Article

3D Volumetric Analysis and Anatomical Considerations for Sinus Bone Graft

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Abstract: The aim of this study is to evaluate anatomical considerations and assess the volume of the maxillary sinus bone graft. There were sixty-three patients (eighty-three sinuses) who had taken CT scans for implant surgery. Patients included those whose height of the residual alveolar bone was less than 5 mm. The position of posterior superior alveolar artery, the thickness of the maxillary sinus wall, and the volume of the maxillary sinus according to the amount of sinus floor elevation were measured. The mean vertical distance of posterior superior alveolar artery was 11.91 ± 4.79 mm from 3.03 mm to 24.05 mm. The mean thickness of the lateral wall was 1.71 ± 0.55 mm in the range of 0.74 mm to 3.93 mm. The volume of 3 mm, 5 mm, 7 mm, and 10 mm from the sinus floor was 0.173 ± 0.11 cm³, 0.526 ± 0.25 cm³, 1.068 ± 0.43 cm³, and 2.184 ± 0.74 cm³ on average, respectively. The knowledge of the posterior superior alveolar artery position, the lateral wall thickness, and the volume of the maxillary sinus can help the clinician for sinus bone graft.

Keywords: cone beam computed tomography; maxilla; maxillary artery; maxillary sinus; sinus bone graft

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1. Introduction

The maxillary sinus is an important anatomical structure due to its anatomical relationship with posterior maxillary teeth [1]. It begins to develop at 10 weeks of intrauterine development, increases to a volume of 6–8 cm³ and has empty space with fluid at birth [2]. The maxillary sinus can be shown to be adult size at 18–20 years of age, and the average maxillary sinus volume is observed to be 15 cm³ [3].

The maxillary sinus pneumatization is the expansion of the sinus towards the alveolar process [4]. The causes of maxillary sinus pneumatization are poorly understood, but heredity, environment, infection, density of the bone, growth hormone, sinus air pressure, sinus surgery, and posterior tooth extraction can cause this process [5,6]. Maxillary sinus pneumatization and alveolar bone resorption affect the volume and height of the residual ridge [7]. Especially in the maxillary second molar region, these processes may reduce available bone; therefore, bone graft may be required during implant surgery [6,8].

The main techniques for sinus bone graft (SBG) are lateral window opening and crestal approach [9]. Maxillary SBG is considered a successful and predictable approach for implant surgery [7,9]. However, sinus abnormalities can cause problems during SBG [10]. The average available bone height in edentulous maxilla is classified into 3 classes [11]. Class 1 has a 10 mm residual bone, class 2 has a 5–10 mm residual bone, and class 3 indicates a 0–5 mm residual bone height. In classes 2 and 3, SBG should be considered; especially in class 3, lateral window opening is preferred over crestal approach.

Schneiderian membrane (SM) perforation is the most common complication during sinus bone graft, and possible causes for this include maxillary septum, pathological

condition, or very thin membrane [12,13]. It occurs in 11–58.3% of SBG surgeries [14–16]. SM perforation can occur while preparing the window or reflecting the membrane to access the sinus [9]. Lateral wall thickness and the angle between the lateral and medial walls are related to the SM perforation. The thickness of the lateral wall of the maxillary sinus varies according to sites. The structures such as buttress of zygomatic bone, maxillary tuberosity, and the canine eminence are related to the thickness [17]. The presence of the maxillary sinus septum is a potential risk factor for SM perforation and should be considered during maxillary SBG. When the maxillary sinus septum is present, the clinician should perform careful manipulation during floor elevation and lateral window opening. The posterior superior alveolar artery (PSAA) and infraorbital artery supply the lateral wall of maxillary sinus and SM [8]. These are the branches of the maxillary arteries that supply the lateral walls and membranes [18–20]. Since they are in close proximity to the lateral window osteotomy, severe bleeding can occur when the PSAA is damaged during maxillary sinus bone graft [12]. Damaging this vessel during surgery may interfere with the procedure as significant bleeding is introduced into the surgical field [21]. Profuse bleeding must be suppressed immediately by various methods such as firm pressure, direct ligation, bone wax, and electrocautery [21]. It is important to understand the anatomy of the maxillary sinus to avoid unnecessary bleeding and perforation of the membrane. Blood vessels with large diameters have a greater risk of bleeding during the surgery [22].

The aim of this study was to evaluate the anatomical features, such as the height of the PSAA, lateral wall thickness of the maxillary sinus, and the volume of the maxillary sinus to be considered during maxillary SBG.

2. Materials and Methods

This retrospective study included 83 sinuses in 63 patients, who visited the Department of Oral and Maxillofacial Surgery for SBG and implant treatment between January 2015 and July 2020. The height of residual bone was less than 5 mm. The average age of the patients was 57.37 y and ranged from 28 to 92 y.

For the preoperative evaluation, cone beam computed tomography (CBCT) was taken (Hitachi, Marunouchi, Japan) and three-dimensional (3D) reconstruction models were created by reformatting the CBCT scan images on Mimics (18.0.0.025) software (Materialise, Leuven, Belgium).

For evaluating the position of PSAA, we measured the distance between the lower border of the artery and the lowest point of inferior border of maxillary sinus on coronal plane (Figure 1).

Figure 1. The height of posterior superior alveolar artery (PSAA). Measured from the lower point of the maxillary sinus to PSAA.

We also measured the thickness of lateral wall of sinus at right immediately below the external branch of PSAA (Figure 2).

Figure 2. Lateral wall thickness was measured at right immediately below the PSAA.

Sinus cavity was segmented for making the 3D model by setting of threshold value with Mimics software and then it was divided into 3 mm, 5 mm, 7 mm, and 10 mm heights based on the lowest point of the sinus floor and then the 3D segmented volumes were measured according to the height from the sinus floor (3 mm, 5 mm, 7 mm, 10 mm) and the total maxillary sinus volume (Figure 3).

Figure 3. 3D modeling of the maxillary sinus. Measuring the volume of the sinus by segmenting it into 3 mm, 5 mm, 7 mm, and 10 mm from the lower point of the sinus.

In order to measure the height of the residual bone, the vertical distance between the tangents of the lower point of the maxillary sinus and the crest of the residual bone was evaluated. A septum of maxillary sinus was identified in CBCT images (Figure 4).

Statistical analysis was calculated using SPSS 20.0 (IBM, New York, NY, USA). The normal distribution was verified through the Kolmogorov–Smirnov test, and the statistical method according to each result was used. Statistical significance was verified through the Mann–Whitney U test, independent t-test and chi-square test. A *p* value of 0.05 was set for statistical significance.

This study protocol was approved by the institutional ethics committee. Written informed consent was obtained from all of the patients. (CUDHIRB 1902007)

Figure 4. The height of residual bone and presence of septum. Measured from the crest of alveolar bone to the sinus floor (A), septum is shown in CT image (B), and clinical picture (C).

3. Results

3.1. The Height of the Posterior Superior Alveolar Artery (PSAA)

The average height of PSAA was 11.91 ± 4.79 mm, ranged from 24.05 mm to 3.03 mm. In the comparison of the results according to gender, 11.94 ± 5.08 mm in male and 11.87 ± 4.40 mm in female were shown, and there was no significant difference (Table 1).

Table 1. Height of the posterior superior alveolar artery (PSAA).

	Height from the Sinus Floor		
	Mean $\pm$ S.D.	Maximum	Minimum
Height (mm)	11.91 ± 4.79	24.05	3.03
(Mean $\pm$ S.D.)			
	Gender		<i>p</i> -Value
	Male	Female	
Height (mm)	11.94 ± 5.08	11.87 ± 4.40	0.952

Statistically significant $p < 0.05$; independent *t*-test.

3.2. Lateral Wall Thickness of the Maxillary Sinus

Lateral wall thickness of the maxillary sinus was 1.71 ± 0.55 mm on average; the maximum was 3.93 mm and the minimum was 0.74 mm. Depending on the gender, it was 1.76 ± 0.60 mm for male and 1.63 ± 0.44 mm for female. There was no significant difference by gender (Table 2).

Table 2. Lateral wall thickness of the maxillary sinus.

	(Mean $\pm$ S.D.)		
	The Lateral Wall Thickness		
	Mean $\pm$ S.D.	Maximum	Minimum
Thickness(mm)	1.71 ± 0.55	3.93	0.74
(Mean $\pm$ S.D.)			
	Gender		<i>p</i> -Value
	Male	Female	
Thickness(mm)	1.76 ± 0.60	1.63 ± 0.44	0.830

Statistically significant $p < 0.05$; independent *t*-test.

3.3. The Volume of the Maxillary Sinus

In the case of maxillary sinus volume, there was no significant difference according to gender. The average total volume of the maxillary sinus was 12.104 ± 4.82 cm³, and average

volume of maxillary sinus according to the height from the sinus floor was $0.173 \pm 0.11 \text{ cm}^3$, $0.526 \pm 0.25 \text{ cm}^3$, $1.068 \pm 0.43 \text{ cm}^3$, and $2.184 \pm 0.74 \text{ cm}^3$ at 3 mm, 5 mm, 7 mm, and 10 mm respectively (Table 3).

Table 3. Volume of maxillary sinus.

(Mean $\pm$ S.D.)			
The volume of maxillary sinus			
	Mean $\pm$ S.D.	Maximum	Minimum
3 mm (cm^3)	0.173 ± 0.11	0.570	0.038
5 mm	0.526 ± 0.25	1.304	0.104
7 mm	1.068 ± 0.43	2.372	0.208
10 mm	2.184 ± 0.74	4.334	0.493
Total	12.104 ± 4.82	25.812	0.495
(Mean $\pm$ S.D.)			
	Gender		<i>p</i> -Value
	Male	Female	
3 mm (cm^3)	0.158 ± 0.11	0.197 ± 0.11	0.082
5 mm	0.513 ± 0.25	0.547 ± 0.25	0.051
7 mm	1.065 ± 0.44	1.072 ± 0.42	0.947
10 mm	2.198 ± 0.77	2.161 ± 0.70	0.825
Total	11.800 ± 5.158	12.587 ± 4.25	0.472

Statistically significant $p < 0.05$; Mann–Whitney test, independent *t*-test.

3.4. The Height of Residual Bone

The average height of the residual bone was $2.97 \pm 1.08 \text{ mm}$. There was no significant difference in the height of the residual bone according to the gender (Table 4).

Table 4. The height of residual bone.

Height from the Sinus Floor to Residual Crest			
	Mean $\pm$ S.D.	Maximum	Minimum
Height	2.97 ± 1.08	4.98	0.93
(Mean $\pm$ S.D.)			
	Gender		<i>p</i> -Value
	Male	Female	
Height (mm)	2.92 ± 1.14	3.05 ± 1.00	0.595

Statistically significant $p < 0.05$; independent *t*-test.

3.5. The Septum of the Maxillary Sinus

The septum was found within 28 maxillary sinuses (33.7%) (Figure 5).

Figure 5. Septum of maxillary sinus.

4. Discussion

Inadequate bone quantity on posterior maxillary area may be associated with maxillary sinus pneumatization, which may contribute to a further decrease of the available bone for implant placement [23]. Maxillary SBG is a predictable technique to increase available bone for implant surgery [7,24]. In order to avoid unnecessary complications such as arterial bleeding and perforation of SM, it is important to know the clinical anatomy for SBG. For evaluating the location and size of PSAA, CBCT is the most appropriate method for detecting vessel [25]. If unnecessary bleeding occurs during SBG, it is caused by injury of PSAA. This can be prevented by recognizing the position of the PSAA in preoperative CT scan and paying attention to preserving the vessel during operation. In this study, PSAA was 11.94 ± 5.08 mm in male and 11.87 ± 4.40 mm in female, and residual bone was 2.92 ± 1.14 mm in male and 3.05 ± 1.00 mm in female on average. In anatomical studies, this distance of PSAA has been shown as 18.9 mm (Kim et al.), 18 mm (Güncü et al.) and 19.6 mm (Mardinger et al.) [8,26,27]. Pandharbale et al. reported that the distances from inferior margin of PSAA to the middle of interdental alveolar crest were 17.19–17.75 mm on first molar and 17.00–17.17 mm on second molar [28]. Kim et al. found that there was no significant difference between age and gender [27]. In this study, we included the patient who had residual bone less than 5 mm and measured the distance of PSAA from the inferior border of maxillary sinus; thus, the distance was smaller than previous studies.

Lateral wall thickness can affect the operation time for making a lateral window and the perforation of the SM [3]. In this study, lateral wall thickness was 1.71 mm on average, maximum 3.93 mm, and minimum 0.74 mm. Danesh et al. found that the state of teeth (dentate state or edentulous state) did not affect the lateral wall thickness and indicated the lateral wall thickness was 1.98 mm on average [29]. Yang et al. found that the lateral wall thickness was 1.75 ± 0.80 mm in edentulous patients [19]. This is very similar to our results. Neiva et al. reported that lateral wall thickness of the white skulls was 0.91 ± 0.43 mm on average [20]. It was thinner than the results of the current study. The reason for this difference is due to the different point of measuring site.

To predict the amount of graft materials for SBG, we measured the sinus volume according to the heights of SBG. Lee et al. reported that the volume of sinus measured at 5 mm height was 0.55 ± 0.41 cm³, and 2.11 ± 0.68 cm³ at 10 mm height [30]. Kim et al. reported that the volume of sinus measured at the height of 5 mm and 10 mm was 0.56 ± 0.13 cm³ and 2.35 ± 0.57 cm³, respectively [31]. These results of volume for SBG were similar to this study, 0.526 ± 0.25 cm³ at 5 mm and 2.184 ± 0.74 cm³ at 10 mm. In this study, the total sinus volume was 12.104 ± 6.56 cm³ on average and there was no difference

with gender. The average volumes of the maxillary sinus were 14.05 cm³, 15.7 cm³, and 20.740 cm³ [5,32,33]. This difference could be due to racial or technical differences. As with other authors, no differences were found with respect to the patient's sinus volume according to gender [4,34–36]. Aktuna et al. reported that the volume of the maxillary sinus increased with age [37,38]. Septum is one of the reasons for membrane perforation during SBG. The prevalence of the sinus septum was reported as 55.2%, 16.1%, 26.5% [2,8,39], and 33.7% in this study.

This study has limitations in terms of volume analysis. In order to predict the volume before surgery, it is necessary to investigate the amount of grafted material at the time of the actual surgery. Therefore, further study is necessary to evaluate the volume of the grafted bone in actual patients and to compare the time-dependent changes regarding the volume of grafted bone through CBCT analysis.

5. Conclusions

PSAA is located at 11.91 ± 4.79 mm on average from the lowest point of the maxillary sinus floor. The clinician should confirm the position of PSAA in CBCT when available bone is not adequate due to the pneumatization and resorption of residual bone. Perceptions of the lateral wall thickness can reduce the operation time and unintentional perforations. The maxillary sinus septum was found in 33.7% of all patients, regardless of gender and age. If there is a maxillary sinus septum, the operator needs to put a surgical plan into consideration. The amount of graft materials according to the height was 0.173 cm³ (3 mm), 0.526 cm³ (5 mm), 1.068 cm³ (7 mm), 2.184 cm³ (10 mm) on average. These results can help the clinicians in regards to sinus bone graft.

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References

1. Traxler, H.; Windisch, A.; Geyerhofer, U.; Surd, R.; Solar, P.; Firbas, W. Arterial blood supply of the maxillary sinus. *Clin. Anat.* **1999**, *12*, 417–421. [[CrossRef](#)]
2. Ilguy, D.; Ilguy, M.; Dolekoglu, S.; Fisekcioglu, E. Evaluation of the posterior superior alveolar artery and the maxillary sinus with CBCT. *Braz. Oral Res.* **2013**, *27*, 431–437. [[CrossRef](#)] [[PubMed](#)]
3. LLawson, W.; Patel, Z.M.; Lin, F.Y. The Development and Pathologic Processes that Influence Maxillary Sinus Pneumatization. *Anat. Rec. Adv. Integr. Anat. Evol. Biol.* **2008**, *291*, 1554–1563. [[CrossRef](#)] [[PubMed](#)]
4. Gulec, M.; Tassoker, M.; Magat, G.; Lale, B.; Ozcan, S.; Orhan, K. Three-dimensional volumetric analysis of the maxillary sinus: A cone-beam computed tomography study. *Folia Morphol.* **2020**, *79*, 557–562. [[CrossRef](#)] [[PubMed](#)]
5. Karakas, S.; Kavaklı, A. Morphometric examination of the paranasal sinuses and mastoid air cells using computed tomography. *Ann. Saudi Med.* **2005**, *25*, 41–45. [[CrossRef](#)]
6. Sharan, A.; Madjar, D. Maxillary sinus pneumatization following extractions: A radiographic study. *Int. J. Oral Maxillofac. Implant.* **2008**, *23*, 48–56.

7. Bergh, J.P.A.V.D.; Bruggenkate, C.M.T.; Disch, F.J.M.; Tuinzing, D.B. Anatomical aspects of sinus floor elevations. *Clin. Oral Implant. Res.* **2000**, *11*, 256–265. [[CrossRef](#)]
8. Güncü, G.N.; Yildirim, Y.D.; Wang, H.-L.; Tözüm, T.F. Location of posterior superior alveolar artery and evaluation of maxillary sinus anatomy with computerized tomography: A clinical study. *Clin. Oral Implant. Res.* **2011**, *22*, 1164–1167. [[CrossRef](#)]
9. Apostolakis, D.; Bissoon, A.K. Radiographic evaluation of the superior alveolar canal: Measurements of its diameter and of its position in relation to the maxillary sinus floor: A cone beam computerized tomography study. *Clin. Oral Implant. Res.* **2013**, *25*, 553–559. [[CrossRef](#)]
10. Ziccardi, V.; Betts, N. Complications of maxillary sinus augmentation. In *The Sinus Bone Graft*; Quintessence Publishing Co.: Berlin, Germany, 1999; pp. 201–208.
11. Nimigean, V.R.; Măru, N.; Sălăvăstru, D.I.; Bădiță, D.; Tuculină, M.J. The maxillary sinus floor in the oral implantology. *Rom. J. Morphol. Embryol.* **2008**, *49*, 485–489.
12. Boffano, P.; Forouzanfar, T. Current Concepts on Complications Associated With Sinus Augmentation Procedures. *J. Craniofacial Surg.* **2014**, *25*, e210–e212. [[CrossRef](#)] [[PubMed](#)]
13. Pikos, M.A. Maxillary sinus membrane repair: Report of a technique for large perforations. *Implant. Dent.* **1999**, *8*, 29–35. [[CrossRef](#)] [[PubMed](#)]
14. Zijdeveld, S.A.; Bergh, J.P.V.D.; Schulten, E.A.J.M.; Bruggenkate, C.M.T. Anatomical and Surgical Findings and Complications in 100 Consecutive Maxillary Sinus Floor Elevation Procedures. *J. Oral Maxillofac. Surg.* **2008**, *66*, 1426–1438. [[CrossRef](#)] [[PubMed](#)]
15. Testori, T.; Wallace, S.S.; Del Fabbro, M.; Taschieri, S.; Trisi, P.; Capelli, M.; Weinstein, R.L. Repair of large sinus membrane perforations using stabilized collagen barrier membranes: Surgical techniques with histologic and radiographic evidence of success. *Int. J. Periodontics Restor. Dent.* **2008**, *28*, 9–17.
16. Pjetursson, B.E.; Tan, W.C.; Zwahlen, M.; Lang, N.P. A systematic review of the success of sinus floor elevation and survival of implants inserted in combination with sinus floor elevation. *J. Clin. Periodontol.* **2008**, *35* (Suppl. 8), 216–240. [[CrossRef](#)]
17. Del Fabbro, M.; Rosano, G.; Taschieri, S. Implant survival rates after maxillary sinus augmentation. *Eur. J. Oral Sci.* **2008**, *116*, 497–506. [[CrossRef](#)]
18. Solar, P.; Geyerhofer, U.; Traxler, H.; Windisch, A.; Ulm, C.; Watzek, G. Blood supply to the maxillary sinus relevant to sinus floor elevation procedures. *Clin. Oral Implant. Res.* **1999**, *10*, 34–44. [[CrossRef](#)]
19. Yang, S.-M.; Park, S.-I.; Kye, S.-B.; Shin, S.-Y. Computed tomographic assessment of maxillary sinus wall thickness in edentulous patients. *J. Oral Rehabil.* **2012**, *39*, 421–428. [[CrossRef](#)]
20. Neiva, R.F.; Gapski, R.; Wang, H.-L. Morphometric Analysis of Implant-Related Anatomy in Caucasian Skulls. *J. Periodontol.* **2004**, *75*, 1061–1067. [[CrossRef](#)]
21. Katranji, A.; Fotek, P.; Wang, H.-L. Sinus Augmentation Complications: Etiology and Treatment. *Implant. Dent.* **2008**, *17*, 339–349. [[CrossRef](#)]
22. Wallace, S.S.; Froum, S. Effect of Maxillary Sinus Augmentation on the Survival of Endosseous Dental Implants. A Systematic Review. *Ann. Periodontol.* **2003**, *8*, 328–343. [[CrossRef](#)] [[PubMed](#)]
23. Lombardi, T.; Bernardello, F.; Berton, F.; Porrelli, D.; Rapani, A.; Piloni, A.C.; Fiorillo, L.; Di Lenarda, R.; Stacchi, C. Efficacy of Alveolar Ridge Preservation after Maxillary Molar Extraction in Reducing Crestal Bone Resorption and Sinus Pneumatization: A Multicenter Prospective Case-Control Study. *BioMed Res. Int.* **2018**, *2018*, 9352130. [[CrossRef](#)] [[PubMed](#)]
24. Eggesbø, H.B. Radiological imaging of inflammatory lesions in the nasal cavity and paranasal sinuses. *Eur. Radiol.* **2006**, *16*, 872–888. [[CrossRef](#)] [[PubMed](#)]
25. Rosano, G.; Taschieri, S.; Gaudy, J.-F.; Weinstein, T.; Del Fabbro, M. Maxillary sinus vascular anatomy and its relation to sinus lift surgery. *Clin. Oral Implant. Res.* **2010**, *22*, 711–715. [[CrossRef](#)]
26. Mardinger, O.; Abba, M.; Hirshberg, A.; Schwartz-Arad, D. Prevalence, diameter and course of the maxillary intraosseous vascular canal with relation to sinus augmentation procedure: A radiographic study. *Int. J. Oral Maxillofac. Surg.* **2007**, *36*, 735–738. [[CrossRef](#)]
27. Kim, J.H.; Ryu, J.S.; Kim, K.-D.; Hwang, S.H.; Moon, H.S. A Radiographic Study of the Posterior Superior Alveolar Artery. *Implant. Dent.* **2011**, *20*, 306–310. [[CrossRef](#)]
28. Pandharbale, A.A.; Gadgil, R.M.; Bhoosreddy, A.R.; Kunte, V.R.; Ahire, B.S.; Shinde, M.R.; Joshi, S.S. Evaluation of the Posterior Superior Alveolar Artery Using Cone Beam Computed Tomography. *Pol. J. Radiol.* **2016**, *81*, 606–610. [[CrossRef](#)]
29. Danesh-Sani, S.A.; Movahed, A.; Elchaar, E.S.; Chan, K.C.; Amintavakoli, N. Radiographic Evaluation of Maxillary Sinus Lateral Wall and Posterior Superior Alveolar Artery Anatomy: A Cone-Beam Computed Tomographic Study. *Clin. Implant. Dent. Relat. Res.* **2016**, *19*, 151–160. [[CrossRef](#)]
30. Lee, J.H.; Han, W.J.; Choi, Y.H.; Kim, E.K. Measurement of maxillary sinus volume and available alveolar bone height using computed tomography. *Imaging Sci. Dent.* **2003**, *33*, 35–41.
31. Kim, H.W.; Lee, S.K.; Chung, J.A.; Shin, J.E.; Um, Y.S.; Kim, K.Y. Measurement of maxillary sinus volume for the placement of graft material—A case control study using CT image. *J. Korean Assoc. Oral Maxillofac. Surg.* **2007**, *33*, 511–517.
32. Kim, J.; Song, S.W.; Yoon, H.R.; Chang, K.-H.; Chun, E.J. Comparative study of the pneumatization of the mastoid air cells and paranasal sinuses using three-dimensional reconstruction of computed tomography scans. *Surg. Radiol. Anat.* **2010**, *32*, 593–599. [[CrossRef](#)] [[PubMed](#)]

33. Sahlstrand-Johnson, P.; Jannert, M.; Strömbeck, A.; Abul-Kasim, K. Computed tomography measurements of different dimensions of maxillary and frontal sinuses. *BMC Med. Imaging* **2011**, *11*, 8. [[CrossRef](#)]
34. Endo, T.; Abe, R.; Kuroki, H.; Kojima, K.; Oka, K.; Shimooka, S. Cephalometric evaluation of maxillary sinus sizes in different malocclusion classes. *Odontology* **2010**, *98*, 65–72. [[CrossRef](#)] [[PubMed](#)]
35. Accucci, M.; Cipriani, F.; Carderi, S.; Di Carlo, G.; D’Attilio, M.; Rodolfo, D.; Festa, F.; Polimeni, A. Gender assessment through three-dimensional analysis of maxillary sinuses by means of cone beam computed tomography. *Eur. Rev. Med. Pharmacol. Sci.* **2015**, *19*, 185–193.
36. Urooge, A.; Patil, B.A. Sexual Dimorphism of Maxillary Sinus: A Morphometric Analysis using Cone Beam Computed Tomography. *J. Clin. Diagn. Res.* **2017**, *11*, ZC67–ZC70. [[CrossRef](#)]
37. Belgin, C.A.; Colak, M.; Adiguzel, O.; Akkus, Z.; Orhan, K. Three-dimensional evaluation of maxillary sinus volume in different age and sex groups using CBCT. *Eur. Arch. Oto Rhino Laryngol.* **2019**, *276*, 1493–1499. [[CrossRef](#)]
38. Emirzeoglu, M.; Sahin, B.; Bilgic, S.; Çelebi, M.; Uzun, A. Volumetric evaluation of the paranasal sinuses in normal subjects using computer tomography images: A stereological study. *Auris Nasus Larynx* **2007**, *34*, 191–195. [[CrossRef](#)]
39. Kim, M.-J.; Jung, U.-W.; Kim, C.-S.; Kim, K.-D.; Choi, S.-H.; Kim, C.-K.; Cho, K.-S. Maxillary Sinus Septa: Prevalence, Height, Location, and Morphology. A Reformatted Computed Tomography Scan Analysis. *J. Periodontol.* **2006**, *77*, 903–908. [[CrossRef](#)]