Int. J. Oral Maxillofac. Surg. 2016; 45: 1135–1141
http://dx.doi.org/10.1016/j.ijom.2016.04.012, available online at http://www.sciencedirect.com

International Journal of Oral & Maxillofacial Surgery

Clinical Paper
Dental Implants

Marginal and apical bone stability after staged sinus floor augmentation using bone condensing implants with variable-thread design: a two-dimensional analysis

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Abstract. Studies on the vertical stability of augmented bone after sinus lifting differ substantially. In addition, long healing periods are usually advocated prior to implant installation. The purpose of this case series study was to evaluate the changes in bone height after sinus lifting with a bovine-derived xenograft and to evaluate the clinical outcome of bone condensing implants installed after a short healing period. Patients treated during the years 2010–2013 were re-examined using peri-apical radiographs to evaluate the changes in augmented bone height (BH) and marginal bone loss (BL). Fifty-seven of 70 eligible subjects (28 male and 29 female, mean age 56 years) attended for reassessment. Data were available for 53 sinus lifts and 105 implants installed after a mean healing period of 4.6 ± 1.5 months. Implant survival was 99% after a mean time in function of 19 ± 9 months. Baseline BH, BH at implant placement, and final BH were on average 3.87 ± 1.74 mm, 13.75 ± 2.12 mm, and 13.11 ± 2.12 mm, respectively ($P < 0.001$). Mean BL was 0.51 ± 0.65 mm. Only limited resorption is to be expected after sinus lifting in the short term. A bone condensing implant can be used in the early healing phase with successful outcomes in terms of implant survival and bone adaptation.

Key words: xenografts; sinus lift; maxillary sinus augmentation; maxillary ridge augmentation; tapered implants; implant survival; bone resorption.

Accepted for publication 19 April 2016
Available online 5 May 2016

0901-5027/0901135 + 07

The use of dental implants to replace missing teeth has become a standard procedure in contemporary dentistry. Even when confronted with a limited amount of bone, a number of possible solutions are available. Short implants and sinus lifting through the transalveolar approach may be considered in the case of moderate bone resorption.[1] Both options are well documented and show good clinical results, as demonstrated in a number of systematic reviews.[2–7] However, in the case of severe maxillary atrophy, sinus lifting by means of the lateral window technique becomes necessary in order to install implants.[8] This procedure enables the clinician to augment large volumes using autogenous bone, xenografts, alloplastic materials, or combinations thereof. Depending on the residual amount of bone, standard to long implants can be installed at the same time or in a second phase. High implant survival rates have been described, regardless of the initial bone height.[7,9–16]

Studies have been published on the vertical stability of augmented bone following sinus lifting.[17–27] However, these have differed substantially in terms of biomaterials, clinical procedures, and evaluation methods. Indeed, combinations of different grafting materials (autografts, allografts, and/or xenografts) have been used,[17–22,25,27] and the clinical protocol (e.g. one- or two-stage protocol, time between augmentation and implant placement) has often varied substantially,[19,24,26,27] or has lacked description.[17,18] In addition, the aforementioned studies have been based on panoramic images to evaluate changes in bone height, which may lack accuracy in comparison to peri-apical radiographs.[28] Hence, the primary objective of this study was to evaluate the changes in augmented bone height on peri-apical radiographs after sinus lifting with a bovine-derived xenograft, on the basis of a retrospectively recruited sample.

Traditional approaches propose a healing time of at least 6 months after sinus lifting prior to implant installation.[9] This recommendation is based on the limited bone quality in the early healing phase, which may be a problem for achieving proper primary implant stability. However, installing a bone condensing implant with variable-thread design allows the compression of premature bone, thus promoting primary implant stability under suboptimal conditions. Thus, the secondary objective of this study was to evaluate the clinical outcome of bone condensing implants with variable-thread design when installed after a shorter healing period following sinus lifting.

Materials and methods

Patient selection

Patients treated with dental implants in the atrophic maxilla in two private practices by two clinicians during the years 2010–2013 were contacted for re-evaluation. Selection criteria were as follows: (1) unilateral or bilateral sinus lifting performed using the lateral window technique; (2) bovine-derived xenograft (Geistlich Bio-Oss, 0.5 g 0.25–1 mm; Geistlich Pharma AG, Wolhusen, Switzerland) and collagen membrane (Geistlich Bio-Gide, 25 × 25 mm; Geistlich Pharma AG) used as biomaterials; (3) one or more NobelActive implants (Nobel Biocare, Gothenburg, Sweden) installed in a second phase; (4) no systemic disease.

All patients had been treated for caries and periodontal disease prior to oral surgery. Patients fulfilling these selection criteria were invited for a reassessment between August and October 2014. The study was conducted in accordance with the Declaration of Helsinki of 1964 as revised in 2013; the study protocol was approved by the ethics committee of the study university hospital in Brussels.

Sinus lifting

Antibiotic therapy (amoxicillin 2× 1 g per day for 4 days) was started 1 h preoperatively. After the administration of local anaesthetic, a full-thickness flap was raised on the buccal aspect of the alveolar ridge using a crestal incision and two vertical releasing incisions. A window was prepared in the lateral wall of the maxillary sinus and the Schneiderian membrane was gently lifted. Small perforations in the Schneiderian membrane were covered with a collagen membrane (Bio-Gide). Bovine-derived xenograft particles (Bio-Oss) were used to fill the space between the internal bone walls and the lifted Schneiderian membrane. A collagen membrane (Bio-Gide) was used to cover the window. Finally, the full-thickness flap was sutured with non-resorbable monofilament sutures (Seralon 5/0; Serag Wiessner, Naila, Germany), which were removed after 2 weeks. Postoperative instructions included the use of 0.12% chlorhexidine mouth rinse (2 times a day for 7 days), antibiotics (amoxicillin 2× 1 g per day for 4 days), and analgesics (ibuprofen 600 mg when deemed necessary by the patient).

Implant surgery

Antibiotic therapy (amoxicillin 2× 1 g per day for 4 days) was started 1 h preoperatively. After the administration of local anaesthetic, a full-thickness flap was raised using a crestal incision and an intra-sulcular incision at the neighbouring tooth/teeth. The osteotomy was then prepared for the installation of one or more NobelActive implants, in accordance with the manufacturer's protocol. Non-submerged healing was chosen in all patients except when a removable partial denture was used as a provisional restoration, or in the case of low primary implant stability (<25 N cm). After implant insertion, the flap was closed using non-resorbable monofilament sutures (Seralon), which were removed after 1 week. The same postoperative instructions as mentioned above were given. All surgical procedures were performed by the same clinician (JC, AE) depending on the centre.

Prosthetic treatment

Depending on the local situation and the preference of the patient, implants were restored by means of a single crown, fixed partial denture, or overdenture. Prosthetic treatment was performed by the referring general dentist.

Bone measurements

Digital peri-apical radiographs were taken with the long-cone paralleling technique using a radiograph positioner for registration of the following parameters: (1) initial height of the native bone (BH-B) in the centre of the area to be augmented (Fig. 1); (2) height of the bone at implant placement (BH-IP) in the centre of the augmented area, i.e. the sum of the initial height and the height of the augmented bone (Fig. 2); (3) height of the bone at final reassessment (BH-F) in the centre of the augmented area, i.e. the sum of the initial height and the height of the augmented bone (Fig. 3).

Marginal bone loss was recorded at the mesial and distal aspect of the most central implant in the augmented area in the case of three neighbouring implants, or for the mesial implant in the case of two implants. These measurements were performed at reassessment, with implant placement as a reference time point. The distance from the implant–abutment interface to the first bone-to-implant contact as assessed on digital peri-apical radiographs (long-cone paralleling technique) was used as the basis for the bone loss calculation. To control for enlargement, the implant length served as the reference distance. Mesial and distal values were averaged to provide one value per implant (BL-S). In