Posterior maxillary segmental osteotomy for the implant reconstruction of a vertically deficient ridge: A 3-year clinical report

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A vertically deficient posterior maxillary edentulous ridge in conjunction with sinus pneumatization or extensive horizontal bone resorption presents significant challenges for implant placement and restoration with an implant-supported fixed prosthesis. Various surgical techniques have been reported for the reconstruction of the vertically deficient posterior maxilla: guided bone regeneration, sinus elevation, block and/or particulate grafting with barrier membranes, and distraction osteogenesis. This clinical report describes the technique, the management of intrasurgical complications, and the 3-year follow-up results of augmenting the vertically deficient posterior maxilla with a segmental osteotomy prior to rehabilitation with an implant-supported fixed prosthesis. (J Prosthet Dent 2013;110:69-75)

The atrophic posterior maxilla may pose a significant challenge for dental implant placement and implant-supported prostheses. The most frequent causes of maxillary atrophy are poor bone quality, excessive sinus pneumatization after tooth loss, traumatic volume loss, and the extensive bone resorption frequently associated with long periods of partial or complete denture use. The resulting morphology of the residual alveolar ridge may preclude ideal implant positioning and rehabilitation, and the deficit may be classified as vertical, horizontal, and/or combination. Various treatments for reconstructing the vertically deficient posterior maxillary edentulous ridge are available: sinus elevation, guided bone regeneration (GBR) with block and/or particulate grafts and barrier membranes or titanium mesh, distraction osteogenesis, and forced orthodontic eruption of failing teeth.[1-12]

Sinus elevation is a predictable procedure but implant placement cannot be performed simultaneously.[4] The procedure requires a prolonged healing time of up to 9 months. Vertical augmentation of the alveolar ridge is necessary in patients with extensive resorption of the alveolar ridge to allow implant insertion and esthetic prosthetic rehabilitation.[2,3,11] Autologous bone, allografts, and xenografts with GBR have been used with variable success.[10,11] A second donor site may be necessary and this aspect may be objectionable to some patients. Forced orthodontic extrusion and distraction osteogenesis have been shown to yield satisfactory bone augmentation, but patient compliance may be difficult to achieve given the significant length of treatment required and the associated potentially high morbidity.[5-7,12] Regeneration of an atrophic ridge is even more difficult if the area of interest is surrounded by an otherwise dentate arch. The health of the remaining dentition must be considered when selecting the appropriate grafting and reconstructive technique.

The segmental osteotomy (SO) is a well-established procedure in orthognathic surgery and allows the repositioning of dentoalveolar segments for the correction of skeletal deformities and malocclusions.[13-18] The posterior maxillary segmental osteotomy (PMSO) is an alternative option that enables the reconstruction of a bony defect by repositioning an osseous segment with rigid fixation to prepare the site for dental implant placement.[13-16] Implant insertion can occur simultaneously with the osteotomy and repositioning of the osseous segment or it can occur after a 4-month consolidation period. The success of the segmental osteotomy is critically dependent on immobilization and the preservation of the blood supply to the repositioned osseous segment.[19]

This clinical report describes the surgical and prosthodontic procedures and the 3-year clinical follow-up of a patient with a severe combination (vertical and horizontal) defect of the right posterior maxilla. The application of the PMSO enabled 3-dimensional (3D) reconstruction of

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the deficiency and prosthodontic rehabilitation with an implant-supported fixed prosthesis.

CLINICAL REPORT

A 33-year-old woman presented to the postdoctoral Prosthodontics clinic at Columbia University College of Dental Medicine, New York complaining of pain and discomfort in the right maxillary quadrant. The patient's medical history was noncontributory, and no contraindications for treatment were noted. The patient denied any use of alcohol or tobacco products. Intraoral evaluation revealed a 3-unit interim fixed dental prosthesis (FDP) extending from the right canine to the second premolar with Miller grade-III mobility.[20] Severe hard and soft tissue loss resulted in a large defect with substantial vertical and transverse components (Fig. 1A). Probing depths for the FDP abutment teeth ranged from 3 to 10 mm, whereas the overall periodontal condition of the rest of the mouth was stable.

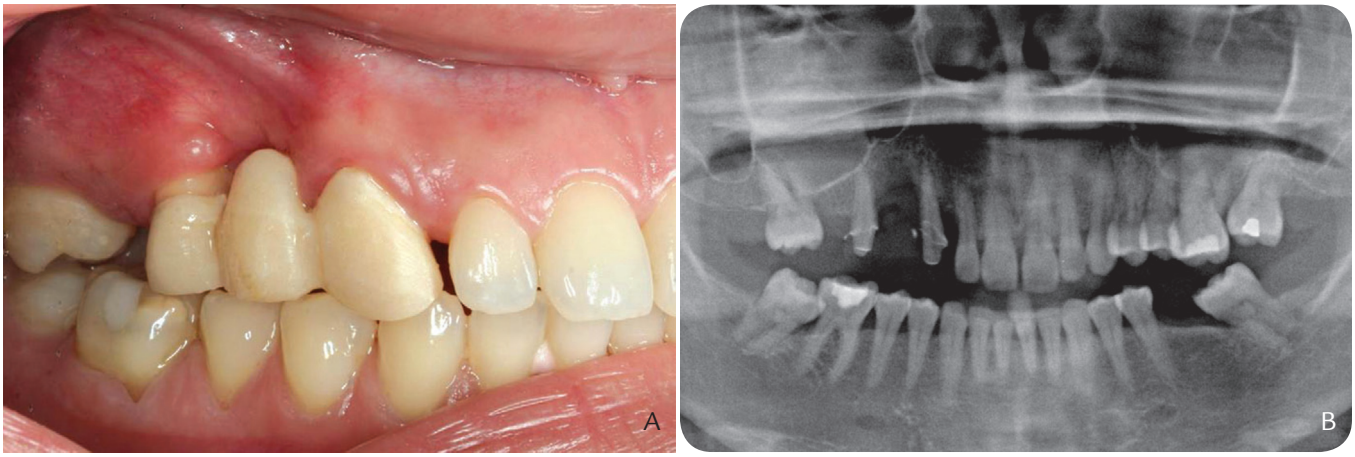
Radiographic examination revealed severe localized bone loss with both vertical and horizontal components in the right maxilla (Fig. 1B). Panoramic and periapical radiographs showed a mucous retention cyst in the right maxillary sinus. The patient was asymptomatic at the time of evaluation and denied recent symptomatology associated with the cyst. Evaluation by the Ear Nose and Throat (ENT) department confirmed the diagnosis and history; immediate removal of the cyst was not indicated at the time of evaluation given its chronic nature.

Occlusal examination showed an Angle Class I canine relationship with a vertical overlap of 4 mm and a horizontal overlap of 2 mm. The mandibular left first molar was missing and the maxillary left first molar was extruded. Anterior guidance was acceptable. The patient had a moderate smile line and exhibited a 1-mm diastema between the central incisors. The periodontal prognosis of the maxillary right canine and second premolar was deemed hopeless because of severe bone loss, mobility, and the probing depths. Extraction of these teeth was recommended.

Various treatment options were discussed with the patient for replacing the teeth to be extracted. The patient expressed a wish for fixed implant restorations and refused to consider any removable prostheses or multiple surgical interventions.

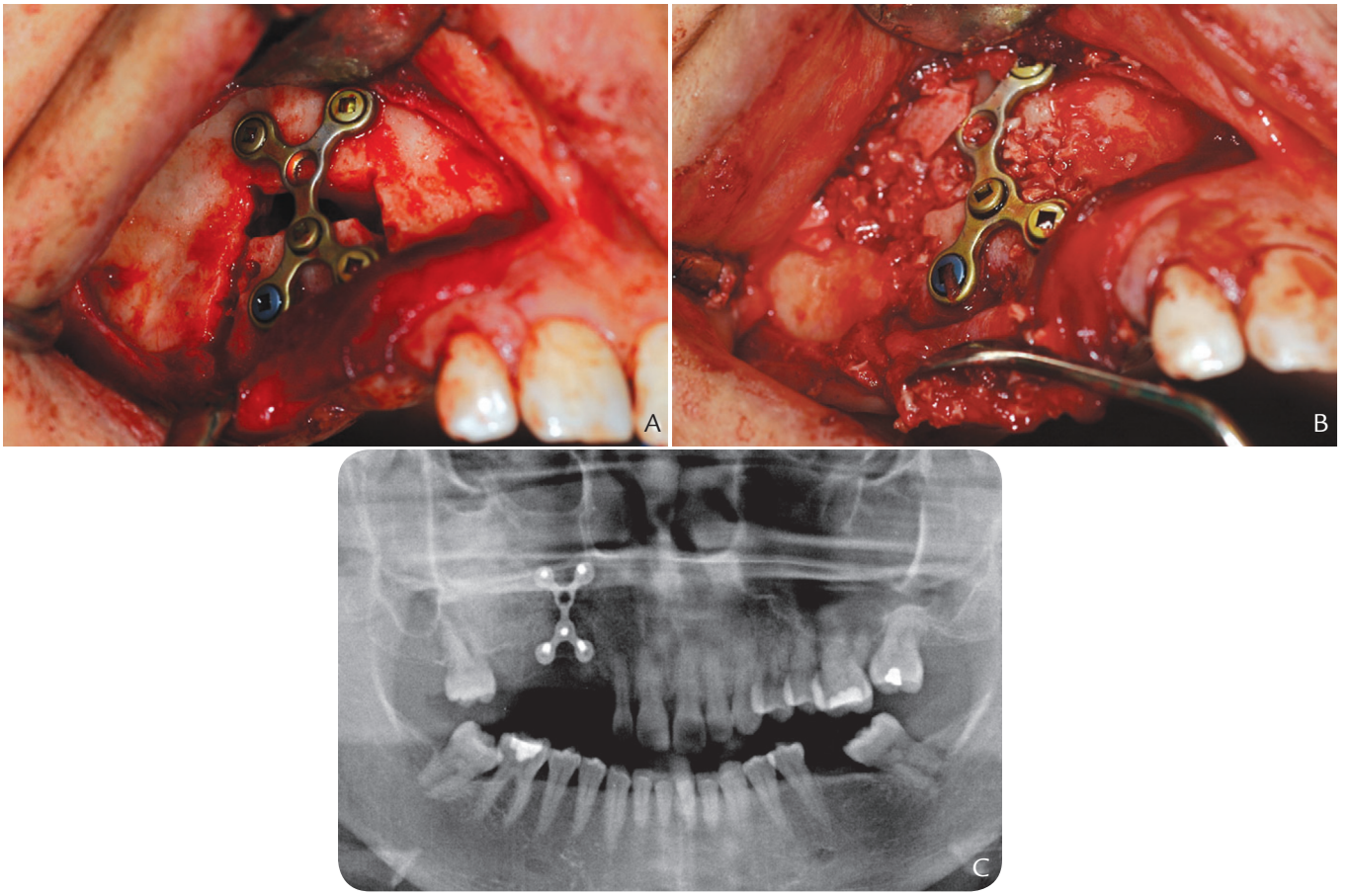
The surgical options discussed with the patient were onlay block grafts (with either intraoral or extraoral harvesting sites), guided bone regeneration (GBR) with particulate grafts in combination with barrier membranes or porous titanium mesh, distraction osteogenesis, and PMSO. Sinus elevation was not immediately considered as an option because of the presence of the mucous retention cyst in the right maxillary sinus. Secondly, the significant vertical deficit already present and the one anticipated after the extraction of the abutment teeth would not allow ideal implant placement. The patient declined the onlay block grafting as she was not willing to undergo a harvesting procedure. In agreement with the patient, the choice was made to proceed with the PMSO to achieve simultaneous vertical and horizontal augmentation of the maxillary crest. The prosthodontic treatment plan included an implant-supported FDP to replace the maxillary right canine, first and second premolars, and first molar. The initial phase of the treatment included the atraumatic extraction of the maxillary right canine and second premolar, followed by insertion of a clear vacuum-formed template (Essix Plastics; Dentsply Raintree Essix, Sarasota, Fla). The area was allowed to heal for 8 weeks (Fig. 2).

The PMSO was performed. Incisions and the extent of dissection were designed to preserve and maximize the blood supply to the osteotomized segment. A full-thickness vestibular incision was made 3 to 4 mm above the mucogingival junction (MGJ) to expose the maxillary bone in the segment. The incision was made anteriorly from the distal aspect of the right maxillary lateral incisor to the mesial aspect of the second molar. A sub-



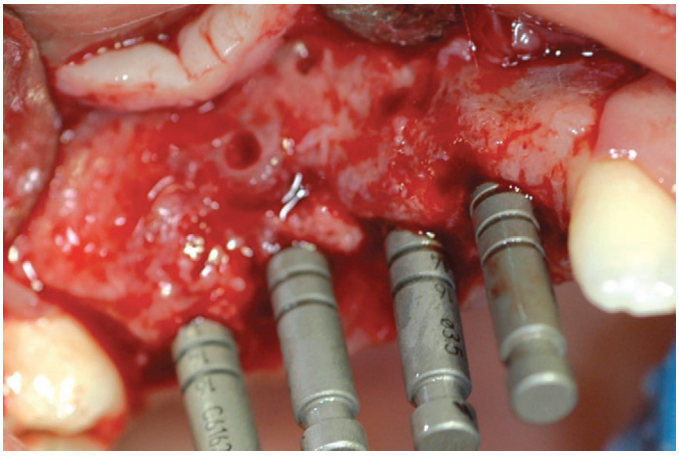
1 A, Initial intraoral clinical view. B, Initial panoramic radiograph.

2 Lateral view at 8 weeks of postextraction healing.



3 Outline of osteotomy. A, Titanium plate stabilizing osseous segment. B, Interpositional grafting with allograft. C, Panoramic radiograph after PMSO.

periosteal dissection was performed to expose a sufficient amount of maxillary bone; care was taken to avoid extending the dissection beyond the maxillary crest towards the palatal aspect. The osteotomy design was trapezoidal with a wide base at the maxillary crest to avoid undercuts and allow a smooth mobilization of the segment. The outline was marked first with a surgical pencil, and a corticotomy was performed with a highspeed surgical handpiece (SABRA, Tokyo, Japan) with a tapered carbide fissure bur (#702; Brasseler USA, Savannah, Ga) (Fig. 3). By using a sequential series of fine osteotomes (KLS Martin, Jacksonville, Fla), segmentation of the maxilla was completed, taking care to reach the medial aspect of the segment without perforating the palatal mucosa. The maxillary segment was mobilized manually with the osteotomes to ensure freedom of movement and confirm the ability to place it in its new position (Figs. 3A, B). The new position was determined



4 Implant placement. Note complete consolidation of osseous segment.

clinically to render the height of the entire maxillary crest equal. The clear vacuum-formed template used as an interim prosthesis provided further confirmation of segment positioning.

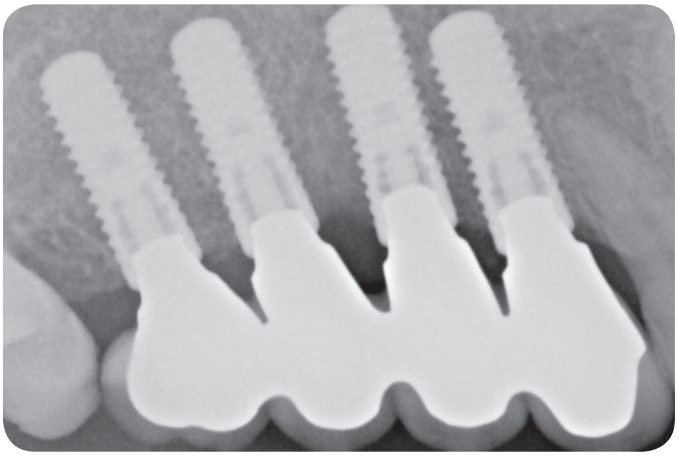
During mobilization of the maxillary segment, accidental perforation of the mucous retention cyst in the maxillary sinus was noted. A standard osseous window to access the maxillary sinus was made and the contents of the cyst were evacuated and the cyst enucleated. The sinus cavity was irrigated with 600 mg clindamycin (Cleocin; Pharmacia and Upjohn, New York, NY) diluted in normal saline solution, and the sinus membrane was elevated with a sinus lift procedure. The perforation was isolated with absorbable collagen membrane (OssixPlus; Johnson and Johnson, New Brunswick, NJ); the area was packed with particulate cadaveric bone-grafting material (Puross; Zimmer Dental, Carlsbad, Calif). The maxillary segment was then rigidly fixed with a standard orthognathic surgery osteosynthesis plate and self-tapping screws (KLS Martin, Jacksonville, Fla). The resulting bone gap was filled with the particulate cadaveric bone grafting material, and releasing periosteal incisions were placed at the base of the flap to ensure tension free closure of the wound. After placement of an absorbable collagen membrane (Biogide; Geistlich Pharma AG, Wolhusen, Switzerland), the flap was repositioned and secured with 3.0 chromic-gut sutures (Ethicon Inc, Sommerville, NJ) in a running interlocking fashion. The patient was placed on postoperative antibiotics, sinus decongestants, and topical corticosteroids and was given instructions not to blow her nose. A postoperative radiograph was made confirming segment position (Fig. 3C). Sutures were removed after 1 week.

Four months after the segmental osteotomy surgery, and with radiographic confirmation of bone consolidation, the patient returned for implant placement. A full-thickness crestal incision placed on the palatal aspect of the crest was made from the distal of the lateral incisor to the mesial aspect of the second molar tooth. Dissection was carried out in the subperiosteal plane to the depth of the vestibule in order to expose the osteosynthesis plate. The osteosynthesis hardware was removed and osseous consolidation was confirmed. Four dental implants (Bone Level SLActive RC; Straumann AG, Basel, Switzerland) were placed with the aid of a surgical template in a nonsubmerged approach. Primary stability was achieved for all implants with insertion torque above 35 Ncm (Fig. 4). The flap was repositioned and sutured with interrupted 3.0 chromic-gut sutures (Ethicon Inc). A postoperative radiograph confirming implant placement and position was made. Sutures were removed after 1 week; the hard and soft tissues were allowed to heal and mature for 6 weeks.

Six weeks after implant placement, successful osseointegration was confirmed at the recall appointment. The open-tray implant level technique was used for the definitive impressions.[21,22] Impression copings were connected to the implants, and the seating of the copings on the implant platforms was confirmed radiographically. Then, the impression copings were connected with dental floss and splinted to each other with autopolymerizing acrylic resin (GC Pattern resin; GC America Inc, Alsip, Ill).[21] The assembly was sectioned in each interimplant area and reconnected with a small amount of the same resin to compensate for polymerization shrinkage. The acrylic resin trays were loaded with polyether impression material (Impregum; 3M ESPE, St Paul, Minn) and additional material was injected around the copings. A double pouring technique with low expansion (0.09%) Type IV die stone (Silky Rock; Whip Mix Corp, Louisville, Ky) was used to generate the implant cast.[21]

At the next visit, a screw-retained interim FDP was inserted. After 4 months of uneventful functional loading, the procedures for definitive restoration commenced. The existing interim screw-retained FDP was used as a guide for the contours of the definitive prosthesis. Metal framework evaluation was performed and accuracy of fit was assessed radiographically and with the single screw test. [22] Shade selection was performed followed by feldspathic porcelain (Willi Geller Creation; Jensen Dental Inc, North Haven, Conn) bisque bake evaluation at the next appointment. A unilateral group function occlusal scheme was used to uniformly distribute the occlusal load to the implants.[23] After minor adjustments, the prosthesis was returned to the laboratory for glazing. The 1-piece, implant-level, screw-retained definitive prosthesis was inserted at the next appointment by tightening the abutment screws to 35 Ncm. The

5 A, Postinsertion panoramic radiograph. B, Definitive prosthesis at insertion. C, Lateral view of postinsertion smile.



6 Periapical radiograph at 3 years postloading.

screw access channels were protected with cotton pellets and composite resin (Z250; 3M ESPE) and a panoramic radiograph was made at the insertion appointment (Fig. 5A). At the 1-week follow-up visit, the patient expressed her increased satisfaction with the esthetic and functional outcome of the rehabilitation (Figs. 5B, C). At the 3-year follow-up appointment, she was still satisfied with the treatment. No biologic complications were encountered. Minor porcelain chipping at the second premolar area was polished. A periapical radiograph confirmed the stable clinical result (Fig. 6).

DISCUSSION

The SO is a well-established procedure in orthognathic surgery and allows repositioning of dentoalveolar segments to correct skeletal deformities and malocclusions. The success of the SO is critically dependent on the preservation of the blood supply

to the mobilized osseous segment. It is especially important to maintain the integrity of the palatal mucosa in order to avoid avascular necrosis of the mobilized segment and limit bleeding from the surgical site.[19] Prior to this report, SO was used in oral implantology as a form of rescue surgery to correct the position of improperly inserted implants, especially in the esthetic zones, to correct interarch relationships before mandibular implant placement, or to perform sandwich osteotomies to vertically augment the posterior mandible.[14-19,24,25] In the report by Fujita,[24] the vertical correction was not greater than 4 mm in either of the 2 patients presented; the implant length used was 8 mm in a surgical site where deficit correction could have occurred with an internal sinus lift technique and without using a short implant. Implant placement was simultaneous with the regeneration surgery, and this may have removed the need for rigid internal fixation of the segment and shortened the treatment time. This approach, however, introduces a complexity in the number of variables that can affect the final outcome. Langer[19] documented the effective use of the segmental down-fracture technique for a single site anterior maxillary segment. In the report by Hwang et al,[25] the PMSO was used to impact an overerupted maxillary segment resulting from the lack of dentition in the opposing arch. A severe vertical deficit was corrected, and a simultaneous sinus lift procedure was performed without placing interpositional allograft to release the Schneiderian membrane and prevent it from tearing during the maxillary impaction.

The PMSO is a delicate, technique-sensitive, and invasive treatment. Its complications (common to other osseous surgery) include hemorrhage, loss of adjacent tooth vitality, and necrosis of the osseous segment.[25] Hemorrhage is the most serious intraoperative complication as the posterior-superior alveolar artery runs along the anterior wall of the maxillary sinus and may produce bleeding that can be difficult to control.

In the present report and during the down-fracture procedure the sinus membrane and the intimately connected cyst lining were unintentionally violated. In the absence of frank purulence in the sinus cavity, all mucous was evacuated and the sinus perforation managed as it would have been during a sinus lift procedure. The choice to continue with the surgery was taken with the full awareness that the surgical field had now been formally "contaminated," even though there was little evidence that infection was present. The cavity was irrigated with antibiotic solution, and the tear in the membrane was repaired with a resorbable collagen membrane.

This incident could have been avoided by removing the cyst prior to the osseous surgery, by planning the surgery with a computerized tomography (CT) scan and surgical planning software to design the osteotomy cuts with greater anatomic accuracy, or by using piezoelectric instrumentation. At the time of completion of this treatment, CBCT scans were just beginning to be commonly available, and software did not allow the fabrication of surgical cutting guides. The use of piezoelectric instrumentation and its effectiveness in avoiding soft tissue injury (including the sinus membrane) may be indicated.[25] At the time of initial treatment of this patient during 2008, piezo instrumentation was not available.

The decision to splint the implants, as was done in the prosthetic management of this patient, is controversial.[26] Prosthesis-driven implant placement allowed the insertion of a screw-retained FDP, which was preferred because of greater retrievability compared to cement-retained FDPs. Recent systematic reviews have shown that biologic and technical complications are frequently encountered with FDPs for partially and completely edentulous patients after 5 to 10 years of clinical function.[27,28] Therefore, where applicable, a segmented prosthetic design may be recommended for implant rehabilitation because of greater hygiene and ease in prosthetic maintenance.[29]

The patient was given home oral health care instructions, including how to use a floss threader and interproximal brushes. Because a complete papilla did not form around the adjacent implants, the embrasure space was minimized with wide interproximal contacts to compensate.[30] Patient preference and final approval had been confirmed during the interim restoration stage.

SUMMARY

Several surgical techniques have been used to reconstruct a vertically deficient posterior maxilla: GBR, sinus elevation, block and/or particulate grafting with barrier membranes, and distraction osteogenesis. This clinical report describes the surgical and prosthodontic procedures after PMSO for the implant restoration of a partially edentulous ridge with a combination defect. The treatment outcome was surgically and prosthetically satisfactory after a 3-year follow-up, showing that PMSO can be implemented successfully as an alternative technique for the reconstruction of residual ridge deficiencies.

REFERENCES

1. 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.
2. 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.
3. Chiapasco M, Zaniboni M, Boisco M. Augmentation procedures for the rehabilitation of deficient edentulous ridges with oral implants. Clin Oral Implants Res 2006;17 Suppl 2:136-59.
4. Wallace SS, Froum SJ, Cho SC, Elian N, Monteiro D, Kim BS, Tarnow DP. Sinus augmentation utilizing anorganic bovine bone (Bio-Oss) with absorbable and nonabsorbable membranes placed over the lateral window: histomorphometric and clinical analyses. Int J Periodontics Restorative Dent 2005;25:551-9.

5. Raghoebar GM, Stellingsma K, Meijer HJ, Vissink A. Vertical distraction of the severely resorbed edentulous mandible: An assessment of the treatment outcome. Int J Oral Maxillofac Implants 2008;23:299-307.
6. Chiapasco M, Zaniboni M, Rimondini L. Autogenous onlay bone grafts vs. alveolar distraction osteogenesis for the correction of vertically deficient edentulous ridges: a 2-4-year prospective study on humans. Clin Oral Implants Res 2007;18:432-40.
7. Jensen OT, Cockrell R, Kuhike L, Reed C. Anterior maxillary alveolar distraction osteogenesis: a prospective 5-year clinical study. Int J Oral Maxillofac Implants 2002;17:52-68.
8. Rocuzzo M, Ramieri G, Bunino M, Berrone S. Autogenous bone graft alone or associated with titanium mesh for vertical alveolar ridge augmentation: a controlled clinical trial. Clin Oral Implants Res 2007;18:286-94.
9. Mardas N, Chadha V, Donos N. Alveolar ridge preservation with guided bone regeneration and a synthetic bone substitute or a bovine-derived xenograft: a randomized, controlled clinical trial. Clin Oral Implants Res 2010;21:688-98.
10. Simion M, Jovanovic SA, Tinti C, Benfenati SP. Long-term evaluation of osseointegrated implants inserted at the time or after vertical ridge augmentation. A retrospective study on 123 implants with 1-5 year follow-up. Clin Oral Implants Res 2001;12:35-45.
11. Lee HJ, Choi BH, Jung JH, Zhu SJ, Lee SH, Huh JY, et al. Vertical alveolar ridge augmentation using autogenous bone grafts and platelet-enriched fibrin glue with simultaneous implant placement. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2008;105:27-31.
12. Smidt A, Gleitman J, Dekel MS. Forced eruption of a solitary nonrestorable tooth using mini-implants as anchorage: rationale and technique. Int J Prosthodont 2009;22:441-6.
13. Basa S, Varol A, Sener ID, Sertgoz A. Posterior maxillary segmental osteotomy for restoring the mandible with dental implants: A clinical report. J Prosthet Dent 2008;99:340-3.
14. Meningaud JP, Pitak-Arnnop P, Corcos L, Bertrand JC. Posterior maxillary segmental osteotomy for mandibular implants placement: case report. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2006;102:e1-3.
15. Poggio CE, Salvato A. Implant repositioning for esthetic reasons: a clinical report. J Prosthet Dent 2001;86:126-9.
16. Kassolis JD, Baer ML, Reynolds MA. The segmental osteotomy in the management of malposed implants: a case report and literature review. J Periodontol 2003;74:529-36.
17. Stacchi C, Chen ST, Raghoebar GM, Rosen D, Poggio CE, Ronda M, et al. Malpositioned osseointegrated implants relocated with segmental osteotomies: A retrospective analysis of a multicenter case series with a 1- to 15-year follow-up. Clin Implant Dent Relat Res 2012 Feb 29 [Epub ahead of print].
18. Raghoebar GM, Visser A, Vissink A. Correction of a malpositioned endosseous implant by a segmental osteotomy: A case report. Int J Oral Maxillofac Implants 2005;20:627-31.
19. Langer B. The segmental down fracture for vertical bone augmentation: case report. Clin Implant Dent Relat Res 2010;12 Suppl 1:e126-31.
20. Carranza FA. Clinical diagnosis. In Newman MG, Takei HH, Carranza FA, editors. Carranza's clinical periodontology, 11th ed. Philadelphia: W.B. Saunders Company; 2011. p. 340.
21. Papaspyridakos P, Benic GI, Hogsett V, White GS, Lal K, Gallucci GO. Accuracy of implant casts generated with splinted and non-splinted impression techniques for edentulous patients: An optical scanning study. Clin Oral Implants Res 2012;23:676-81.
22. Papaspyridakos P, Lal K, White GS, Weber HP, Gallucci GO. Effect of splinted and non-splinted impression techniques on the accuracy of fit of implant fixed prostheses in edentulous patients: a comparative study. Int J Oral Maxillofac Implants 2011;26:1267-72.
23. Taylor TD, Wiens J, Carr A. Evidence-based considerations for removable prosthodontic and dental implant occlusion: a literature review. J Prosthet Dent 2005; 94:555-60.
24. Fujita A. Vertical alveolar ridge expansion and simultaneous implant placement in posterior maxilla using segmental osteotomy: Report of two cases. J Oral Implantol 2008;34:313-8.
25. Hwang JH, Jung BY, Lim CS, Cha IH, Park W. Posterior maxillary segmental osteotomy concomitant with sinus lift using a piezoelectric device. J Oral Maxillofac Surg 2011;69:2339-44.
26. Vigolo P, Zaccaria M. Clinical evaluation of marginal bone level change of multiple adjacent implants restored with splinted and nonsplinted restorations: a 5-year prospective study. Int J Oral Maxillofac Implants 2010;25:1189-95.
27. Papaspyridakos P, Chen CJ, Chuang SK, Weber HP, Gallucci GO. A systematic review of biologic and technical complications with fixed implant rehabilitations for edentulous patients. Int J Oral Maxillofac Implants 2012;27:102-10.
28. Pjetursson BE, Brägger U, Lang NP, Zwahlen M. Comparison of survival and complication rates of tooth-supported fixed dental prostheses (FDPs) and implant-supported FDPs and single crowns (SCs). Clin Oral Implants Res 2007;18 Suppl 3:97-113.
29. Papaspyridakos P, White GS, Lal K. Flapless CAD/CAM-guided surgery for staged transition from failing dentition to complete arch implant rehabilitation: a 3-year clinical report. J Prosthet Dent 2012;107:143-50.
30. Tarnow D, Elian N, Fletcher P, Froum S, Magner A, Cho SC, et al. Vertical distance from the crest of bone to the height of the interproximal papilla between adjacent implants. J Periodontol 2003;74:1785-8.

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