Apical and marginal bone alterations around implants in maxillary sinus augmentation grafted with autogenous bone or bovine bone material and simultaneous or delayed dental implant positioning

Key words: augmentation techniques, autologous bone graft, bone remodeling, bovine bone material, dental implants, sinus bone resorption

Abstract
Objective: A re-pneumatization phenomenon was recorded in sinuses grafted with different materials. The specific aims of this paper were to assess the dental implant survival rate and the behavior of marginal and apical bone remodeling around dental implants placed following sinus augmentation.

Materials and methods: A retrospective study was conducted on consecutive patients treated in two surgical centers. Different surgical techniques were adopted for sinus augmentation: simultaneous or delayed dental implant insertion with bovine bone-material augmentation or autologous bone grafting (chin and iliac crest). Survival rates were recorded for the overall number of implants (patients of group A). Apical and marginal bone levels (ABL and MBL, respectively) were radiographically measured, and statistical analysis was performed in implants of a subgroup of patients (group B).

Results: A total of 282 dental implants were positioned. Recorded cumulative survival rates (CSRs) were 95.6% and 100% for autogenous and bovine bone material, respectively, while CSRs at 2-year follow-up for immediate and delayed procedures were 99.3% and 96.5%. For the subgroup B, 57 sinus augmentation procedures were performed in 39 patients, with the positioning of 154 implants. Generally, the apical- and marginal-bone resorption of the bovine bone-material group was less than that of the autogenous group. The differences between the ABL values of the bovine bone-material and iliac-crest groups were statistically significant at 1 year, whereas this significance disappeared at the 2-year follow-up; tests showed that a statistical difference was recorded in the bovine bone-material group between the 1- and 2-year follow-ups. With regard to MBL comparisons between simultaneous and delayed implantation, the differences maintained their significance at the 2-year follow-up also.

Conclusions: Differences regarding apical bone alteration between autogenous bone from the iliac crest and bovine bone material at the 1- and 2-year follow-ups, as well as in the bovine bone-material group between the 1- and 2-year follow-ups, attested to slower but more prolonged physiologic bone remodeling in the bovine-graft-material group than in the autogenous-bone group. The MBL analysis showed that remodeling in the delayed implant group demonstrated a greater resorption in the cervical portion than was seen in the simultaneous implant group.

Reconstructive procedures aimed at dental implant positioning for prosthetic rehabilitation are deemed necessary in cases of posterior maxillary alveolar bone loss and maxillary sinus hyperpneumatization (Sharan & Madjar 2008). One of a number of standard augmentation procedures, applied in cases of extreme pneumatization of the maxillary sinus (Chiapasco et al. 2005), is the lateral approach, in order to fill the bottom of the sinus cavity with autogenous bone, bone substitute, or a mixture of these materials (Hatano et al. 2004; Kirmeyer et al. 2008).

This method, of lateral wall sinus augmentation, has yielded a high degree of predictability and low complication rates (Schwartz-Arad et al. 2004b; Levin & Schwartz-Arad 2005; Herzberg et al. 2006).

A recent review reported autogenous bone as the material of choice in cases of severe atrophy, resolved by a combination of sinus- with onlay-grafting procedures; conversely, the non-autogenous...
Material and methods

Study design/sample
A retrospective study was conducted on consecutive patients treated in two surgical centers, one in Italy and the other in Israel. All patients were affected by atrophy of the maxillae coupled with sinus pneumatization, requesting implant-supported fixed-prosthesis rehabilitation, and were treated from January 1995 through December 2002.

Group A included 118 sinus augmentation procedures with autogenous bone or bovine bone material, performed in 93 patients (58 females and 35 males, ranging in age from 37 to 83 years [mean 51.9 ± 8.5]) during the period from January 1995 through December 2002. Thirty-nine sinus augmentation procedures were performed in 26 patients in Italy, and another 79 such procedures were performed in 67 patients in Israel.

All patients, who required fixed prosthesis rehabilitation, were affected by hyperpneumatization of the maxillary sinus and atrophy of the maxillary alveolar crest, and were included in the clinical survey. Fifty-three of the 93 patients were non-smokers. Atrophy of the maxilla was the result of a long-standing edentulous condition treated by removable prosthesis, alveolar bone loss due to periodontal disease, and/or major trauma; immediate implant insertion could replace compromised teeth. No patient had received bone resection as part of an oncologic treatment. Two hundred and eighty-two dental implants were placed in the reconstructed areas. Panoramic radiographs from patients who underwent sinus augmentation procedures in the two large surgical centers were evaluated.

A subgroup taken from the overall group of patients was derived to form group B according to the following inclusion criteria: sinus augmentation procedure with implant placement (one or two stages); availability of consecutive panoramic radiographs: pre-operative, post-sinus augmentation, and pre-implant placement for a two-stage procedure, two follow-up panoramic radiographs at least 1 year apart. The implants of patients in group B were further measured in bone remodeling analysis.

Variables
Bone measurements after implant positioning for the evaluation of alterations in the augmented bone within maxillary sinususes were performed from the apex of implants placed inside the maxillary sinus to the upper-most part of the visible grafted material at two points per implant (mesial- and distal-apical bone level, mABL and dABL, respectively).

Marginal bone level (MBL) after implant positioning on the mesial and distal aspects of each implant (mMBL and dMBL, respectively) were also evaluated during the follow-up time.

All measurements were also performed at the 1- and 2-year follow-ups after implant placement. All variables were grouped according to the type of the sinus graft (autologous from the chin, autologous from the iliac crest, or xenogenic) or to the type of procedure of implant placement (simultaneous or delayed).

Surgical methods
Before surgery, when sinuses were not free of clinical and/or radiological pathologic signs (Wippold et al. 1995), patients underwent nasal endoscopy, followed by medical therapy with appropriate chemo-antibiotics and corticosteroids, and if required, functional endoscopic sinus surgery (Pfeifer 1987).

Pre-operative CT scan analysis was performed to measure residual bone volume, in order to assess the need for sinus augmentation for implant placement, and to guide the choice of procedure (Mardinger et al. 2007; Sbordone et al. 2009). Briefly, all patients underwent appropriate antibiotic prophylaxis and analgesic anti-inflammatory therapy. The lateral wall approach was used for all sinus procedures.

Root-form, rough-surfaced, screw-type titanium dental implants were inserted with simultaneous or delayed procedures. The manufacturers of the implants used were Nobel Biocare (Goteborg, Sweden), Implant Innovations (Palm Beach Gardens, FL, USA), Zimmer Dental (Carlsbad, CA, USA) and Sweden & Martina (Due Carrare, Padua, Italy).

Prosthetic restoration was performed 6–9 months after implanting; all patients received fixed prosthetic restoration with metal ceramic crowns and bridges, either cemented over a custom metal abutment or via a UCLA-type abutment.

Simultaneous and delayed procedure with bovine bone material
Lateral wall sinus augmentation procedure was performed according to a previously described protocol (Levin et al. 2004; Schwartz-Arad et al. 2004b; Levin & Schwartz-Arad 2005; Herzberg et al. 2006). Local anesthesia was administered using a maxillary nerve block via a greater paltine approach (Schwartz-Arad et al. 2004a). The sinus membrane was carefully peeled back from the sinus floor and medial sinus wall. Once there was sufficient exposure, the membrane was examined for perforations. If no visible perforations were observed, the space was filled with saline, and the patient was asked to gently perform the Valsalva maneuver. Air bubbles indicated the presence of a perforation. An overlapping resorbable collagen membrane (Bio-Gide; Geistlich, Wolhusen, Switzerland) was used to repair perforations. After the particulate bovine bone material grafting (Bio-Oss 1–2 mm particles; Geistlich Pharma AG, Wolhusen, Switzerland), the fenestrated lateral wall of the maxillary sinus was covered with a resorbable collagen mem-
The bone level was measured parallel to the long axis of the studied implant, and at a distance of 0.5 mm mesially and 0.5 mm distally from the peri-implant outline, taking the apex of each dental implant as the axis origin, as depicted in Fig. 1.

The ABL vectors could be positive or negative: a negative number would indicate that a position of the new sinus floor was coronal to the implant apex, while a positive number would signal the presence of bone apical to the dental implant apex, between the apex and the sinus.

The MBL value was determined by subtracting the crestal bone height, measured as above (-setting the axis origin as implant apex), from the implant length, considering that the implant hex-base had been initially positioned at bone level.

Implant survival and success rates
The survival criteria were chosen according to Albrektsson et al. (1986), and included the following: the absence of persistent subjective complaints, such as dysesthesia, a foreign-body sensation, and/or pain; absence of peri-implant infection with suppuration; absence of mobility; and absence of a continuous radiolucency around the implant.

Statistical analysis
Statistical analyses of data were carried out with MatLab 7.0.1 (Statistics Toolbox, MatLab 7.0.1, The MathWorks Inc., Boston, MA, USA). Normal distribution for each data set was carried out, but not confirmed, by the Lilliefors test for all the subgroups of group B, because some sample subgroups were too small to satisfy the criteria of the central limit theorem. The data are assumed to come from a continuous, symmetrical distribution around its median.

In the multiple comparisons tests, to overcome the dependency among implants, one implant per patient was randomly selected (Herrmann et al. 2005). The Kruskal–Wallis test with Bonferroni correction was chosen for multiple comparisons of the three grafting material groups [autogenous from the chin or the iliac crest, and bovine bone material] of unmatched data. Pair comparisons of bone level were performed between experimental groups for each treatment type (among the three grafting-material groups, and between delayed and simultaneous procedures), using the Wilcoxon rank-sum non-parametric test both for mesial and distal sites.

The level of statistical significance was set at 0.05. Data are reported as mean and standard deviation, unless otherwise indicated.

A life-table was compiled adopting implant loss and implant failure as a dichotomous event, as defined previously. Annual failure rates, calculated by dividing the number of events [failures] in the numerator by the total number of dental implants with each procedure in the denominator, and cumulative survival rates (CSRs) were evaluated as described by Romeo et al. (2004).

Results
Implant clinical survival
A total of 282 dental implants were positioned in the grafted sinuses. Of the 136 implants positioned into autologous bone areas, a total of six implant failures occurred. With regard to the chin group, all failures were recorded at the 1-year follow-up [five failures in three different female patients], while the other failure was found at the second year in the iliac-crest group in a female patient.

Thus, the CSR for autologous bone implants were, at the second year, 94.4% and 97.9% for the chin- and iliac-crest groups, respectively.

Of the 146 implants positioned in bovine bone material, no failure was recorded at the 2-year follow-up, resulting in an overall 2-year CSR of 100% at the second year.

Of the 282 dental implants, 138 were positioned with an immediate procedure, with only one failure being recorded, whereas 144 dental implants were placed with a delayed procedure, with five failures (four early), yielding CSRs at the 2-year follow-up of 99.3% and 96.5% for immediate and delayed procedures, respectively.

The distribution of both implants and sinus grafting procedures according to grafting typology...
Table 1. Number of treated patients, sinuses and placed dental implants sorted by graft type

<table>
<thead>
<tr>
<th>No. of procedures graft source</th>
<th>Clinical survey (2 years)</th>
<th>Radiological survey (2 years)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Treated sinuses</td>
<td>Implants</td>
</tr>
<tr>
<td>Overall autogenous</td>
<td>59</td>
<td>136(6)</td>
</tr>
<tr>
<td>Autogenous chin</td>
<td>36</td>
<td>89(5)</td>
</tr>
<tr>
<td>Autogenous crest</td>
<td>23</td>
<td>47(1)</td>
</tr>
<tr>
<td>Bovine bone material</td>
<td>59</td>
<td>146(0)</td>
</tr>
</tbody>
</table>

In parentheses, number of failures.

Table 2. Life-table analysis for implant survival of 282 implants inserted in grafted sinus areas

<table>
<thead>
<tr>
<th>Inlay graft procedure</th>
<th>Interval (years)</th>
<th>Implants at start of interval</th>
<th>Drop-outs</th>
<th>Implants at risk</th>
<th>Failures during interval</th>
<th>SR (%)</th>
<th>CSR (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Autogenous chin</td>
<td>0–1</td>
<td>89</td>
<td>0</td>
<td>89</td>
<td>5</td>
<td>94.4</td>
<td>94.4</td>
</tr>
<tr>
<td></td>
<td>1–2</td>
<td>84</td>
<td>0</td>
<td>84</td>
<td>0</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Autogenous crest</td>
<td>0–1</td>
<td>47</td>
<td>0</td>
<td>47</td>
<td>0</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>1–2</td>
<td>47</td>
<td>0</td>
<td>47</td>
<td>1</td>
<td>97.9</td>
<td>97.9</td>
</tr>
<tr>
<td>Bovine bone material</td>
<td>0–1</td>
<td>146</td>
<td>0</td>
<td>146</td>
<td>0</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>1–2</td>
<td>146</td>
<td>0</td>
<td>146</td>
<td>0</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

SR, survival rate; CSR, cumulative survival rate.

is shown in Table 1, whereas the relevant data for survival rate are summarized in life-table (Table 2). The number of implants that failed in augmented areas with chin grafts was five, occurring in two smokers (three failures) and in one non-smoking patient (two failures). One implant failed in the iliac-crest graft group, and occurred in a non-smoker.

Apical implant radiographic bone remodeling

Thirty-one of the 57 sinus augmentation procedures in group B were performed in 24 patients with bovine bone material, and the other 26 were performed in 15 patients with autogenous bone harvested from either the chin or the iliac crest. One hundred and fifty-four dental implants were inserted: 92 were positioned in sinuses treated with bovine bone material, while 62 were placed in sinus-grafted areas treated with autogenous bone (19 in augmented areas from the chin and 43 in grafted areas with iliac crest bone). The distribution of both implants, and patients, and sinus grafting procedures according to grafting typology are shown in Table 1. The data on the remodeling of peri-implant apical bone measured at the 1- and 2-year follow-ups are reported in Tables 3 and 4, which show the mean distance and standard deviations of linear measurements and the results of both multiple comparisons and pair comparisons, respectively.

The Kruskal–Wallis test recorded differences at a statistically significant level only between autogenous crest and bovine bone material at the 1-year follow-up. The mean distances at the 1-year follow-up between the implant apex and the new sinus floor (ABL) in the autogenous-grafted areas from iliac crest were 0.6 ± 1.5 mm mesially and 0.8 ± 1.8 mm distally. The average distances at the 1-year follow-up between the implant apex and the new sinus floor (ABL) for the bovine bone material group were 3.5 ± 3.2 mm mesially and 2.5 ± 2.3 mm distally. The differences between these groups were statistically significant, with P-values of 3.4 × 10⁻³ and 7.4 × 10⁻⁴ for mesial and distal data, respectively (Table 4), whereas the significance disappeared at the 2-year follow-up, showing that the bovine bone material reabsorbed, yielding a result similar to that found in the autogenous group. A statistically significant difference was recorded between the two autogenous groups at the 1-year follow-up, for which the values obtained of mesial ABL were 1.4 ± 1.5 and 0.6 ± 1.5 mm for chin and iliac crest, respectively, with a P-value of 0.019, the significance disappeared at the 2-year follow-up. Another statistically significant difference was found for bovine bone material dABL values between the 1- and 2-year follow-ups (2.5 ± 2.3 and 1.3 ± 2.1 mm, respectively), with a P-value of 4.7 × 10⁻³.

Marginal implant radiographic bone remodeling

Out of 154 dental implants inserted, 82 were simultaneous – at the time of sinus augmentation – and positioned in sinuses treated with bovine bone material, while 72 were delayed, and placed in sinus-grafted areas treated with autogenous bone or bovine bone material.

The mean distances between the implant hexabase and the alveolar crest, as MBL, 1 year after implant insertion are reported in Table 3: the mean distances in the maxillary areas related to a two-stage procedure were 1.8 ± 1.9 mm mesially and 2.1 ± 2.1 mm distally at the 1-year follow-up, and 1.4 ± 0.7 mm mesially and 1.5 ± 1 mm distally at the 2-year follow-up. These average distances for the maxillary areas related to the simultaneous implant group were 0.5 ± 0.8 mm mesially and 0.6 ± 0.8 mm distally at the 1-year follow-up, and 0.5 ± 0.9 mm mesially and 0.7 ± 1 mm distally at the 2-year follow-up. The differences between the delayed and simultaneous groups are statistically significant, with P-values of 2 × 10⁻⁷ mesially and 7.5 × 10⁻⁷ distally at the 1-year follow-up, and 3.3 × 10⁻⁴ mesially and 4.8 × 10⁻³ distally at the 2-year follow-up, as presented in Table 4.

Discussion

The purpose of this study was to conduct a clinical and radiological survey at the 2-year follow-up of immediate and delayed implants, placed in sinuses grafted with autogenous bone (from the chin or the iliac crest) or bovine bone material, in patients with maxillary atrophy coupled with sinus pneumatization.

The hypothesis is that the amount of linear graft remodeling depends on the nature of the inlay graft (bovine bone material or autogenous bone from the chin and the iliac crest) with regard to apical measurement, and on the type of procedure of implant insertion (simultaneous or delayed) with regard to cervical measurement.

The primary aims were to evaluate implant survival rates of the different groups presented and to find statistical differences in the linear apical bone resorption between the autologous and the bovine bone-material groups following sinus floor elevation procedures and dental implant placement, as well as to evaluate marginal bone loss of each implant to test differences between simultaneous and delayed procedures.

The rehabilitation of patients with functional implant-supported prosthesis is the ultimate purpose of all sinus graft procedures performed. The loss of a portion of implant osseointegration due to cervical bone resorption and/or to the implant apex bulging into the sinus cavity could jeopardize long-term implant success.

The results of the present study, with a CSR of 97.9%, are superior to those reported by Wallace & Froum (2003) who, in a systematic review, calculated a survival rate of 89.5% for rough implants placed into iliac crest bone block sinus lift areas. The value of the CSR at the second year for the chin-graft group, that is 94.4%, seemed to be in the range of the values of survival rates of implants placed in augmented sinuses with autogenous bone grafts presented in a previous sys-
A review of Chiapasco suggested that the primary stability of an implant cannot be obtained in simultaneous implant positioning when the quality and quantity of the residual alveolar bone are poor, as in the case of a residual height of <4–5 mm. Regarding implant survival, the review showed a significantly lower survival rate of simultaneous implants as compared with implants placed in more than 5 mm of residual bone [56% vs. 100%] (Chiapasco et al. 2006). In contrast to these findings, in the present study, the CSR at the 2-year follow-up for simultaneous implants, placed in a residual bone with a height ranging from 1 to 10 mm, was 99.3%; this was higher than the CSR of delayed implants, which was 96.5% at the second year.

The remodeling phenomenon was verified by three dimensional measurements both for autogenous bone and bovine bone material, showing mean values of graft remodeling ranging from 0.4% to 54% of the primary-grafted bone, where a volumetric reduction was represented by the minus sign [Kirmeier et al. 2008]. In a previous study, apical linear resorption was measured for autogenous bone graft in the bucco-palatal direction, showing mean remodeling ranging from 1.1 ± 2.3 to −2.7 ± 1.4 mm [negative value indicated implant bulging] (Sbordone et al. 2009), whereas the bulging of the implant apex into the sinus cavity of a 2:1 autogenous bone/xenograft mixture at the implant apex was negligible at the 2-year follow-up; however, at the 3-year follow-up, the ratio between sinus-graft height and the implant length was 0.89 ± 0.19 mm, indicating that the implant apex was not completely covered by the grafted materials (Hatano et al. 2004).

In this retrospective study, differences regarding apical remodeling between autogenous bone from the iliac crest [mesial and distal graft heights at the top of the implant apex were 0.6 ± 1.5 and 0.8 ± 1.8 mm, respectively] and bovine bone material [mesial and distal graft heights at the top of the implant apex were 3.5 ± 3.2 and 2.5 ± 2.3 mm, respectively] were statistically significant at the 1-year follow-up, with P-values of 3.4 × 10^-3 and 7.4 × 10^-4, with the significance disappearing at the 2-year follow-up; this behavior was also verified by the Wilcoxon test, which recorded a statistical difference in the bovine bone-material groups between the 1- and 2-year follow-ups, with a P-value for the distal site of

### Table 3. Mean linear distance (in mm ± SD) of sinus floor from the implant apices apical bone level (ABL), and of marginal bone level (MBL) from implant plates

<table>
<thead>
<tr>
<th>Time</th>
<th>Bone level</th>
<th>Graft source</th>
<th>ABL</th>
<th>MBL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1-year</td>
<td>Mesial</td>
<td>1.1</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>2-year</td>
<td>Distal</td>
<td>1.1</td>
<td>1.0</td>
</tr>
</tbody>
</table>

### Table 4. Statistical analysis significance; comparing linear remodeling at implant apices and cervices between autologous and bovine bone-material groups

<table>
<thead>
<tr>
<th>Groups compared</th>
<th>Multiple comparisons (implants no.)</th>
<th>Kruskal-Wallis’s test (Bonferroni’s correction)</th>
<th>Pair comparisons (implants no.)</th>
<th>Wilcoxon’s test</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-year ABL</td>
<td>Autogenous chin vs. bovine bone material</td>
<td>5 10 24</td>
<td>17 vs. 92*</td>
<td>0.055 0.116</td>
</tr>
<tr>
<td>1-year ABL</td>
<td>Autogenous crest vs. bovine bone material</td>
<td>10 24</td>
<td>43 vs. 92*</td>
<td>3.4 × 10^-5 7.4 × 10^-4</td>
</tr>
<tr>
<td>2-year ABL</td>
<td>Autogenous chin vs. bovine bone material</td>
<td>5 10 24</td>
<td>17 vs. 92*</td>
<td>0.019 0.062</td>
</tr>
<tr>
<td>2-year ABL</td>
<td>Autogenous crest vs. bovine bone material</td>
<td>10 24</td>
<td>42 vs. 92*</td>
<td>0.051 0.266</td>
</tr>
<tr>
<td>Auto-genous chin ABL</td>
<td>1 vs. 2-year</td>
<td>17 vs. 17*</td>
<td>0.476 0.623</td>
<td></td>
</tr>
<tr>
<td>Auto-genous crest ABL</td>
<td>1 vs. 2-year</td>
<td>43 vs. 42*</td>
<td>0.434 0.491</td>
<td></td>
</tr>
<tr>
<td>Bovine bone material ABL</td>
<td>1 vs. 2-year</td>
<td>92 vs. 92*</td>
<td>0.108 4.7 × 10^-3</td>
<td></td>
</tr>
<tr>
<td>1-year MBL</td>
<td>Delayed vs. simultaneous</td>
<td>70 vs. 82*</td>
<td>2 × 10^-7 7.5 × 10^-7</td>
<td></td>
</tr>
<tr>
<td>2-year MBL</td>
<td>Delayed vs. simultaneous</td>
<td>69 vs. 82*</td>
<td>3.3 × 10^-4 4.8 × 10^-3</td>
<td></td>
</tr>
<tr>
<td>Delayed MBL</td>
<td>1 vs. 2 year</td>
<td>70 vs. 69*</td>
<td>0.806 0.674</td>
<td></td>
</tr>
<tr>
<td>Simultaneous</td>
<td>1 vs. 2 year</td>
<td>82 vs. 82*</td>
<td>0.404 0.313</td>
<td></td>
</tr>
</tbody>
</table>

Statistically significant values (Wilcoxon’s rank-sum test* and Wilcoxon’s signed-rank test’) are given in bold.
Our current report suggests that statistically significant differences between the delayed group (at 1-year, 1.8 ± 1.9 and 2.1 ± 2.1 mm, mesially and distally, respectively, and at 2-years, 1.4 ± 0.7 and 1.5 ± 1 mm, mesially and distally, respectively) and the simultaneous group (at 1-year, 0.5 ± 0.8 and 0.6 ± 0.8 mm, mesially and distally, respectively, and at 2-years, 0.5 ± 0.9 and 0.7 ± 1 mm, mesially and distally, respectively) were recorded both on the 1- and 2-year follow-ups, with extremely significant P-values (ranging from 4.8 × 10^{-3} to 2 × 10^{-7}) as shown in Table 4; the remodeling of delayed implants in the cervical portion showed a greater resorption than did simultaneous implants.

This may be due to a less demanding surgical procedure in the immediate implant insertion procedure with regard to the peri-implant biological dimension.

In conclusion, regarding remodeling in augmented sinus areas, the behavior of the autogenous bone from the iliac crest and the xenograft material was ultimately very similar at the implant apex, even though for bovine bone material the resorption was much slower than that of this autogenous graft. The behavior of autologous bone from the chin seemed similar to that of xenogenic material, probably because of the dense cortical composition of such grafts.

The differences between immediate and delayed procedures of implantation, in regard to marginal bone, indicated a lesser resorption process of the former as compared with the latter.

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