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Volumetric and linear assessment of maxillary, mandibular and zygomatic bone as donor sites for alveolar ridge augmentation using CBCT: A cross sectional study

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Abstract---Objective: To analyze preoperative CBCT assessment of intraoral donor sites (symphysis, ramus buccal shelf of bone, zygomatic buttress and maxillary tuberosity) for purpose of autogenous block graft. Materials and Methods: Twenty (5 for each graft) participants were included in the study, (informed consent was signed by each participant) Participants were recruited according to certain eligibility criteria. Results: The measurements of the block grafts showed that there was a significant difference between different sites ($p < 0.001$). The highest value was found in mandibular symphysis (1.56 ± 0.44), followed by mandibular ramus (0.99 ± 0.19), then zygomatic buttress (0.49 ± 0.06), while the lowest value was found in maxillary tuberosity (0.31 ± 0.07). Post hoc pairwise comparisons showed value of mandibular symphysis to be significantly higher than other sites ($p < 0.05$). In addition, they showed mandibular ramus value to be significantly higher than values of zygomatic buttress and maxillary tuberosity ($p < 0.05$). Conclusion: According to this study, mandibular donor sites showed larger segmented pieces and larger

volumes than their maxillary counterparts. For multiple missing teeth, the most appropriate block grafts will be the symphysis and ramus spanning the largest mesio-distal dimension. In terms of implant stability, the rami and maxillary tuberosities showed the largest thicknesses, which will ultimately help in implant stability.

Keywords---Intraoral autograft, implant planning, symphysis graft, buccal shelf graft, maxillary tuberosity, zygomatic buttress autograft, CBCT autograft, CBCT.

Introduction

In implant dentistry, the reconstruction of alveolar bony defects after tooth loss is one of the biggest and important challenges. Decrease bone volume may occur as a result of mainly prolonged edentulous span after teeth loss, trauma, congenital anomalies, periodontal disease, and infection [5].

For augmentation of existing bone defects, grafts of various origins have been used e.g. xenografts, allografts, alloplastic grafts and autografts. The mode of graft integration with respect to regeneration depends primarily on its origin and composition. Xenografts, allografts as well as alloplastic materials of natural or synthetic origin have osteoconductive properties, hence serves as scaffolds for new bone growth originating from the native bone. However, autogenous block bone grafts offers many benefits, such as being osteoinductive, osteogenic and osteoconductive with significant regenerative capability in comparison to all other grafts, in addition to it exhibits no immunogenic reactions [8, 10].

This is why autogenous block bone grafts, represents the gold standard for bone alveolar atrophy and bone defect augmentation [1, 5]. If the bone volume is inadequate, several surgical techniques and materials may be used for bone augmentation of the deficient ridge. The morphology of a bony defect is an important consideration in the selection of a method for ridge augmentation [1, 11]. Generally speaking, autogenous bone grafts are either extra oral such as iliac crest and are mainly used in large defects or intraoral that is used in medium or small defects. The main advantages of intraoral grafts are the proximity of donor and recipient sites, the reduction in operative time due to their convenient surgical access, with less amount of anesthetic, less morbidity, less hospitalization and discomfort to patients [8].

Despite such good qualities and advantages, nevertheless, the careful preoperative planning and analysis of the graft volume to be harvested, is highly necessary to decrease postoperative complications at the donor site during autogenous graft surgeries [7]. Cone Beam Computed Tomography (CBCT) has been increasingly used in dentistry. CBCT technologies allow a precise three-dimensional evaluation of the bone quality and quantity of the donor site. It allows evaluation and comparison of intraoral harvest sites for grafting prior to implant placement, providing great importance for preoperative planning and postoperative success of the procedure [4, 11].

Materials and methods

Sample grouping

Twenty participants (5 for each graft area) were included in the study, and an informed consent was signed by each participant, from Egyptian patients who attended the Oral Radiology Department, Faculty of Dentistry, Cairo University for CBCT scanning for different dental purposes between the dates of 10/2019 to 7/2020. Participants were recruited according to certain eligibility criteria:-

Inclusion criteria were: Normal (volunteering) Egyptian population with normal facial morphology, indicated for CBCT imaging for both jaws, free from any systemic disease affecting the jaws and free from implant or any surgical intervention in the donor sites.

Exclusion criteria were: Patients with fracture, lesion or developmental malformation in donor sites, pregnant females and edentulous patients.

Variables

- Block graft of symphysis.
- Block graft of ramus buccal shelf of bone.
- Block graft of zygomatic buttress.
- Block graft of maxillary tuberosity.

Image Analysis

In all cases, adjustment of the volume orientation was done, where the sagittal plane was adjusted to be coinciding with the nasal septum and the axial plane to be coinciding with the hard palate. Then, determination of the anatomical boundaries of each site was plotted with subsequent measurements of: Linear measurements of donor sites, Then after measuring the three dimensions, the volume (in mm³) was calculated, the Thickness of cortical and spongy bone in each block graft and Volumetric measurements of donor sites using segmentation (manual or semiautomatic depending on the donor site complexity). Figures (1, 2, 3 & 4)

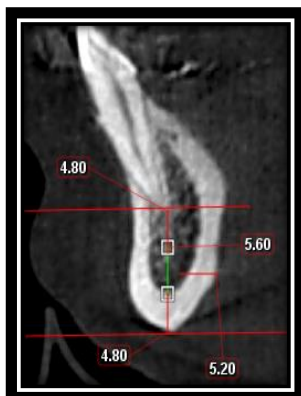


Fig. (1): Mandibular symphysis length measurement (green line) from the sagittal plane

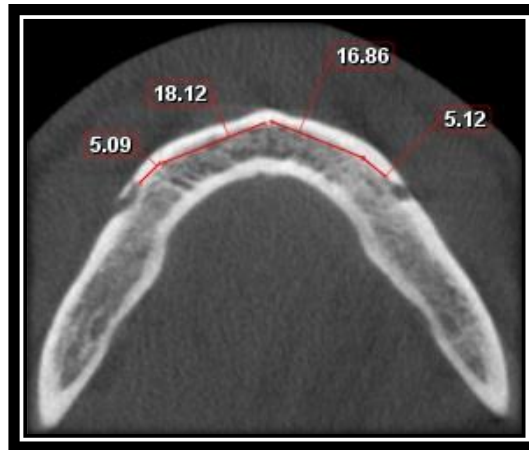


Fig. (2): Axial cut showing the mandibular symphysis measurement of the width in both sides (18.12 and 16.86 mm)

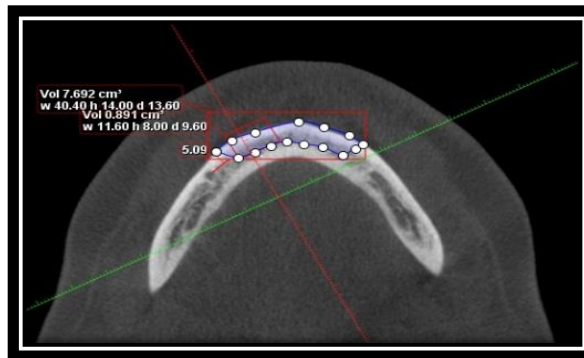


Fig (3): Manual segmentation of the symphyseal area

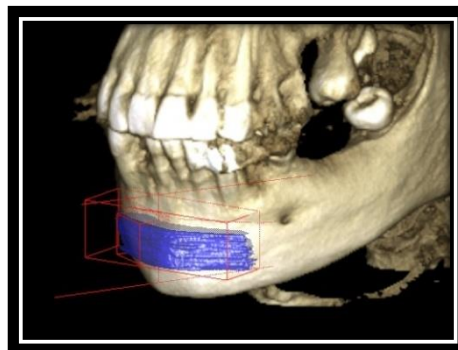


Fig (4): 3D volume rendering showing the symphyseal graft area and its relation to the roots and the mental foramen

Statistical analysis

Categorical were presented as frequency and percentage values. Numerical data were presented as mean and standard deviation values and were tested for normality using Shapiro-Wilk test. Data showed parametric distribution so they

were analyzed using one-way ANOVA followed by Tukey's post hoc test for intergroup comparisons and paired t-test for intragroup comparisons. Correlations were analyzed using Pearson's correlation coefficient. Reliability was analyzed using intraclass correlation coefficient (ICC). Dahlberg error was calculated according to the following formula:

The significance level was set at $p \leq 0.05$ within all tests. Statistical analysis was performed with R statistical analysis software version 4.1.2 for Windows¹.

Results

Volume comparison between different sites:

- **Segmentation:**

There was a significant difference between different sites ($p < 0.001$). The highest value was found in mandibular symphysis (1.56 ± 0.44), followed by mandibular ramus (0.99 ± 0.19), then zygomatic buttress (0.49 ± 0.06), while the lowest value was found in maxillary tuberosity (0.31 ± 0.07). Post hoc pairwise comparisons showed value of mandibular symphysis to be significantly higher than other sites ($p < 0.05$). In addition, they showed mandibular ramus value to be significantly higher than values of zygomatic buttress and maxillary tuberosity ($p < 0.05$).

- **Linear:**

There was a significant difference between different sites ($p < 0.001$). The highest value was found in mandibular symphysis (1.97 ± 0.42), followed by mandibular ramus (1.49 ± 0.55), then zygomatic buttress (0.82 ± 0.41), while the lowest value was found in maxillary tuberosity (0.76 ± 0.15). Post hoc pairwise comparisons showed value of mandibular symphysis to be significantly higher than values of zygomatic buttress and maxillary tuberosity ($p < 0.05$).

Figure (5).

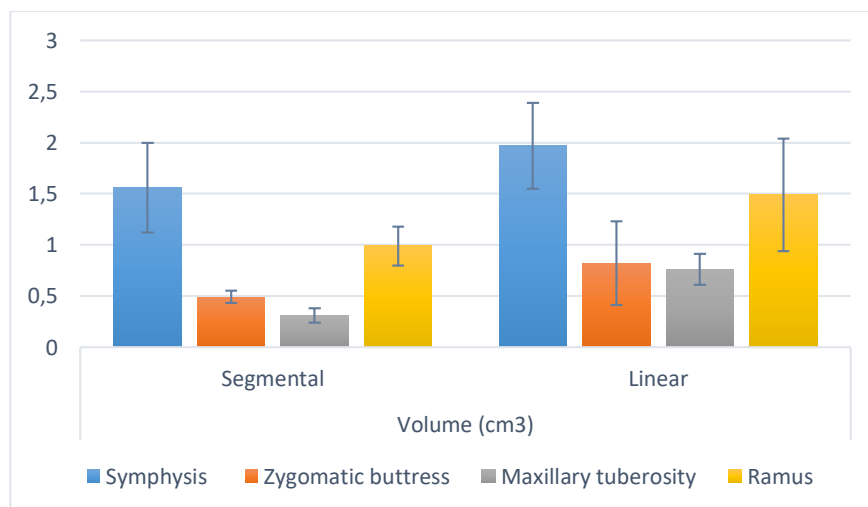


Figure (5): Bar chart showing intergroup comparison of volume (cm3)

Thickness comparison between different sites

Intergroup comparisons of thickness (mm) were presented in table (1). There was a significant difference between different sites ($p=0.003$). The highest value was found in maxillary tuberosity (10.16 ± 2.20), followed by mandibular ramus (7.59 ± 1.48), then mandibular symphysis (6.41 ± 0.79), while the lowest value was found in zygomatic buttress (4.23 ± 3.17). Post hoc pairwise comparisons showed value of maxillary tuberosity to be significantly higher than value of zygomatic buttress ($p=0.002$).

Table (1)
Intergroup comparison of thickness (mm) (A)

Mean $\pm$ SD (mm)				p-value
Symphysis	Zygomatic buttress	Maxillary tuberosity	Ramus	
6.41 $\pm$ 0.79 ^{AB}	4.23 $\pm$ 3.17 ^B	10.16 $\pm$ 2.20 ^A	7.59 $\pm$ 1.48 ^{AB}	0.003*

Means with different superscript letters within the same horizontal row are significantly different *; significant ($p \leq 0.05$)

Discussion

The knowledge about the shape of the graft and its linear measurements is as important as the total graft volume. This may help surgeons in choosing and tailoring the harvested graft according to the defect size and shape.

According to the above descriptive data, it can be deduced that for multiple missing teeth, the most appropriate grafts will be the symphysis and ramus spanning the largest mesio-distal dimension. This was in concordance with *Desai et al. 2013* and *Pikos 2005*. It was reported that the symphysis and retromolar intraoral donor sites are indicated in cases of large reconstructions in the mandible.

A mean of 7.68 mm length, 40.17 mm width and 6.41 mm thickness and 2.4 mm cortical thickness were found for the symphysis in the present study. Similarly, *Yavuz et al. 2009* on his CT-based radiographic study, reported cortico-cancellous chin bone block graft of around 38.75 mm $\times$ 11.05 mm $\times$ 7.80 mm measurements with about 2 mm thick porous cortical. In terms of ramus coverage, our findings showed a mean of 6.51 mm length, 29.87 mm width and 7.59 mm thickness. Likewise, *Stoyanov and Deliverska 2018* mentioned that the mean anteroposterior width of the ramus was 30.5 mm and the mean vertical distance between the superior edge of the canal and the cortical surface along the external oblique ridge is approximately 7 mm in the second molar region.

Ramus results in our sample showed a mean of 2.29 ± 0.32 mm for cortical and 5.30 ± 1.33 mm for cancellous bone of 30.71% and 69.29% respectively. This was in agreement with *Yates et al. 2013*, stating that the thickness of the buccal cortical plate was $2.3 \text{ mm} \pm 0.7 \text{ mm}$ and the cancellous component was $4.05 \text{ mm} \pm 1.10 \text{ mm}$. Conversely, *Maiorana et al. 2020* stated that the mandibular ramus is

almost 100% cortical in nature. This again depends on the part of ramus to be harvested where it may differ from harvesting a big portion of the ramus that reaches below the coronoid or only harvesting the external oblique ridge or buccal shelves of bone.

Their symphysis analysis was 65% cortical bone and 36% cancellous bone, which was quite the opposite of our findings, showing nearly 39% cortical and 61 % cancellous bone. Regarding the cortical/cancellous parameter, *Safi et al 2021* evaluated the microstructure of the mandibular symphysis as a donor site for autologous bone harvesting and reported that the cancellous/cortical ratio was 1.51 ± 0.11 , and ours was 1.63.

Regarding the zygomatic buttress and maxillary tuberosity, these sites were reported as a relatively recent intraoral block donor sites appropriate for small and limited bone augmentations especially in the maxilla. Zygomatic buttress and maxillary tuberosity were claimed to augment from 4 to 6 mm bone loss or 1 to 2 teeth loss. This was stated by *Gellrich, et al. 2007, Reininger et al. 2017 and Sakkas et al. 2015* findings.

Our findings showed that the thinnest graft was the zygomatic buttress with a mean thickness of 4.23 ± 3.17 , which varied massively among the five cases with a 95% CI of 1.45 to 7.01. The maxillary tuberosity was 11.48 and 6.68 mm for length and width with the highest score of length of the sites indicating that prominent tuberosity could be harvested as a block graft. But care should be taken in consideration to avoid schneiderian membrane perforation and consequently fistulous formation as stated by *Faverani et al. 2014*. Regarding the segmented volumes, a significant difference was found between all sites except for the zygomatic buttress and the tuberosity. The highest value was found in mandibular symphysis (1.56 ± 0.44), followed by mandibular ramus (0.99 ± 0.19), then zygomatic buttress (0.49 ± 0.06), while the lowest value was found in maxillary tuberosity (0.31 ± 0.07).

But none of the above donor sites can properly raise an arch with a defect of 12 mm in length except for zygomatic buttress and tuberosity having proper lengths but lack structure in other dimensions. Therefore, it might be mandatory to use other sources if the augmentation of the alveolar bone is important.

The correlation between a defected site in an enrolled patient and the to-be harvested dimensional measurements of the graft was not applied in this current study. Therefore, it is advocated to do a prospective study on patients with real alveolar defects, displaying segmented volumes of the defects versus volumes of the appropriate selected donor sites.

Conclusion

Mandibular donor sites showed larger segmented pieces and larger volumes than their maxillary counterparts. For multiple missing teeth, the most appropriate block grafts will be the symphysis and ramus spanning the largest mesio-distal dimension. For implant stability, the rami and maxillary tuberosities showed the largest thicknesses, which will ultimately help in implant stability. The one with

the highest is the mandibular symphysis, followed by the ramus. None of the assessed donor sites can properly raise an arch with a defect of 12 mm in length except for zygomatic buttress and tuberosity having proper lengths but lack structure in other dimensions. Therefore, it might be mandatory to use other sources if the augmentation of the alveolar bone is important.

References

1. Desai, A. J., Thomas, R., Kumar, A. T., & Mehta, D. S. (2013). Current concepts and guidelines in chin graft harvesting: A literature review. *International Journal of Oral Health Sciences*, 3(1), 16.
2. Faverani, L. P., Ramalho-Ferreira, G., Santos, P. H. D., Rocha, E. P., Garcia Júnior, I. R., Pastori, C. M., & Assunção, W. G. (2014). Surgical techniques for maxillary bone grafting-literature review. *Revista do Colégio Brasileiro de Cirurgias*, 41, 61-67.
3. Gellrich, N. C., Held, U., Schoen, R., Pailing, T., Schramm, A., & Bormann, K. H. (2007). Alveolar zygomatic buttress: a new donor site for limited preimplant augmentation procedures. *Journal of oral and maxillofacial surgery*, 65(2), 275-280.
4. Jacobs, R., Salmon, B., Codari, M., Hassan, B., & Bornstein, M. M. (2018). Cone beam computed tomography in implant dentistry: recommendations for clinical use. *BMC Oral Health*, 18(1), 1-16.
5. Khoury, F., & Hanser, T. (2015). Mandibular bone block harvesting from the retromolar region: a 10-year prospective clinical study. *Int J Oral Maxillofac Implants*, 30(3), 688-697.
6. Maiorana, C., Ferrario, S., Poli, P. P., & Manfredini, M. (2020). Autogenous Chin Block Grafts in the Aesthetic Zone: A 20-Year Follow-Up Case Report. *Case reports in dentistry*, 2020.
7. Nagla'a, A., & Bahammam, M. A. (2018). Cone Beam CT-Based Preoperative Volumetric Estimation of Bone Graft Required for Lateral Window Sinus Augmentation, Compared with Intraoperative Findings: A Pilot Study. *The Open Dentistry Journal*, 12, 820.
8. Reininger, D., Cobo-Vázquez, C., Rosenberg, B., & López-Quiles, J. (2017). Alternative intraoral donor sites to the chin and mandibular body-ramus. *Journal of clinical and experimental dentistry*, 9(12), e1474.
9. Safi, Y., Amid, R., Kadkhodazadeh, M., Mortazavi, H., Sharifi, M. P., & Gandomi, S. (2021). Bone quality and quantity of the mandibular symphyseal region in autogenous bone grafting using cone-beam computed tomography: a cross-sectional study. *Head & Face Medicine*, 17(1), 1-9.
10. Sakkas, A., Schramm, A., Karsten, W., Gellrich, N. C., & Wilde, F. (2016). A clinical study of the outcomes and complications associated with zygomatic buttress block bone graft for limited preimplant augmentation procedures. *Journal of Cranio-Maxillofacial Surgery*, 44(3), 249-256.
11. Stoyanov, H., & Deliverska, E. (2018). Preoperative CBCT Assessment of Donor Site-Symphysis and Ramus Buccal Shelf for Alveolar Ridge Augmentation. *Journal of IMAB-Annual Proceeding Scientific Papers*, 24(1), 1909-1913.
12. Pikos, M. A. (2005). Mandibular block autografts for alveolar ridge augmentation. *Atlas of the oral and maxillofacial surgery clinics of North America*, 13(2), 91-107.

13. Yates, D. M., Brockhoff II, H. C., Finn, R., & Phillips, C. (2013). Comparison of intraoral harvest sites for corticocancellous bone grafts. *Journal of Oral and Maxillofacial Surgery*, 71(3), 497-504.
14. Yavuz, M. S., Buyukkurt, M. C., Tozoglu, S., Dagsuyu, İ. M., & Kantarci, M. (2009). Evaluation of volumetry and density of mandibular symphysis bone grafts by three-dimensional computed tomography. *Dental Traumatology*, 25(5), 475-479.