Bernard JP, Blanes ZM, Belser UC. A 10-year prospective study of ITI dental implants placed in the posterior region. II: influence of the crown-to-implant ratio and different prosthetic treatment modalities on crestal bone loss. Clin Oral Implants Res 2007; 18:707–714.
- McGuire MK, Nunn ME. Prognosis versus actual outcome III. The effectiveness of clinical parameters in accurately predicting tooth survival. J Periodontol 1996; 67:666–674.
- Tawil G, Younan R. Clinical evaluation of short, machinedsurface implants followed for 12 to 92 months. Int J Oral Maxillofac Implants 2003; 18:894–901.
- 35. Rokni S, Todescan R, Watson P, Pharoah M, Adegbembo AO, Deporter D. An assessment of crown-to-root ratios with short sintered porous-surfaced implants supporting prostheses in partially edentulous patients. Int J Oral Maxillofac Implants 2005; 20:69–76.
- Schulte J, Flores AM, Weed M. Crown-to-implant ratios of single tooth implant-supported restorations. J Prosthet Dent 2007; 98:1–5.

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