Quantitation of Mandibular Symphysis Volume as a Source of Bone Grafting

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ABSTRACT

Background: Autogenous intramembranous bone graft present several advantages such as minimal resorption and high concentration of bone morphogenetic proteins. A method for measuring the amount of bone that can be harvested from the symphysis area has not been reported in real patients.

Purpose: The aim of the present study was to intrasurgically quantitate the volume of the symphysis bone graft that can be safely harvested in live patients and compare it with AutoCAD® (version 16.0, Autodesk, Inc., San Rafael, CA, USA) tomographic calculations.

Materials and Methods: AutoCAD software program quantitated symphysis bone graft in 40 patients using computerized tomographies. Direct intrasurgical measurements were recorded thereafter and compared with AutoCAD data. The bone volume was measured at the recipient sites of a subgroup of 10 patients, 6 months post sinus augmentation.

Results: The volume of bone graft measured by AutoCAD averaged 1.4 mL (SD 0.6 mL, range: 0.5–2.7 mL). The volume of bone graft measured intrasurgically averaged 2.3 mL (SD 0.4 mL, range 1.7–2.8 mL). The statistical difference between the two measurement methods was significant. The bone volume measured at the recipient sites 6 months post sinus augmentation averaged 1.9 mL (SD 0.3 mL, range 1.3–2.6 mL) with a mean loss of 0.4 mL.

Conclusion: AutoCAD did not overestimate the volume of bone that can be safely harvested from the mandibular symphysis. The use of the design software program may improve surgical treatment planning prior to sinus augmentation.

KEY WORDS: AutoCAD®, bone graft, symphysis

INTRODUCTION

Bone augmentation may be required prior to dental implant placement. Autogenous intramembranous bone graft present several advantages such as minimal resorption, good volume maintenance, and high concentration of bone morphogenetic proteins.[1–7] However, a method for measuring the amount of bone that can be safely harvested from the mandibular symphysis area has not been reported in real adult patients.

Bähr and Coulon[8] used computerized tomography of 28 children and reported an average of 0.4 mL mandibular symphysis bone volume. Montazem and colleagues[9] used 16 dentate adult cadavers and reported a bone volume of 2.9 mL. Gungormus and colleagues[10] examined 16 adult cadaver dry skulls and measured a bone volume of 4.5 mL, while Neiva and colleagues[11] reported a bone volume of 1.7 mL after examining 22 Caucasian skulls.

The aim of the present study was to intrasurgically quantitate the volume of mandibular symphysis bone graft that can be safely harvested in live patients. The obtained measurements were compared with presurgical tomographic measurements of the bone volume by using AutoCAD® (version 16.0, Autodesk, Inc., San Rafael, CA, USA) software.

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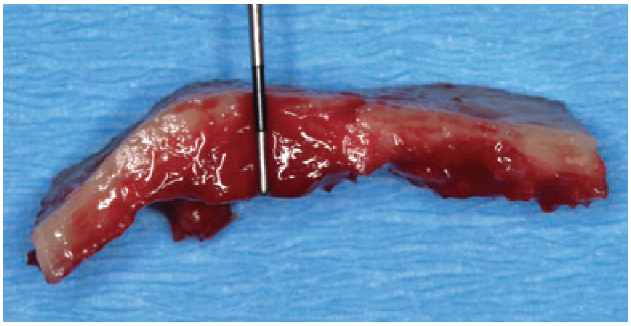

Figure 1 One-piece symphysis block graft.

MATERIALS AND METHODS

The University of Southern California Institutional Review Board approved the present research project (IRB #04-06-201).

Intrasurgical Measurement of the Bone Volume

The mandibular symphysis block grafts were harvested for sinus augmentation ($n = 10$) (Figures 1 and 2). The volume of the particulated grafts was measured intrasurgically by using a graduated cylinder with 0.5 mL markings. After inserting the particles inside the cylinder, a compacting pressure of 100 g was applied, and saline solution (1 mL) was added to fill the voids. From the final measured volume, 1 mL was subtracted to account for the previous saline addition.

Tomographic Measurement of the Bone Volume

AutoCAD software program was used to measure the tomographic bone volume at the mandibular symphysis for 40 consecutive patients and 6 months thereafter at the recipient site of a subgroup of 10 consecutive patients (Figure 3). AutoCAD is a computer-aided design software application used in the architecture, construction, and manufacturing.

Figure 3 The volume gain in augmented sinus was measured at 6 months using the AutoCAD design software program.

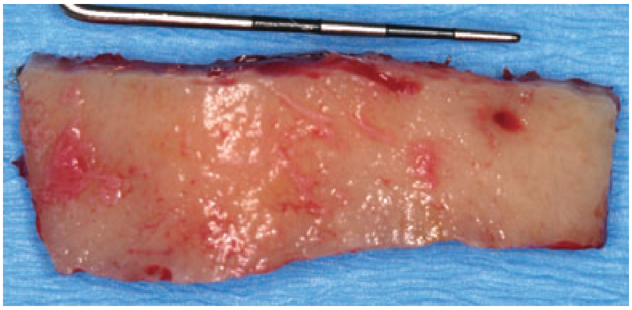

Figure 2 One-piece symphysis block graft. Buccal view.

Cross-sectional images were imported to the software program file and each 1 mm cut was mapped by a polyline (Figure 4). A 5 mm safety margin was outlined caudal to the apices of the teeth, cephalad to the inferior border of the mandible, and anterior to the mental foramen. First, the surface area and then the volume of each mapped polyline were measured. The total volume was then calculated by adding the consecutive cuts.

In addition, morphometric measurements were made at midline and canine areas (midway apicocoronally), recording the buccal cortical, lingual cortical, and medullary bone thickness. All measurements of

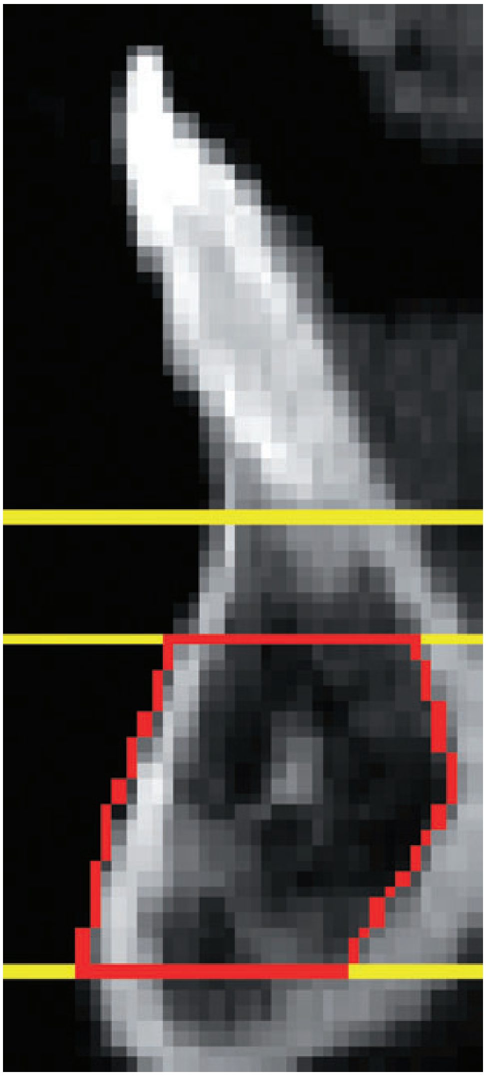

Figure 4 Surface area mapped by a red polyline. The yellow horizontal lines demarcate the 5 mm margins of safety.

thickness were carried out 5 mm apical to the apices and 5 mm coronal to the inferior border of the mandible (Tables 1 and 2).

Data Analysis

Descriptive analysis of data was expressed as mean ± standard deviation. The commercially available SPSS® software program (version 14.0, SPSS Inc., Chicago, IL, USA) was utilized to analyze the different variables and draw the box plot graphics. The student's *t* test was used for paired observations to compare values within groups: mean thickness and volumes, particulated graft harvested, and volume gained. Statistical significance was set at $p < .05$.

RESULTS

The tomographic bone volume in the 40 consecutive patients averaged 1.4 mL (SD 0.6 mL, range: 0.5–2.7 mL). Intrasurgically, the mean bone volume measured in 10 consecutive patients was 2.3 mL (SD 0.4 mL, range: 1.7–2.8 mL). The difference between the two measurement methods was statistically significant ($p < .0001$) (Figure 5).

In the computerized measurement group ($n = 40$, 22 females, mean age: 48 years, range: 28–75), the following were calculated: at the midline, buccolingual thickness of the symphysis averaged 12.8 mm (SD 1.8 mm, range: 9.3–17.0 mm), cancellous bone averaged 8.2 mm (SD 1.3, range: 5.1–10.8 mm), and buccal cortical plate averaged 2.2 mm (SD 0.4 mm, range: 1.1–3.2 mm) (see Table 1). At the canine area, buccolingual thickness of the symphysis averaged 11.5 mm (SD 2.5 mm, range: 8.0–19.0 mm), cancellous bone averaged 6.8 mm (SD 1.7 mm, range: 4.1–11.0 mm), and buccal cortical plate averaged 2.1 mm (SD 0.5 mm, range: 1.3–3.5 mm) (see Table 1). The mean lingual cortical plate thickness was 2.7 mm (SD 0.5 mm, range: 2.0–4.0 mm) at the midline and 2.8 mm (SD 0.7 mm, range: 1.9–5.2 mm) at the canine area.

The mean harvestable bone volume (excluding the lingual cortex) was 1.4 mL (SD 0.6 mL, range: 0.5–2.7 mL). In 14 patients for whom the volume was ≥1.4 mL, the mean buccolingual thickness was 13.7 mm (SD 1.6 mm) at the midline. In 16 patients for whom the volume was less than 1.4 mL, the mean buccolingual thickness decreased to 12 mm (SD 1.6 mm). The difference was statistically significant ($p < .005$, one-tailed) (see Table 2). When the $5 \times 5 \times 5$ mm of security was excluded, the mean volume increased to 2.1 mL (SD 0.8 mL, range: 0.8–4.0 mL) ($p < .0001$).

The AutoCAD evidenced sinus augmentation of 1.9 mL (SD 0.3 mL), which compared with the initial harvested volume (2.3 mL ± 0.4) yields a decrease of 0.4 mL (Figure 6).

DISCUSSION

In the present study, the volume of mandibular symphysis that can be safely harvested was measured 2.3 mL intrasurgically and 1.4 mL by AutoCAD software. Buchman and colleagues[12] used microcomputed tomography for the evaluation of membranous bones in an animal model. The technique was deemed as a highly

TABLE 1 Thickness of Bone at Harvested Areas: Buccolingual (BL), Cancellous (Cancell), and Buccal Cortical Plate (BC)

	Midline	Canine	Difference
BL thickness	12.8 ± 1.8	11.5 mm ± 2.5	1.3 $p < .05$*
Cancell thickness	8.2 mm ± 1.3	6.8 mm ± 1.7	1.4 $p < .001$*
BC thickness	2.2 mm ± 0.4	2.1 mm ± 0.5	0.1 $p > .2$

*Difference was statistically significant.

accurate tool to measure changes in bone stereology, bone volume, and microarchitecture. Other authors have also suggested that the accuracy and reproducibility of caliper or cephalometric measurements are questionable because of bone irregularity and human error.[12–14] The present study showed that, in cases where a minimum buccolingual width of 13.7 mm is present, an average of 2.3 mL of particulated bone graft can be harvested (see Table 2). The suggested measurements may be used in surgical treatment planning prior to maxillary sinus augmentation.

TABLE 2 Average BL Thickness in Group A (Volume ≥ 1.4 mL) vs. Group B (Volume < 1.4 mL)

Group A ≥ 1.4 mL $n = 14$	Group B < 1.4 mL $n = 16$
13.7 ± 1.6*	12.0 ± 1.6*

*$p < .005$.
BL = buccolingual.

Montazem and colleagues[9] used dry skulls and reported an average volume of 4.7 mL of harvestable bone graft. The 5 mm safety distance to the apices of teeth and the mental nerve, along with the full preservation of lingual cortical plate and the inferior border of the mandible, which were respected in the present study, explains the difference with the study performed by Montazem and colleagues. Gungormus and colleagues[10] also used dry skulls and a considerably large, one-piece bone block excluding safety margins and reported a volume of 4.5 mL. Neiva and colleagues,[11] on their morphometric analysis of implant related anatomy, reported a volume similar to the present tomographic findings. They used dry skulls and performed osteotomies at the symphysis area to harvest two separate blocks, preserving the

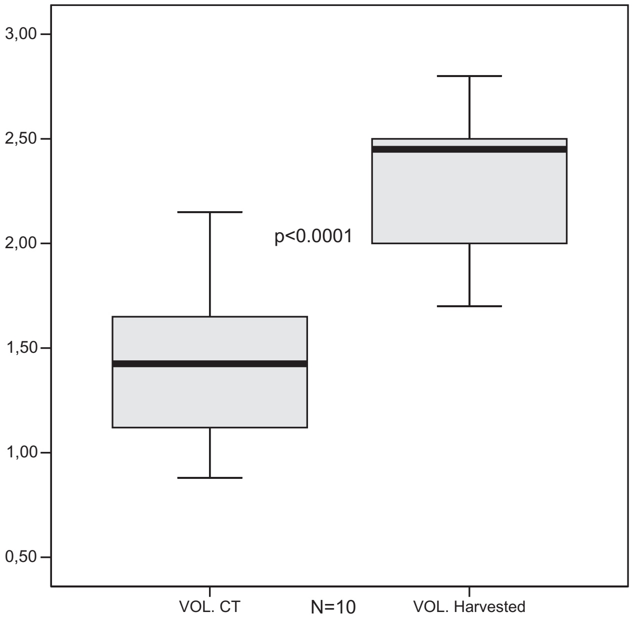

Figure 5 The volume calculated intrasurgically vs. tomographic measurement of the bone volume.

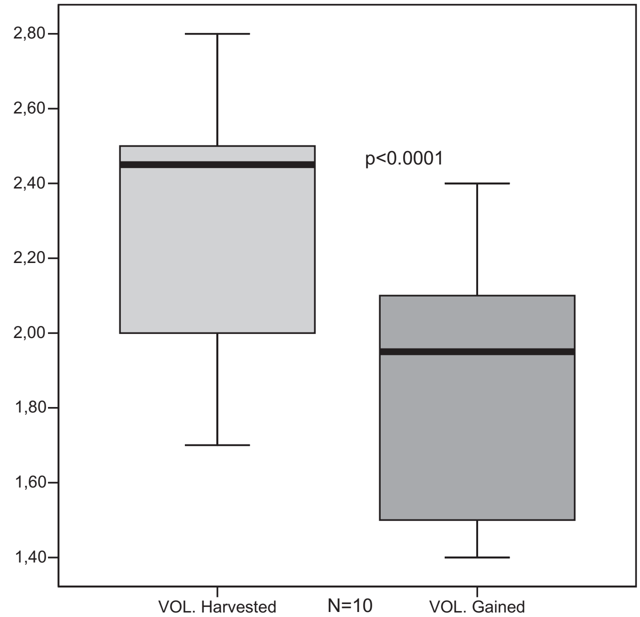

Figure 6 Normal distribution of the volumes at the time of harvest vs. sinus gain at 6 months.

midline. The average volume for both blocks was 1.7 mL. In the present study, the volume gained at 6 months post sinus augmentation (1.9 mL) was closer to the intrasurgical measurements than the tomographic calculations (see Figure 6 vs. Figure 7). The increased surface area of particulated bone graft can explain this finding.

Donor site morbidity is one of the factors to consider when selecting mandibular symphysis as a source of bone grafting. Although the mandibular symphysis provides a good access, postoperative complications have been reported. Stiffness and limited mobilization of the vestibule in the anterior sextant along with altered and decreased sensibility in the innervated areas of the mandibular incisors and canines have been reported but with a low incidence when proper surgical execution has been performed. Recovery is influenced by the patient's age, sex, surgical parameters, and direct surgical injuries.[15] Myelinic and amyelinic small-diameter fibers such as those conducting thermal and nociceptive sensation seem to recover much faster than myelinic larger diameter fibers (conducting discriminative and epicritic sensation).[16–18] Clavero and Lundgren[19] compared the donor site morbidity and complications of the mandibular ramus and symphysis. Altered sensation was diagnosed in 16 of the 53 patients at 18 months. Fifteen belonged to the symphysis group (impaired nerve function was related to the mental nerve branches), and only one was in the ramus group (impaired nerve function was related to the buccal nerve injury). In a long-term retrospective examinationof 60 patients postsymphysis graft, Weibull and colleagues[20] reported 7.6% impaired soft tissue tactility and sensitivity and 1% apical pathology. The cephalometric evaluation of the donor site in a subgroup of 45 patients showed good remineralization in 42 patients (93.3%). Therefore, the normal cascade of physiological healing events in response to injury might favor the bone repair at the donor site. This phenomenon was proposed by Frost[21] as a regional accelerated process of increased bone turnover in response to a noxious stimuli. Further investigation is granted to evaluate the osseous repair after harvesting and whether bone substitutes are indeed needed to fill in the donor site. In the present study, the incidence of temporary altered sensation in the form of hypesthesia was 50%. The most frequent disturbance was impaired sensibility in the soft tissues of the chin. In patients who received a sulcular incision, no paresthesia was observed. In contrast, paresthesias were associated with incisions performed within the alveolar mucosa, apical to the mucogingival line. No apical pathology around the mandibular teeth was detected at 6 months.

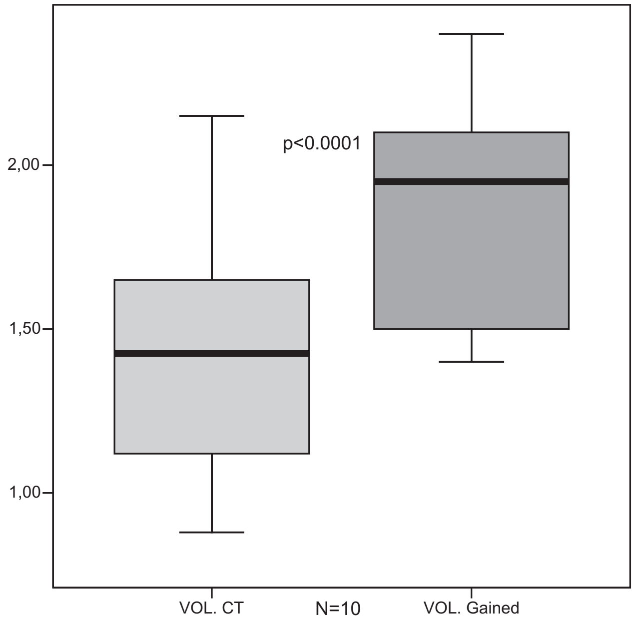

Figure 7 The volume gained at 6 months post sinus augmentation (1.9 mL) was closer to the intrasurgical measurements than the tomographic calculations.

CONCLUSIONS

AutoCAD did not overestimate the volume of bone that can be safely harvested from the mandibular symphysis. The symphysis bone harvested averaged 2.3 mL intrasurgically and 1.4 mL tomographically. The buccolingual width of the symphysis can be used to anticipate the bone volume that can be harvested. The use of the design software program can improve surgical treatment planning prior to sinus augmentation.

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None of the authors have any conflict of interest in this study.

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