Quantity and Quality of Intraoral Autogenous Block Graft Donor Sites with Cone Beam Computed Tomography

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Purpose: The autogenous bone block graft is regarded as the gold standard material due to reported osteoconductive, osteoinductive, and osteogenic properties. Various intraoral donor sites for autogenous block grafts are presented in the literature. The aim of this study was to radiographically evaluate the maximum dimensions, volume, and bone quality values of these sites. Materials and Methods: According to the inclusion criteria, 50 cone beam computed tomography (CBCT) images from 50 subjects were evaluated. The maximum length, width, height, and volume of autogenous regions where block grafts could be harvested were measured. Radiographic bone quality was calculated by using Hounsfield units derived from CBCT (CBCT-HU). Results: The mean age of 50 subjects (19 men and 31 women) was 55.84 ± 15.9 years. In this study, the symphyssis was the largest potential donor site (3.14 ± 1.05 cm³), while maxillary tuberosity was the smallest (0.53 ± 0.34 cm³). These results correlated with bone density values, where the symphyssis retained the highest values (937.31 ± 160.59 CBCT-HU) and the maxillary tuberosity had the lowest values (360.87 ± 141.48 CBCT-HU). Conclusion: Intraoral bone blocks have restrictions due to surrounding vital anatomical structures. The surgeons should consider these vital structures using accurate CBCT evaluation. The volume and density of the maximal bone harvest from the symphyssis was statistically higher in comparison with ramus, palatal, and maxillary tuberosity bone blocks. Int J Oral Maxillofac Implants 2020;35:782–788. doi: 10.11607/jomi.8079

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Oral rehabilitation of edentulous sites using dental implants is considered to be the preferred treatment to recover oral esthetics and function with predictable outcomes.1,2 However, bone defects of the alveolar ridge resulting from periodontal disease, atrophy, and trauma may cause inadequate bone volume or unfavorable vertical, transverse, and/or sagittal interarch relationship(s), resulting in challenging implant placement.3 Therefore, quantity and quality of bone at the site of preferred restorative space is a prerequisite for successful oral rehabilitation with oral implants.4 In addition to the factors related to surgery, consideration of prosthetic factors is essential for treatment success.5 Crown-to-implant ratios, numbers, angles, and sites of oral implants are critical factors for the esthetic outcome and survival of dental implants.5,6 Moreover, increased crown-to-implant ratio may be associated with a higher risk of crestal bone loss and prosthetic complications such as screw loosening, implant or abutment fracture, and chipping of ceramic.6–8 Numerous surgical procedures have been described to augment deficient bone volume sites.9,10 For severely atrophic ridges, block grafting procedures are presented as predictable approaches.11,12 Autogenous bone, xenografts, allografts, and alloplastic materials are used during block grafting procedures.13 For block grafting, the use of autogenous bone is claimed to be the gold standard, as only autogenous bone combines osteoconductive, osteoinductive, and osteogenic properties.14,15

Various extraoral and intraoral donor sites are available for harvesting bone grafts.16 Extraoral bone block grafts (calvarial or iliac crest) provide greater quantities of bone but have numerous disadvantages, including increased cost, morbidity at the donor site, and creation of a second surgical site. While the amount of available bone for harvest from intraoral sites has limited volume, its primary advantage is the potential for harvest with minimal morbidity. In addition, harvesting bone from the same surgical area may decrease the duration of the procedure, minimize the surgical field, and limit surgical interventions.17–19 A variety of donor sites are available intraorally, such as the mandibular ramus, symphyssis, palatal, and maxillary tuberosity.20 Block grafts can be harvested from these donor sites in different sizes and volumes with attention given to distances between critical structures.
from critical anatomical structures. \(^{21,22}\) Dimensions and volumes of intraoral donor sites, and their adjunct anatomical structures, can be evaluated using CBCT. \(^{18}\) CBCT images provide the surgeons with detailed information about anatomical structures, bone morphology, anatomical variations, and pathologies. \(^{23-25}\) Although numerous studies have been published on block grafts, to the best of the authors’ knowledge, there is no radiologic study published in English comparing the potential dimensions and volumes of intraoral donor sites. The aim of this study was to evaluate the maximum dimensions and volume of various intraoral autogenous block graft donor sites and to evaluate the bone quality of these donor sites.

**MATERIALS AND METHODS**

**Study Design**

Ninety CBCT images from 90 subjects were evaluated. All CBCT images acquired from the patients visited the College of Dentistry between January 1, 2004 and August 31, 2017. The study was approved by the Institutional Review Board of University of Illinois at Chicago (Protocol no: 2017-0968).

In this retrospective study, the age of the subjects ranged from 18 to 99 years. CBCT images fulfilling the following criteria were included: (1) no previous bone grafting or sinus surgery; (2) no jaw fracture; (3) good visibility in the CBCT scan; and (4) no artifacts resulting from movement during image acquisition.

**CBCT Image Analysis**

The CBCT scans were made using a single CBCT machine (i-CAT Model 17-19, Imaging Science International) operating at 1.4 mA and 120 kV, providing a field of view of 11 cm with a resolution of 0.2 voxels. The images of the scans were saved in a Digital Imaging and Communications in Medicine (DICOM) format. The high-resolution, limited-volume CBCT images were viewed on a monitor with a resolution of 1.6 MP (Dell) and calibrated for medical imaging using software (SIMPLANT Pro 17.01, Dentsply Implants) on a computer running the Windows 7 (Microsoft) system. The software acquires images in the axial plane and reconstructs in coronal and sagittal views. It also provides a 3D reconstructed model of the area of interest. Standardization of software utilization and interpretation of CBCT scans were provided over several sessions. All images were reviewed and measurements performed separately for the right and left sites by one examiner (E.T.A.D).

**Assessment of Mandibular Ramus Donor Site Quantity**

The maximum height of the mandibular ramus donor site was measured between the inferior alveolar crest and 2 mm above the inferior alveolar canal (Fig 1). The maximum width of the donor site was measured (mm) between the buccal surface of the mandible and 2 mm buccal to the lingual plate. The maximum length of bone graft harvest from the ramus was measured between 2 mm distal to the most distal tooth and the area perpendicular to the inferior alveolar canal crossing through the intersection between the cranial surface of the mandible and the first bucco-oral CBCT reconstruction with a consistently visible ascending ramus. The volume of maximum bone graft potentially harvested from the ramus was calculated in cm\(^3\) by marking the bone block in each scan.

**Assessment of Mandibular Symphysis Donor Site Quantity**

The maximum height of the mandibular symphysis donor site was measured between the incisor teeth and 2 mm apical to the mandibular basis (Fig 2). The maximum width of the donor site was measured between the buccal surface and 2 mm
buccal to the lingual plate. The maximum length of the donor site was measured between 5 mm mesial to the right and left mental foramen. The volume of maximum bone graft harvested from symphysis was calculated in cm$^3$ by marking the bone block in each scan. A mono-block measurement including the right and left sides was made.

**Assessment of Palatal Donor Site Quantity**

The maximum length of the palatal donor site was measured between the distal border of the second premolar and 2 mm to the incisive foramen (Fig 3). The maximum height of the donor site was measured between the palatal surface and 2 mm to the sinus or nasal cavity. The maximum width of the donor site was measured between the palatal surface and 2 mm to the buccal plate or 2 mm to the root surface. The volume of maximum bone graft harvesting from the palatal region was calculated in cm$^3$ by marking the bone block in each scan.

**Assessment of Maxillary Tuberosity Donor Site Quantity**

To measure the maximum width of the maxillary tuberosity donor site, the buccolingual distance of the alveolar crest of the maxillary tuberosity was measured (Fig 4). The maximum potential length of a donor site was measured 2 mm distal to the most distal tooth to

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**Fig 2** (a) Cross-sectional and (b) axial view of maximum harvesting of bone from the symphysis. (1) Maximum width, (2) maximum height, and (3) maximum length.

**Fig 3** (a) Cross-sectional and (b) axial view of maximum harvesting of bone from the hard palate. (1) Maximum width, (2) maximum height, and (3) maximum length.

**Fig 4** (a) Cross-sectional and (b) panoramic view of maximum harvesting of bone from the maxillary tuberosity. (1) The maximum width, (2) the maximum height, and (3) the maximum length.
the distal border of the tuberosity.\textsuperscript{27} The maximum height of a donor site was measured from the crestal surface to 2 mm from the sinus cavity.\textsuperscript{26} The potential volume of maximum bone graft harvesting from the tuberosity was calculated in cm\(^3\) by marking the bone block in each scan.\textsuperscript{19}

### Evaluating Bone Quality of Intraoral Block Graft Donor Sites\textsuperscript{28}

Radiographic bone quality was calculated with a tool incorporated in the software with a 1-mm edged square. The bone density measurements were obtained in Hounsfield units from post-processed CBCT DICOM data using software (Simplant) (CBCT-HU). A high CBCT-HU indicated high bone density. Conversely, a low CBCT-HU pointed to low bone density.

### Statistical Analysis

All statistical data were processed using IBM SPSS Statistics for Windows, Version 24.0. Means and SD values were used for description-based statistics for intermittent and continuous numeric variables. Student t test was used for the average of independent pairs. Correlations between continuous and intermittent numeric variables were investigated using Pearson’s correlation test. Comments and assessments were based on comparisons with a statistical significance of .05. Data from 10 patients were reevaluated by the same examiner (E.T.A.D.), while intraclass and interclass correlation coefficients (ICC) for numeric measurements were calculated to assess the intraexaminer reliabilities.

### RESULTS

Ninety scans were identified for this study. According to the exclusion criteria, 18 images had bone augmentation/sinus procedures, and 22 CBCT images with artifacts and/or poor image quality were excluded. In total, 50 subjects were included in the present study. The mean age of 50 patients (19 men and 31 women) was 55.84 ± 15.90 years (men = 61.42 ± 16.19 years; women = 52.41 ± 14.97 years). The maximum potential dimensions and volumes of grafts according to harvest area are demonstrated in Table 1. It was noted that the symphysis had the highest graft dimensions and volume, while the maxillary tuberosity had the lowest. When evaluating the difference between the left and right sides, significant differences were noted for all parameters in the ramus and maxillary tuberosity sites (P < .05). However, no significant difference was found between the left and right sides in the palatal site (P > .05). Moreover, sex had no significant effect on the dimensions or volumes of the potential autogenous grafts for all donor sites.

Bone quality values of the autogenous potential donor sites are presented in Table 2. The symphysis had the highest bone density values, while the maxillary tuberosity had the lowest values. In general, mandibular donor sites showed higher CBCT-HU than maxillary donor sites. The differences between the left and right sides were not significant for any donor site (P > .05). Sex had no impact on bone density values of donor sites (P > .05).

#### Table 1 Maximum Dimensions and Volumes of Autogenous Grafts According to Harvesting Sites

<table>
<thead>
<tr>
<th></th>
<th>Right side</th>
<th>Left side</th>
<th>P value</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ramus</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Length (mm)</td>
<td>9.82 ± 4.29</td>
<td>10.02 ± 4.28</td>
<td>.021*</td>
<td>9.94 ± 4.29</td>
</tr>
<tr>
<td>Width (mm)</td>
<td>8.15 ± 3.02</td>
<td>8.04 ± 2.93</td>
<td>.026*</td>
<td>8.09 ± 2.97</td>
</tr>
<tr>
<td>Height (mm)</td>
<td>10.53 ± 3.77</td>
<td>10.38 ± 3.61</td>
<td>.023*</td>
<td>10.46 ± 3.70</td>
</tr>
<tr>
<td>Volume (cm(^3))</td>
<td>0.91 ± 0.45</td>
<td>0.89 ± 0.40</td>
<td>.004*</td>
<td>0.90 ± 0.42</td>
</tr>
<tr>
<td><strong>Symphysis</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Length (mm)</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>29.76 ± 7.17</td>
</tr>
<tr>
<td>Width (mm)</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>8.38 ± 2.66</td>
</tr>
<tr>
<td>Height (mm)</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>13.36 ± 3.71</td>
</tr>
<tr>
<td>Volume (cm(^3))</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>3.14 ± 1.05</td>
</tr>
<tr>
<td><strong>Tuberosity</strong></td>
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<td></td>
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<tr>
<td>Length (mm)</td>
<td>14.51 ± 4.93</td>
<td>14.42 ± 5.01</td>
<td>.298</td>
<td>14.47 ± 4.81</td>
</tr>
<tr>
<td>Width (mm)</td>
<td>5.82 ± 1.79</td>
<td>5.74 ± 1.77</td>
<td>.202</td>
<td>5.76 ± 1.69</td>
</tr>
<tr>
<td>Height (mm)</td>
<td>9.91 ± 2.94</td>
<td>9.76 ± 2.91</td>
<td>.182</td>
<td>9.81 ± 2.69</td>
</tr>
<tr>
<td>Volume (cm(^3))</td>
<td>0.61 ± 0.32</td>
<td>0.58 ± 0.33</td>
<td>.343</td>
<td>0.60 ± 0.30</td>
</tr>
</tbody>
</table>

*Statistically significant differences (P < .05). N/A = not available.

#### Table 2 Bone Quality (CBCT-HU) Values of the Autogenous Graft Donor Sites

<table>
<thead>
<tr>
<th></th>
<th>Right side</th>
<th>Left side</th>
<th>P value</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ramus</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>887.22 ± 164.35</td>
<td>877.63 ± 142.00</td>
<td>.248</td>
<td>880.74 ± 151.37</td>
</tr>
<tr>
<td><strong>Symphysis</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>937.31 ± 160.59</td>
</tr>
<tr>
<td><strong>Palatal</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>556.60 ± 153.56</td>
<td>563.41 ± 149.11</td>
<td>.243</td>
<td>558.46 ± 148.22</td>
</tr>
<tr>
<td><strong>Tuberosity</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>364.12 ± 139.35</td>
<td>358.98 ± 147.72</td>
<td>.238</td>
<td>360.87 ± 141.48</td>
</tr>
</tbody>
</table>

N/A = Not available.

* A monoblock measurement including right and left sides were made.
DISCUSSION

Autogenous bone is regarded as the most predictable graft material and a gold standard for augmentation procedures, although various alternatives exist. Autogenous grafts can be harvested from intraoral donor sites (eg, ramus, symphysis, palatal, and tuberosity) as well as extraoral sites (eg, iliac and calvaria). Quality and quantity of bone and high predictability of uneventful healing events are important parameters when selecting optimal donor sites. Harvesting of autogenous bone from extraoral donor sites has been reported to be associated with a hospital stay, increased costs, and high morbidity in the literature. However, low morbidity risk and outpatient treatment were advantages of preferring intraoral donor sites.

Intraoral ramus, symphysis, and tuberosity block grafts are commonly used for augmentation procedures. The advantages of tuberosity block grafts over mandibular intraoral donor sites are accessibility and fewer postoperative complications. Moreover, the disadvantages of bone harvested from the tuberosity include a higher volume of cancellous structure, thinner cortex, and greater susceptibility to resorption. However, ramus and symphysis bone blocks provide denser and higher bone quality than tuberosity. Successful augmentation procedures utilizing bone derived from various sites in the mandible (ramus, symphysis, etc) have been reported, although consideration of the position of vital structures, such as teeth, nerves, and arteries, may restrict its use. In the maxilla, palatal bone blocks are one of the donor site options for augmentation. The palatal block harvest procedure has the potential to enclose both the donor and the recipient site in the same surgical field and may limit complications associated with a second surgical area. The disadvantages of palatal blocks include difficulty in accessing the donor site, harvesting limited bone volume due to the incisive canal, the nasal floor form, and the maxillary roots of the teeth. Unfortunately, there is a lack of studies comparing intraoral block site dimensions and volumes in the literature. Hence, the aim of this study was to evaluate the maximum intraoral bone block dimensions, volume, and bone quality of donor sites.

Radiographic imaging allows for measurement of the potential volume and bone density. In the present study, the maximum length, width, and height measured were: 9.94 ± 4.29 mm, 8.09 ± 2.97 mm, and 10.46 ± 3.70 mm for the ramus, and 29.76 ± 7.17 mm, 8.38 ± 2.66 mm, and 13.36 ± 3.71 mm for the symphysis, respectively. In addition, the maximum bone volume was calculated at 0.90 ± 0.42 cm³ for the ramus and 3.14 ± 1.05 cm³ for the symphysis. In a cadaver study, the average size of symphysis bone block was reported to measure 20.9 mm × 9.9 mm × 6.9 mm, while the volume was 4.71 mL. Güngörmüş and Yavuz calculated 2.36 mL for the volume of the ascending ramus bone block. The amount of bone harvested from the symphysis and ramus was assessed in a study using 59 cadaver specimens where volumes were calculated at 1.15 and 2.02 mL for the symphysis and ramus, respectively. In another study, the volume, size, and HU of bone blocks that can be harvested from the symphysis were analyzed on 15 CT images, and values were reported to be 3,491.08 ± 772.12 mm³, 38.75 × 11.05 × 7.8 mm, and 958.95 ± 98.11 HU, respectively. Verdugo et al also calculated the volume of symphysis and ramus block grafts at 1.4 ± 0.5 mL and 0.8 ± 0.2 mL, respectively. In another study, Zeltner et al assessed symphysis and retromolar regions using 60 CBCT images. CBCT scans yielded maximum potential bone volumes of 3.5 ± 1.3 mL and 1.8 ± 1.1 mL for the symphysis and ramus, respectively. The results of the present study were in the range of the results published in the literature. Among the studies, differences in values may be explained by different anatomical border selection and different study methods and designs.
In this study, the maximum bone volume was calculated to be 0.62 ± 0.30 cm³ for the palatal harvest site, and the dimensions of the maximum graft were 5.76 ± 1.69 mm × 9.71 ± 2.69 mm × 14.72 ± 4.81 mm. In a separate study, the authors evaluated the diameter and height of the potential bone block with a cylindrical shape for each maxillary incisor, canine, and first premolar tooth in 76 CBCT scans. The osteotomy diameter was 7.8 mm. However, the osteotomy lengths in the central, lateral, canine, and first premolar areas were 5.9, 5.2, 4.7, and 4.1 mm, respectively.21 Contrary to that study, the present study measured one-piece rectangular block graft for the same region, which may explain differences in values based on various graft designs.

Maxillary tuberosity is widely preferred as a donor site in various augmentation techniques.22,41,42 However, no study published in English has evaluated the tuberosity bone block graft sizes and volume. In the present study, the authors calculated the maximum potential width, length, height, and volume as 7.80 ± 3.87 mm, 7.92 ± 4.10 mm, 7.23 ± 4.09 mm, and 0.53 ± 0.34 cm³, respectively.

In the literature, mandibular edentulous sites are reported to have higher HU values than maxillary edentulous sites.43,44 In addition, increasing bone density values were identified as measured from the posterior to anterior for both arches.43,44 In agreement with other studies, the present study noted that the symphysis possessed the highest density values, while the maxillary tuberosity had the lowest density values. This is important, as bone density may be a key factor in preventing bone resorption and maintenance of osteoconductive function of autogenous bone graft.

Intraoral bone blocks can provide surgeons with an adequate amount of autogenous, intramembranous bone with minimal morbidity for successful clinical outcomes. When selecting the optimal donor site, the amount of bone required for the recipient site, the average quantity and quality of bone available, and the potential complications should be accurately evaluated. CBCT scans are essential for planning these procedures. The results of the study present overall dimensions, volume, and bone quality values as guidance for practitioners. When interpreting the results of the present study, the following limitation should be taken into consideration. Evaluating bone density using grayscale values derived from CBCT seems to not be as accurate and stable as HU derived from CT.45,46 However, a strong correlation between the grayscale values of the CBCT scan and HUs of the CT scan was also presented.47 Contrary to this, CBCT-HU can be applied to assess the bone density by using the “HU” option of the Simplant software according to a recent publication.28 Within the limitation of the present study, while comparing all potential intraoral bone block sites, symphysis had a larger bone volume with high bone quality. Maxillary tuberosity had lower density values with a possible tendency to resorb during the healing period after augmentation procedures.

CONCLUSIONS

The use of intraoral bone blocks for bone augmentation procedures has various restrictions due to surrounding vital anatomical structures. The surgeons should consider all parameters, and accurate CBCT evaluation should be performed. Based on the results, the volume and CBCT-HU of the maximum bone block harvesting from the symphysis was higher in comparison with the ramus, palatal, and tuberosity bone blocks.

ACKNOWLEDGMENTS

The authors reported no conflicts of interest related to this study.

REFERENCES


