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Anatomical variations of maxillary sinus: a cone-beam computed tomography study

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ABSTRACT

The goal of current project was to evaluate the maxillary sinus dimensions using cone-beam computed tomography (CBCT) to assess anatomical variations. A total of 86 CBCT examinations were retrospectively performed in this regard. In this study, the Promax 3D CBCT unit was used for the dimension determination in para-axial, occlusal and panoramic views. In para-axial view, sinus height and width were 31.7 mm and 23.2 mm, in panoramic view (frontal plan) 29.9mm and 27.9 respectively and in occlusal view mean sinus length and width were 33.9 mm and 23.1 mm respectively. The dome-shaped maxillary sinus cyst was observed in 27% of patients. Sinus septum was determined in 29 % of patients (the mean height =8.1 mm). Other results were included the distances from the anterior wall of maxillary sinus to the midline mean distance (31.4 mm, SD= 8.3) and the mean distance from the lower border of the maxillary sinus to the alveolar crest of the maxilla (11.0 mm, SD= 4.4). Anatomical variations of maxillary sinus can change some vital surgery planning. The cone-beam computed tomography (CBCT) can be applied for an accurate assessment and additional validation of maxillary septum existence and avoid unnecessary surgical examinations.

Keywords: *Sinus anatomy; Anatomical variations; Septum; Cyst.*

1. INTRODUCTION

The maxillary sinus, a two-sided air-filled cavity, is the largest of the four paranasal sinuses that are located in the maxillary complex [1]. Almost, all the surgical actions in the posterior maxillary area contain comprehensive information of the maxillary sinus anatomy and probable anatomical variations [2]. In adults, maxillary sinus is a pyramid-form cavity in the facial skull with its base at the lateral nasal wall and its apex extending up to the zygomatic process of the maxilla. Maxillary sinus may show anatomic variations including hypoplasia, pneumatization, antral septa, exostosis, and variations in the location of the arteries [3,4].

A varied group of factors could affect the maxillary sinus volume that most of these factors could be asymptomatic. Pathological findings, as a result of the proximity of the premolars and canines to the maxillary sinuses, sinus pneumatization and/or sinus expansion can occur after the extraction of these teeth [5-7]. To minimize the risk of postoperative complications of maxillary sinus floor lift and in all on four implant techniques in the maxilla, it is crucial to be familiar with different anatomic and pathologic findings in sinus [8-10].

The septa sinus is one of the important topographies in sinus floor elevation. According to the literature, the occurrence of sinus septa varies from 16% to 58%. The location of sinus septa also differs based on reports. The presence of maxillary sinus septa can be identified in panoramic radiographs. Sinus septa can be divided into primary septa that arise from the development of the maxilla and secondary septa that arise from the irregular pneumatization of the sinus floor after tooth losing [11].

Insertion of an implant in the maxillary part depens on quality and quantity of the alveolar bone of the maxilla [12]. Sinus bone graft (sinus lifting) is a predictable technique to prepare a safe basis for the placement and improving the long-term retention of dental implants [13]. This procedure needs detailed information of maxillary sinus anatomy and anatomical variations.

Existing of some kinds of cysts in the maxillary sinus can contraindicate sinus lifting [14, 15]. The cyst formed at the maxillary sinus is categorized as four types including pseudocysts, mucoceles, postoperative maxillary cysts, and mucous retention cysts. The blockage of the salivary gland near the maxillary sinus leads to expansion and mucous retention cyst that are in most times small and cannot be recognized well [16]. Retention cysts are common in paranasal sinuses and are informed to occur in between 1.4% to 9.6% of the general population. In the literature and reports, retention cysts have only been recognized in the maxillary sinuses [17].

The maxillary sinus dimensions have mainly been determined in order to examine the volumetric changes before and after rapid maxillary expansion. The measurement of the maxillary sinuses has been performed with conventional two-dimensional visualization during the past years [18]. These procedures were restricted in terms of defining a complex three-dimensional anatomic structure. Lately, new developments has occur in medical imaging leads to approaches such as computerized tomography (CT) scanning as a widely used imaging modality for evaluating the paranasal sinus volumes [19-21]. Appropriate valuation of the achievement of axial, sagittal, and coronal sections are the most important aids of this methodology. Cone-beam computed tomography (CBCT) scanning is one of the current methods for testing external and internal dental morphology that has become as an excellent standard for broadly assessing of the position of the impacted canines in recent years [22, 23]. CBCT may be suggested as a low-cost dose-sparing method compared with another standard medical tomography, however, CBCT has slightly more radiation

exposure than routine panoramic radiography for dentomaxillofacial imaging [4]. The objective of this study was to measure all of the anatomical landmarks of maxillary sinus using CBCT scans.

2. EXPERIMENTAL SECTION

This experimental study included 86 CBCT scans retrospectively were selected from a patient with partially edentulous maxilla. The scans had been taken as part of a diagnostic procedure for implant supported rehabilitation. The age of patients recruited for this study was in a range of 25 to72 years with an average age of 48 years, 95% of the subjects were 30-70 years old. Among the participants, 44% were women and 56% were men. For this purpose, CBCT images of the adult patients that shown dentate maxillary sinuses were included in this study as a sample. The images of patients with systemic problems and the sign of earlier trauma or manipulation of the maxillary sinuses, as well as scans with any evidence of pathologic variations in maxillary sinuses, were excluded from the study. The CBCT examinations were obtained using the Promax 3D (Planmeca, Finland) CBCT unit, which automatically sets the proper exposure parameters for each patient. To standardize the reading and interpreting of the CBCT images, the acquired images were handled with the Romexis software. Measurements were completed using the measurement tools of the Romexis software under magnification ×3. Reformatted cross-sectional images with a 1- mm slides, panoramic views, and occlusal images were carefully evaluated to study anatomical variations of maxillary sinuses in the frontal, sagittal and axial plan. This study included sinus height and length in 3 plan, presence and height of septum, the distances from the anterior wall of the sinus to the midline and to the distal of canine and the distance from the lower border of the maxillary sinus to the alveolar crest of the maxilla. Data were analyzed using the SPSS software (Ver. 18.0) and the descriptive analysis was shown as frequency, mean (SD), and the range.

3. RESULTS AND DISCUSSION

From 86 CBCT images, 38 cases belonged to females (45%) and 48 to males (55%). in para-axial view mean sinus height and width were 31.7 (SD=6.0) mm and 23.2 mm (SD=6.1), in panoramic view(frontal plan) 29.9mm (SD=7.4) and 27.9 (SD=7.2) respectively and in occlusal view mean sinus length and width were 33.9 (SD=4.5mm) and 23.1mm (SD=4.9) respectively.

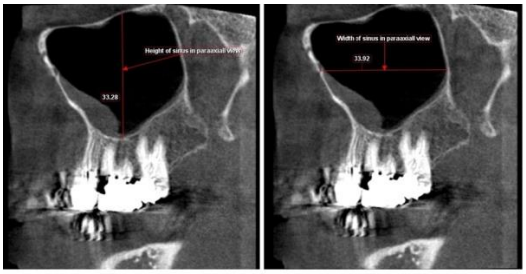

Fig. 1. Height and width of sinus in paraxial view; From 86 CBCT images, in para-axial view mean sinus height and width were 31.7 (SD=6.0) mm and 23.2 mm (SD=6.1) respectively.

Table 1. The measured landmarks for maxillary sinus derived from 86 CBCT images; The results are included mean, max, min and SD amounts.

Maxillary sinus	Mean	SD	MAX	MIN
Coronal plan L	29.9	7.4	43.4	11.9
Coronal plan W	27.9	7.2	41.4	10.9
Sagittal plan L	31.7	6.0	45.8	18.0
Sagittal plan W	23.2	6.1	33.4	13.0
Axial plan L	33.9	4.5	41.7	24.4
Axial plan W	23.1	4.9	35.5	13.7
Anterior wall distance to midline	31.4	8.3	60.6	18.0
lower wall distance to alveolar crest	11.0	4.4	22.8	9.1
Sinus septa	8.1	4.3	17.2	4.0
Size of sinus cyst	9.7	6.1	28.1	2.7

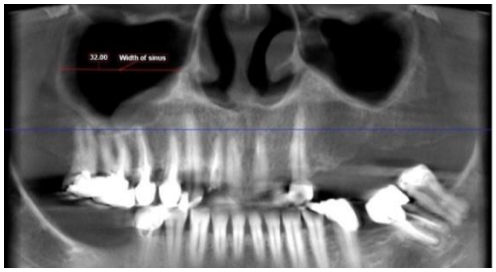

Fig. 2. Height and width of sinus in panoramic view (frontal plan) were determined 29.9mm (SD=7.4) and 27.9 (SD=7.2) respectively.

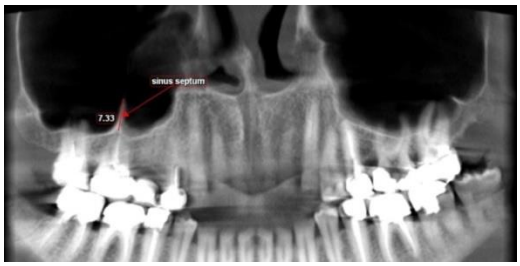

Fig. 3. Sinus septum: the mean height of sinus septum was determined 8.1 mm. The minimum and maximum height of the right sinus septum were 3.7 and 14.6 mm respectively. These numbers for the left sinus septum were 2.7 and 17.2 mm, respectively.

The mean values of the maxillary sinus length, height, and volume in females were 25% smaller than man. The maxillary sinus cyst (dome-shaped) was found in 27% of patients. Sinus septum was determined in 29 % of patients (the mean height was 8.1 mm) that 2 % of them had septum with a height of more than 15 mm. The minimum and maximum height of the right sinus septum were 3.7 and 14.6 mm respectively. These numbers for the left sinus septum were 2.7 and 17.2 mm, respectively. Other results were included the distances from the anterior wall of maxillary sinus to the midline and to the distal of canines, the mean distance was 31.4mm (SD=8.3) and 7.1mm (SD=2.8). The mean distance from the lower border of the maxillary sinus to

the alveolar crest of maxilla was11.0 mm (SD= 4.4). The results are summarized in Table 1. Furthermore, some important dimensions are shown in Figures 1-3. CBCT images show accurate and reliable measurements for reformation and imaging of dental structures. This imaging technique is very significant and clinically applicable for the finding of maxillary sinus variations as well as pathologic problems. Maxillary sinuses are located in the maxillary bones and can be of various sizes and shapes. The obtained results from this study revealed that the mean value of maxillary sinus length, height, and volume for males were greater than that of females. In a study by Fernandes et al, the maxillary sinus in European and Zulu have been measured using computed tomography and the outcomes showed that the mean value of maxillary sinus length, width, and height in European males were greater than European female. Even though in Zulu the maxillary sinus width were higher for females [24]. Parks et al reported the results for the maxillary sinuses of normal Korean adults that showed the greater numbers for males compared to females [24]. The presence of maxillary sinus septa can be identified in panoramic radiographs. However, CBCT scans are certainly the preferred methods for the valuation of this anatomic variation [25]. In this study, sinus septum was determined in 29 % of patients that 2 % of them had septum with a height of more than 15 mm. According to studies, the occurrence of sinus septa varies from 16% to 58% according to the literature [11]. Underwood [26], Krennmair et al. [27] and Kim et al [28] reported 33%, 14-31% and 26.5% prevalence of septum, respectively. The location of sinus septa also differs and the most common location described by Underwood reported the posterior region as the most common location of the septum [26]. However, Krennmair et al found a majority of septa in the anterior/premolar region of edentulous maxillae and dentate maxillae [27]. Kim et al observed the common location of septa are in the middle/molar region [28]. Furthermore, Krennmair et al stated that panoramic radiograph may result in false diagnosis regarding the positive or negative identification of septa in 21.3% of cases while CT imaging is favored technique for identifying the presence (or absence) of sinus septa as it can show the high-resolution scanning of delicate bony structures [29]. In a study by Faramarzie et al, the occurrence of at least one septum was 29.5% [30]. In a review by Maestre-Ferrin et al, this number was reported 13-35% for 11 reviewed studies.

One of the significant anatomical structure within the maxillary sinus is the distance of anterior wall of maxillary sinus to the midline and to the distal of canine [31]. In our study, these numbers were 31.4 mm (SD=8.4) and 7.1mm (SD=2.8) respectively. The other investigators reported different amounts that may be due to the anatomic variation in the locations of the anterior wall and the tested populations. This data may be valuable in clinical phases during osteotomies, bone reconstructions, screw, or other reconstruction apparatus needs on the maxilla [32]. Extensive variations happen in jaw anatomy with different races and different populations. So, the location of such a vital structure differs among the individuals within significantly normal limits. According to our study, the location of the maxillary sinus from alveolar crest varied. This may be due to the degree of pneumatization varies from individual to individual and from side to side [33]. A study done by Japanese displayed that the sinus floor to the alveolar crest on the right side and left side in edentulous jaws were 6.9 ± 4.75 mm and 6.6 ± 4.78 mm respectively [34]. The mean distance may showed differences among individuals as well as from right to left maxillary sinus in the same person. Furthermore, it is possible that within a given population, depending on the patient's stature, age, sex and the position of these important structures may vary. In this study, we found a dome shape cyst in maxillary sinus in % 27 of patients. Existing some type of cysts in the maxillary sinus can contraindicate sinus lifting [35-39]. Mardinger et al claimed that sinus lifting should be done only when there is no cyst in the maxillary sinus. However, in some reports stated that a cyst in the maxillary sinus does not effect on of sinus lifting [40]. Maiorana et al examined 10 patients with mucosal cyst. According to authors, the implants were placed after sinus lifting, and the implants osseo-integrated successfully for 28 months during observation with a 100 % survival rate [41]. Then, based on obtained data, it can be suggested that CBCT is a low-cost dose-sparing method compared with another standard medical tomography, as has been mentioned by other investigators [42-44].

4. CONCLUSION

In the current study, the anatomical measurements of the maxillary sinus were determined using cone-beam computed tomography (CBCT) scans of the maxilla. Since prior to implant placement the location of the vital anatomic structures should be evaluated by clinical examination and radiographic analysis, this data may be useful in clinical stages during osteotomies, bone reconstructions, screw, or other reconstruction apparatus requests on the maxilla. Certainly, CBCT images are useful for evaluating maxillary sinus morphology, and normal variations which may be used to modify the surgical treatment plan to achieve more successful treatments.

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