A Comparative Volumetric Study of Symphysis Donor Defects, Unfilled or Filled with Bone Substitute

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ABSTRACT

Objectives: Background Intraoral autogenous bone grafts are a convenient source of bone in reconstruction of the residual ridge before dental implant placement.

Purpose: The aim of this study was to evaluate bone volume of symphysis donor defects filled with bone substitute compared with unfilled symphysis donor defects.

Patients, Materials and Methods: The study included 26 patients who underwent either alveolar ridge reconstruction or maxillary sinus elevation. Two groups were studied: symphyseal donor defects filled with bone substitute and unfilled symphyseal donor defects. Pre- and postoperative volumetric variables were determined using computed tomography scans and the software program SimPlant® (Materialise Dental Italia, Roma, Italy).

Results: At 6 months postsurgery, the filled donor defects exhibited a significant increase in bone volume compared with unfilled donor defects (97.7% and 73.4%, respectively). At 18 months postsurgery, volume of unfilled donor defects was reevaluated with no significant increase in bone volume.

Conclusions: Six months following block harvesting procedure, filled donor defects maintained bone volume, while unfilled donor sites generated defects that cannot achieve full regeneration; even not 18 months postblock harvesting.

KEY WORDS: autogenous bone graft, bone substitute, dental implants, donor site, harvesting, mandibular symphysis, onlay graft, symphysis revisiting

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INTRODUCTION

Placement of an endosseous implant requires sufficient bone volume for complete coverage, which can be accomplished by using allogeneic bone, alloplastic materials, or autogenous bone graft.[1] However, in the reconstruction of the residual ridge for implant placement, autogenous bone graft has several advantages, mainly its osteoinductive, osteoconductive, and osteogenic properties.[2–4] Implants placed in these augmented areas have high survival and success rates, with minimal bone loss.[1,5] Possible sources for autologous bone grafting may be extraoral (e.g., ilium, rib, calvarium, and tibia) or intraoral (maxilla, mandible, zygoma).[1,5–7]

Intraoral grafting provides several advantages over extraoral sources. The procedure can be performed in the office or in an outpatient clinic. While general anesthesia is optional, the close anatomic similarity between donor and recipient sites reduce surgical and anesthesia time.[1,2,6,8] The mandible, as a preferable donor site, has

advantages that include no cutaneous scar formation, good bone quality, convenient surgical access, little volume loss, good incorporation with a short healing time, high biocompatibility, embryological proximity, and decreased morbidity.[1,2,5,7,9–11] Risks involved in harvesting bone from the symphysis include root damage to the canines, possible postoperative temporary altered sensation of the mandibular anterior teeth, and possible pulpal damage.[2,9]

Today, when considering intraoral autogenous bone grafting, the mandibular ramus is the area of choice because it provides good bone quality with fewer postoperative complications compared with the symphysis area.[7] However, symphysis bone harvesting is preferable when a larger bone volume is needed or where the harvesting area in the ramus is close to the inferior alveolar canal nerve.[2]

Bone substitute materials enhance bone formation or improve bone healing after bone trauma or surgery. These materials serve as an osteoconductive scaffold for bone regeneration from the residual bone, that is, the bone substitute becomes integrated with time and subsequently replaced by newly formed bone.[2,12,13] Filling donor site with bone substitute may allow symphysis revisiting after 5 months for an additional bone harvest procedure,[1,2] thus serving as a renewable reservoir of high-quality bone, as was shown by Schwartz-Arad and Levin.[1]

To date, there is no clear consensus regarding the importance of filling donor defects as well as the optimal filling materials and procedures. The aim of this study was to evaluate the volume of symphyseal donor sites filled with bone substitute compared with unfilled symphyseal donor sites, following bone harvesting procedure.

PATIENTS AND METHODS

A retrospective cohort study was conducted on 26 consecutive patients (11 women and 15 men), aged 34.9 to 67 years (mean 52 years), who were treated at two surgical centers: Schwartz-Arad Surgical Center, Ramat-Hasharon, Israel, and Department of Surgery, University of Pisa, Pisa, Italy. All patients underwent autogenous block bone grafting harvested from the mandibular symphysis for implant-supported fixed-prosthesis rehabilitation. These patients were treated from January 2002 through July 2009.

A symphysis bone harvesting procedure was performed on 13 patients for alveolar ridge reconstruction. The donor sites were filled with bovine bone material ("filled group", Schwartz-Arad Surgical Center). As well, a symphysis bone harvesting procedure was performed on 13 patients for maxillary sinus elevation and alveolar ridge reconstruction. The donor sites were not filled ("unfilled group," Department of Surgery, University of Pisa).

Symphysis Graft Harvesting Procedure Followed by Defect Filling

Patients in the "filled group" underwent block bone grafting, where the symphyseal area was chosen as a donor site. Patients who had preoperative and 6-month postoperative computed tomography (CT) scans were included in this study.

Block bone grafts from the symphyseal area were harvested for alveolar ridge reconstruction as previously described[1] and performed under general anesthesia. Briefly, an intrasulcular incision and two vertical releasing incisions were made between the premolar regions, reflecting the mucoperiosteal flap at the facial side. After exposing the symphysis and locating the mental foramina, a reciprocating saw was used to outline a rectangle in the required size. The superior aspect of the rectangle was ≥3 to 5 mm below the tooth apex, and the integrity of the lower border of the mandible was maintained. Laterally, the osteotomy performed was ≥5 mm anterior to the mental foramina. Osteotomes were used to free the block graft and to harvest cancellous bone. Closure of the donor sites were achieved after fixation of the bone grafts and closure of the recipient sites. Donor sites were filled with bovine bone material (Bio-Oss®; Geistlich Pharma AG, Wolhusen, Switzerland) mixed with platelet-rich plasma, and covered by platelet-poor plasma or a bioabsorbable collagen membrane (BioGide®, Geistlich CH, Wolhusen, Switzerland).

Symphysis Graft Harvesting Procedure without Defect Filling

The "unfilled group" of patients underwent block bone grafting for maxillary sinus elevation or alveolar ridge reconstruction, where the symphyseal area was chosen as a donor site. The procedure was performed as previously described[14] and under general anesthesia. Briefly,

one or two corticocancellous bone blocks, depending on need, were harvested from the parasymphyseal area. Osteotomy cuts were made with a reciprocating saw and the bone blocks harvested using curved chisels. No material was used to fill the residual defect in the donor area. The lower margin of the mandible was preserved to avoid altering the chin contour.

Variables

Volumetric bone variables were measured in the filled and unfilled donor defects. The volume of the potentially harvesting site was determined using the preoperative CT scans (T_0). Lateral boundaries were set from mental foramen to mental foramen. The lowest position of all the root apices of the mandibular incisors and canines were the upper border. Additionally, the posterior and inferior boundaries were the lingual and lower borders, respectively, excluding the mandibular cortex (median of all examined cortexes at the lower border and lingual plates).

These boundaries used for the preoperative CT scans (T_0) were also used in 6-month postoperative CT scans (T_1) and in 18-month scans (T_2) for unfilled donor defects only.

In this report, the lingual cortex and lower border of the mandible were excluded from the symphyseal potential harvesting area to avoid potential complications. Thus, when the chosen borders are used, all of the symphyseal potential harvesting area may be available, though the harvested area is selected according to requirements: the volume needed for augmentation in each patient.

Volumetric measurements of harvesting sites and donor defect areas, set among described boundaries, were measured for the following available time points: V_{T0} (preoperative volume) and V_{T1} (6 months postoperative volume), for filled and unfilled defects, as well as V_{T2} (18 months postoperative volume) for unfilled defects only.

Donor defect volume (filled and unfilled) at T_1 ($V_{0\rightarrow1}$) was determined using equation 1:

$$V_{0\rightarrow1} = V_{T0} - V_{T1} \quad (1)$$

In addition, donor defect volume (unfilled only) at T_2 ($V_{0\rightarrow2}$) was determined using equation 2:

$$V_{0\rightarrow2} = V_{T0} - V_{T2} \quad (2)$$

All volumetric measurements were taken as previously described by Smolka and colleagues.[15] In this study, SimPlant® 12.02 (Materialise Dental Italia, Roma, Italy) was used in order to determine bone volume of the defects.

Statistical Analyses

Descriptive analyses, such as the distribution of graft procedures, were performed using a statistical tools package (Statistics Toolbox, MatLab® 7.0.1, The MathWorks, Natick, MA, USA). All measurements in the text and tables are described as mean, $\bar{m}$, and standard deviation, ±SD.

Normal distribution for each data set was carried out, and hypothesis of normality was confirmed for measurements, by the Lilliefors test applied to all subgroups.

For normally distributed data, *t*-test for matched samples was used to determine significant differences in volume between T_0 and T_1 of filled defects, T_0 and T_1 of unfilled defects, and between T_1 and T_2 of unfilled defects only. *t*-Test for unmatched samples was used to determine significant differences in volume between filled and unfilled defects at time T_0 and T_1. Statistical analyses of data were carried out with MatLab 7.0.1. Level of significance was set at 0.05 for all analyses.

RESULTS

Median bone volume of the potential harvesting area from the symphysis was 5.95 (2.56) cc (range 3.48–9.28 cc), as measured from mental to mental and from root apices of incisors and canines to the mandible without the cortical plate. All examined cortexes at the lower border and lingual plates showed a median of 3 mm. The volume of the harvested block was one-fifth of the potential harvesting area (1.2 cc on average), which is in accordance with other studies.[16,17]

Bone Volume

A significant difference in bone volume remodeling was found at T_1 between filled (Figure 1, A and B) (-0.20 ± 0.40) and unfilled donor defects (Figure 1, C and D) (0.90 ± 0.42) with $p = 7 \cdot 10^{-5}$. Accordingly, over a 5- to 6-month period ($T_0 \rightarrow T_1$), filled defects exhibited 101.7% of volume recovery, which was equivalent to bone volume measured before the harvesting procedure (Figure 2, A and B), while volume recovery of unfilled defects was 79.8%. At 18 months postsurgery (T_2), measured bone volume of unfilled donor defects was

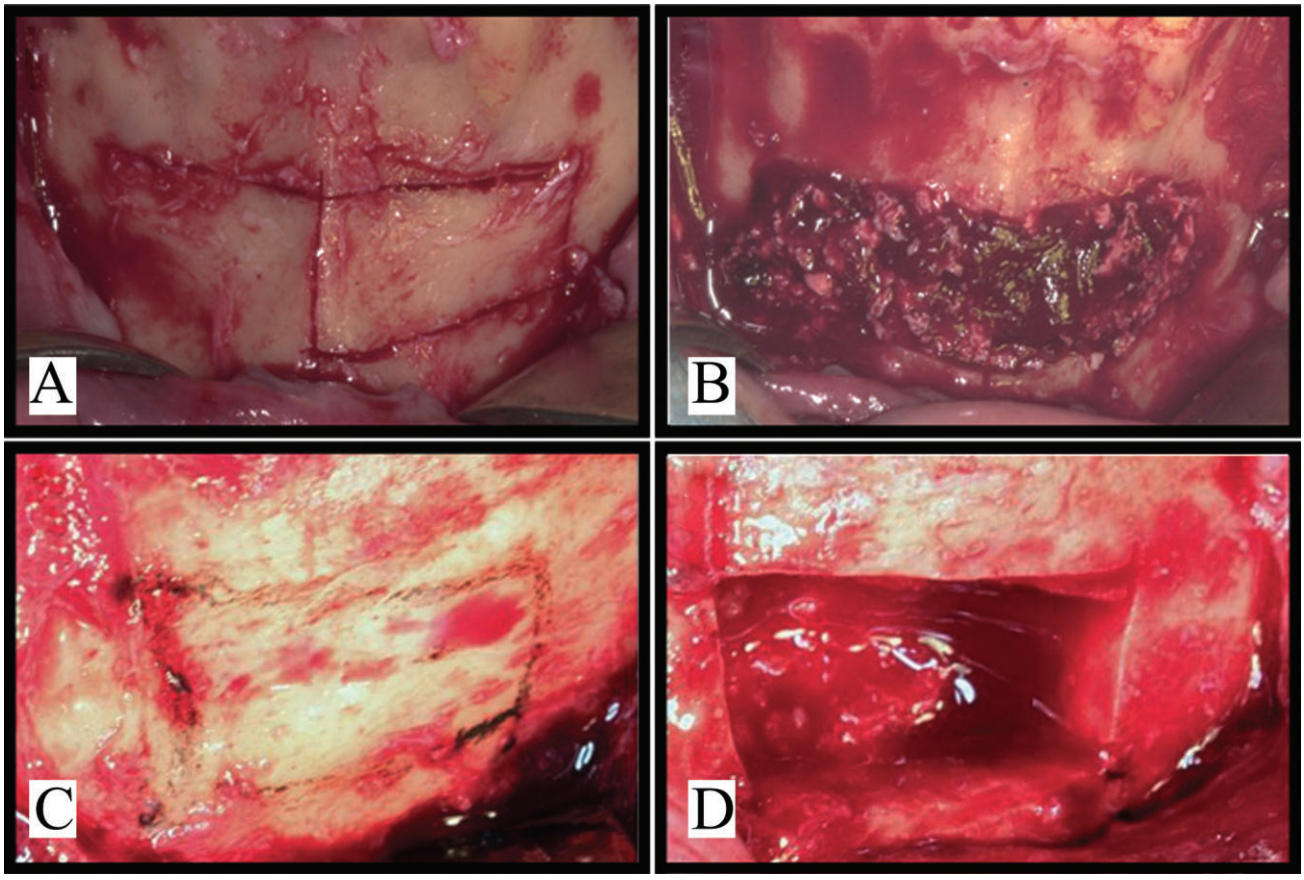

Figure 1 Filled defect: bone block harvested from the mandibular symphysis before (A) and after (B) block harvesting, filled with bovine bone material. Unfilled defect: bone block harvested from the mandibular symphysis before (C) and after (D) block harvesting.

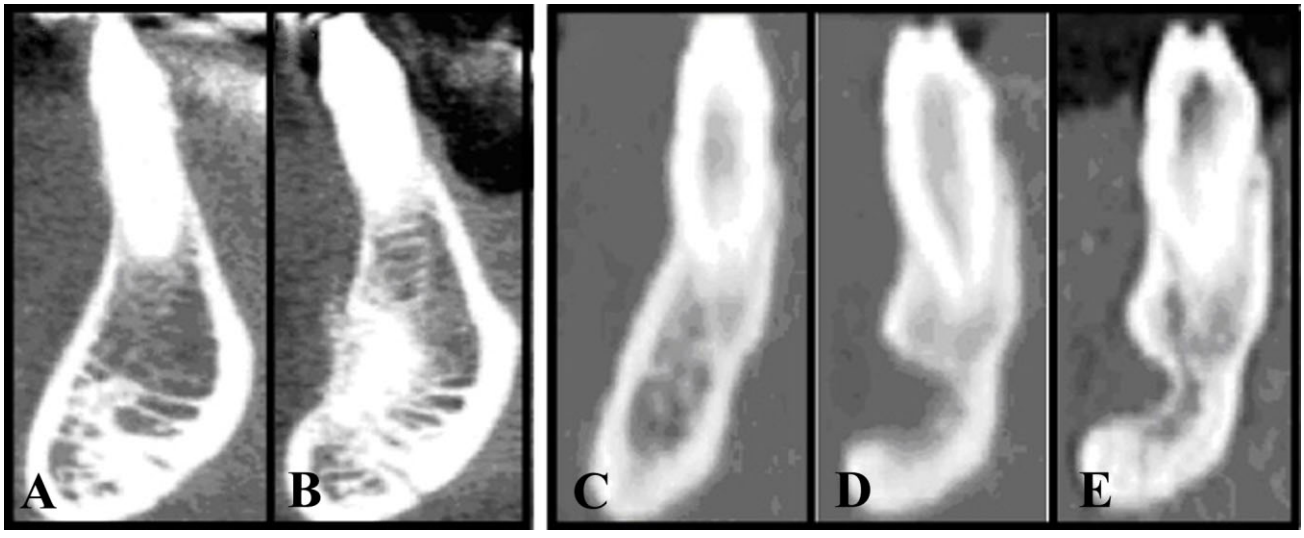

Figure 2 Radiographic views of filled defect: before harvesting procedure (T_0) (A); 6 months postharvesting procedure filled with bovine bone material (T_1) (B). Radiographic views of unfilled defect: before harvesting procedure (T_0) (C); 6 months postharvesting procedure (T_1) (D); 18 months postharvesting procedure (T_2) (E).

TABLE 1 Bone Volume of the Harvesting Sites and Donor Defects of Filled and Unfilled Areas Measured at T_0 (Preoperative) and at T_1 and T_2 (6 and 18 Months Postoperative, Respectively)

		Volume (cc)	
Time	Variables	Filled	Unfilled
T_0	Potential harvesting site	5.36 ± 2.04	6.67 ± 1.23
	Donor defect	—	—
T_1	Harvesting site	5.45 ± 2.00	5.32 ± 1.66
	Donor defect	–0.20 ± 0.40	0.90 ± 0.42
T_2	Harvesting site	—	6.11 ± 1.42
	Donor defect	—	0.72 ± 0.25

Values are described as mean ± standard deviation.

0.72 ± 0.25 cc, showing an increase of 20.0% compared with the value at T_1 but the differences were not significant ($p = .1322$) (Figure 2, C–E, Table 1). The difference between healed filled defects and healed unfilled defects is also shown by three-dimensional CT scans (Figure 3).

No significant differences were found in harvesting site volume between the filled and unfilled groups at times T_0 ($p = .1346$) and T_1 ($p = .8689$), in the filled defects group between T_0 and T_1 ($p = .2282$), and in unfilled defects group between T_1 and T_2 ($p = .2037$) (see Tables 1 and 2). An adjunctive statistical difference was found in harvesting site volume for the unfilled group between time T_0 (6.67 ± 1.23 cc) and T_1 (5.32 ± 1.66 cc), $p = .0049$ (see Tables 1 and 2).

DISCUSSION

Symphysis bone harvesting results in an osseous defect, which is either left to heal spontaneously (unfilled) or is filled with bone substitutes,[18] and thus filled donor defects may show bone volume and shape restoration. This study aimed to evaluate bone volume of filled donor defects compared with bone volume of unfilled donor defect, 6 months postbone harvesting procedure.

Present results show bone volume restoration of filled defects, which was equivalent to that measured before bone harvesting procedure, while unfilled defects exhibited incomplete bone volume restoration, at 6 months postsurgery. Moreover, unfilled defects exhibited a nonstatistically significant increase in bone volume at 18 months postsurgery. This result is in accordance with other reports.[19,20] The reduced bone volume of unfilled defects as compared with the filled defects does not allow the use of the same donor sites for block reharvesting at 6 or even 18 months postoperationally. This is due to its concave shape that obtained because the increase in bone volume of unfilled defects is mainly at the defect margins.[21]

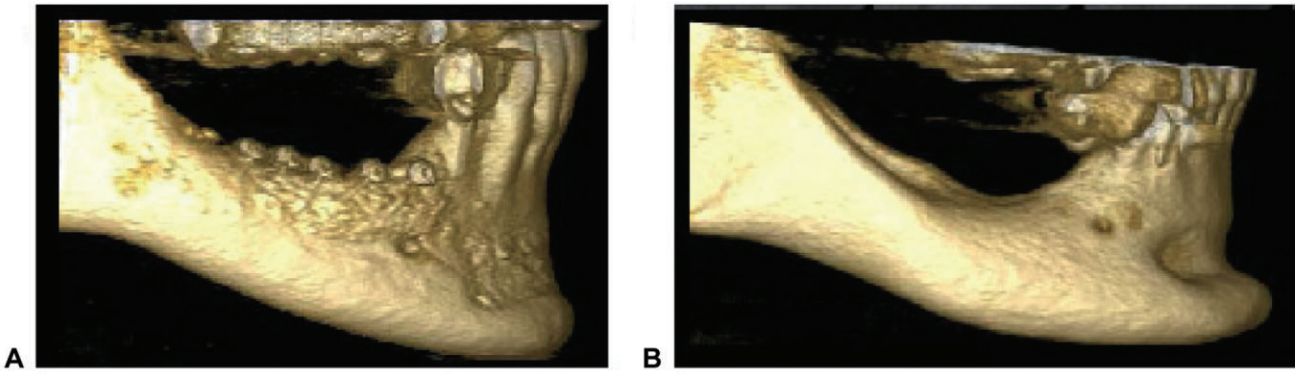

Figure 3 Representative postharvesting three-dimensional CT images: (A) healed filled symphysis donor defect and (B) healed unfilled symphysis donor defect.

TABLE 2 Statistical Pair Comparisons

	Compared groups	Volume (cc)	
		Harvesting site	Donor defect
T_0	Filled versus unfilled	0.1346*	—
T_1	Filled versus unfilled	0.8689*	**$7 \cdot 10^{-5}$***
Filled	T_0 versus T_1	0.2282†	—
Unfilled	T_0 versus T_1	**0.0049**†	—
Unfilled	T_1 versus T_2	0.2037†	0.1322†

**t*-test for unmatched samples, between groups (filled vs unfilled).
†*t*-test for matched samples assessed the changes in time for each procedure among T_0, T_1, and T_2. Statistically significant values are given in bold.

Restricted by mathematical and technical limitations, it is important to note that the chosen boundaries of the harvesting site (from mental to mental and from the apices of the frontal teeth to the posterior and inferior border of the mandible, excluding 3 mm of lingual and lower cortical plates) dictate a relatively large area compared with the small area of the defect (5:1). This may mask even greater differences in bone volume and density between filled and unfilled defects.

Long-term follow-up studies have shown that symphysis bone healing is not regenerated to the preoperative level when defects are left unfilled.[11,20,22] Although no alteration in chin contour is observed, a radiologic concavity usually remains, particularly in older patients.[11,22] However, no postoperative alteration in chin contour is observed either clinically or radiographically,[8] when the symphysis donor area is filled with a bone substitute material. Additionally, psychological discomfort may also be avoided as patients sometimes feel troubled by the fact that they are being left with an osseous damage.

Bone substitutes are usually used for guided bone regeneration at the recipient site.[2,23,24] However, their use as filler material at the donor site is not less important. Symphyseal bone regeneration after bone harvesting is important for the following reasons: (1) it can serve as a renewable reservoir of high-quality bone when augmentation is needed in other areas of the oral cavity; (2) it gains adequate bone quantity and quality for potential future placement of dental implants in the harvesting area; (3) it may enable simultaneous bone grafting and implant placement at the harvesting site; and (4) hypothetically, the defect may affect, to an undetermined degree, symphyseal bone strength and stability because this area is subjected to high occlusal and biting forces. However, according to the results of this study, only one-fifth of the symphyseal area was grafted on average and the unfilled defects showed 79.8% increase in bone volume with time. Therefore, symphysis strength and stability may not be affected to an extensive degree. To the best of our knowledge, no data exists regarding the effect of the harvesting procedure on the mechanical properties of the bone.

In an early case report,[18] complete regeneration of the symphysis was achieved 6 months after bone harvesting using a resorbable membrane placed over the bone defect site with no bone substitute material of any kind. Though the importance of bone regeneration at the donor site is emphasized, the use of a membrane to cover the site with no bone substitute material may have several drawbacks. The most notable is early collapse of the membrane, which could lead to incomplete osseous healing. A possible solution may be the use of nonresorbable membranes. However, it demands a reentry procedure after a 6-month healing period, thus increasing patient discomfort. Contrary to membrane usage, filling donor sites with a bone substitute material helps to support the membrane, enhances bone regeneration, and minimizes patient discomfort.[1,18]

Bone regeneration involves the differentiation of new cells and formation of new bone tissue that results in an overall increase in volume of new skeletal tissues, that is, in contrast to repair, where only restoration of the continuity of the injured tissues occurs without necessarily increasing bone volume.[25] As was previously reported, the clinical appearance of donor sites filled with bovine bone combined with platelet-rich plasma is compatible with newly formed bone. Histological analysis shows bovine bone particles surrounded by woven bone with areas of mature bone with well-organized

osteons. Thus, bone healing after block harvesting enables the use of the same donor sites for block reharvesting after 5 months.[1] Accordingly, donor site revisiting is a good alternative when multiple site grafting or allograft material is considered and thus the routine use of bone substitute materials to fill donor sites following a graft procedure should be considered.

Bone substitute should have, among others, the advantage of slow absorbance which enables the replacement of the bone substitute by newly formed bone and is used as scaffold to prevent collapse at the donor site and thus enables maintaining shape and volume of the mandible. In this study, we used anorganic bovine bone material. Paper by Schwartz-Arad and Levin shows that biopsy taken 5 months postoperation revealed almost complete absorbance of the bovine bone material and new bone was formed.[1] Nevertheless, further research should be conducted to investigate other bone substitute materials and to determine their absorbance time, bone volume augmentation with time, and the quantity and quality of newly formed bone.

CONCLUSION

Tomographic evaluation showed increased bone volume of symphysis donor defects filled with bovine bone material compare to unfilled symphysis donor defects, after bone harvesting procedure. This difference in bone volume was maintained even 18 months postoperatively.

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