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Volume changes of autogenous bone after sinus lifting and grafting procedures: A 6-year computerized tomographic follow-up

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ABSTRACT

Objectives: To evaluate long-term bone remodelling of autografts over time (annually, for 6 years), comparing the block and particulate bone procedures for sinus floor elevation, as well as to evaluate the survival of positioned dental implants.
Patients and methods: Twenty-three sinus lift procedures with autogenous bone were performed: seven sinus lift procedures using particulate graft and 10 with block autogenous bone were performed in 17 patients. Employing a software program, pre- and post-surgical computerized tomography (CT) scans were used to compare the volume (V) and density (D) of inlay grafts over time (up to 6 years), and to determine the percentage of remaining bone (%R). All variable (V, D and %R) measurements were then compared statistically.
Results: At the 6-year survey for block form, a resorption of 21.5% was seen, whereas for particulate grafts there was a resorption of 39.2%. Both groups exhibited bone remodelling between the first and second follow-up which was significant regarding volume for the block form and regarding density for the particulate group.
Conclusions: During the initial period of healing, the cortico-cancellous block bone grafted into the maxillary sinus underwent a negative remodelling of the volume, which is most probably due to graft cortex resorption, coupled with, primarily, an increase in density in the spongious area; for the particulate grafts, significant augmentations in density were obtained. The lack of significant differences among volumes was due to the wide degree of dispersion of the data. The rough data presented in this paper seem to support the use of a bone-block grafting procedure in maxillary sinus augmentation.

1. Introduction

Dental implant treatment in the posterior maxilla often requires bone augmentation procedures due to a high degree of pneumatization of the maxillary sinus, which can be coupled with a reduction in residual bone height. Where vertical augmentation has not been deemed a necessary cause for modifying the crown/root ratio (McAllister and Haghighat, 2007; Sakka and Krenkel, 2011), well-established and reliable maxillary sinus grafting procedures have been performed with autografts or non-autogenous grafting materials (Chiapasco et al., 2006; Acocella et al., 2011; Sakka and Krenkel, 2011; Barone et al., 2012).

The success of the implant-supported prosthesis depends on the long-term survival rate of dental implants placed in the grafted maxilla, so every factor that can jeopardize implant stability must be carefully considered: great attention was paid to a possible re-pneumatization phenomenon of the grafted maxillary sinus, revealed by linear and volumetric measurements, both for particulate

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autogenous bone and for bovine bone materials (Hatano et al., 2004; Kirmeier et al., 2008; Sbordone et al., 2009a; Covani et al., 2011).

Only diagnostic three-dimensional imaging can lead to accurate estimates regarding volumetric changes of sinus inlay grafts. Data regarding short-term outcomes of volumetric remodelling of sinus inlays, performed with either autograft or non-autogenous grafting materials, have been analyzed (Johansson et al., 2001; Smolka et al., 2006; Kirmeier et al., 2008; Sbordone et al., 2010; Dasmah et al., 2011), although the long-term results concerning volumetric stability of sinus inlay autografts are still not known. The aim of this retrospective chart review was to evaluate long-term bone remodelling of autografts over time (annually, for 6 yr), and to compare two procedures for sinus floor elevation: block and particulate bone. A second objective was to evaluate the clinical survival of implants positioned in the posterior maxillary areas.

2. Materials and methods

A retrospective chart review of 32 patients who had undergone sinus floor elevation with different autogenous bone-grafting procedures (particulate or block form) was performed: pertinent information regarding patients treated from January 2000 to December 2005, such as age (years), sex, and smoking habits, as well as that relating to the harvesting procedure (number, location and source), to dental implant placement, to surgical treatment outcomes, and to subsequent surgical procedures, with the addition of the number and points in time of CT scans, were collected and analyzed. No patient had undergone bone resection as part of an oncologic treatment. Fifteen patients not having a complete set of computed tomography (CT) scan data were excluded; maxillary CT scans up to 72 months postoperatively were considered. Written informed consent was obtained from all subjects included, and approval for this study was obtained from the Ethical Committee of the University of Pisa, Pisa, Italy (Ethical Approval Form 2626/2008 Protocol Number 58183).

2.1. Surgical methods

The need for sinus lifting, as well as the choice of surgical procedure, were determined by a preoperative CT scan analysis. In the event of a sinus pathology, that is, any clinical sign of sinusitis and/or radiologic signs of localized disease (sinus membrane thickness of 3 mm or greater on preoperative CT scan [Wippold et al., 1995]), patients underwent a nasal endoscopy followed by medical therapy, with appropriate chemo-antibiotics and corticosteroids, as well as, if necessary, functional endoscopic sinus surgery (Pfleiderer, 1987).

The mandibular parasymphysis and the iliac crest area were used as intraoral or extraoral harvesting sites: 1 or 2 blocks, depending on need, were harvested from the chin following the procedure described by Balaji (2002) (Sbordone et al., 2009b), but using a horizontal mucosal incision 5 mm apical to the mucogingival junction. Iliac crest grafts were obtained according to the technique described by Grillon et al. (1984), using a cutaneous approach via elective lines of incision, and the harvested bone was then treated as previously described. When autogenous bone was not grafted as a single block, it was reduced to particulate chips with a bone mill (Biocomp Minimill; Walter Lorenz Surgical, Jacksonville, FL).

Sinus lifting with autogenous bone was performed approaching the recipient site through two different procedures: Sailer's (Sailer, 1995), when performing a block graft secured to the pristine sinus floor with a "lag screw technique" (Fig. 1) (Keller et al., 1999; Sbordone et al., 2010), or that of Tatum when using a particulate graft (Tatum, 1986) as was previously reported (Sbordone et al., 2009a; Sbordone et al., 2011a).

After reconstructive surgery, delayed titanium dental implants (root-form, external-hex, and rough-surface) were inserted into the grafted areas at 3 months, in the case of bone-block grafts (Krekmanov and Heimdahl, 2000), or at 5 months, for particulate grafts (Crespi et al., 2007).

Patients received fixed prosthetic restoration with metal ceramic crowns and bridges, cemented 6–9 months after implant placement either over a custom metal abutment or via a University of California, Los Angeles (UCLA)–type abutment.

2.2. Variables and data collection

As part of the standard treatment protocol, patients had CT scans (High Speed double detector CT scanner, General Electric Medical System, Milwaukee, WI, USA) taken immediately before bone grafting, 3–5 months after the graft and just before implant insertion (Krekmanov and Heimdahl, 2000; Crespi et al., 2007), and then annually following clinical and radiologic examination, as provided in the postoperative maintenance program; a survey of the dental implants was also conducted.

Values of the volume and density of the inlay grafts were taken using axial CT slices having a thickness of 1 mm. Before the numerical computation of volume, axial images of the original CT scans were reoriented parallel to the palatine vault: measurements of the sinus vacuum were performed using SimPlant Pro 12.02 with Segment tool (Materialise Dental Italia. Via L. Fincati 13/f, 00154 Roma, Italy), as per Krennmair et al. (2006), with total height preset to the maximum distance between the alveolar crest and the apical portion of the inlay bone graft. For the Density measurement, tomographic CT scan data were entered into a software program, and pre- and postoperative axial images were superimposed (Image Processing Toolbox, MatLab 7.0.1, The MathWorks, Natick, MA), as was recently suggested by Sbordone (Sbordone et al., 2012). The numerical computation of density was performed using SimPlant Pro 12.02 with Prepare for planning tool (Materialise Dental Italia, Via L. Fincati 13/f, 00154 Roma, Italy) with dental implant areas deletion from all axial CT slices.

The timing of the CT scans allowed data ranking, with the six time intervals being set as follows: T1 (0–12 mos), T2 (13–24 mos), T3 (25–36 mos), T4 (37–48 mos), T5 (49–60 mos) and T6 (61–72 mos). Volume measurements of the bone grafts, relating to the CT scans acquired after dental implant placement (V2, V3, V4, V5 and V6), were compared to the data obtained from CT scans recorded at time T1 (V1), in order to determine the percentage of residual bone graft (%R): i.e., %RX at X-time (with $X = 2,3,4,5$ and 6) was obtained as the ratio between the volume at time X (or VX) and the time T1 block volume (V1). Percentages were rounded off to the nearest 0.1%.

2.3. Statistical analysis

All patient-related data were entered into a database (Access, Microsoft Corp, Redmond, WA), allowing calculations to be performed automatically. Descriptive statistical analyses were performed using a statistical tools package (Statistics Toolbox, MatLab 7.0.1, The MathWorks, Natick, MA).

A normal distribution for each data set was carried out, but not confirmed, using the Lilliefors test for data, establishing different follow-up time intervals. The data are assumed to come from a continuous, symmetrical distribution around its medians.

All measurements in the text and Tables are described as median and interquartile range (difference between 75th and 25th percentiles). In the Figures, distributions have been depicted by box-and-whiskers plot, in which the box line represents the lower quartile, median, and upper quartile values, while the whisker lines include the rest of the data. Outliers were data with values beyond the ends of the whiskers.