Relationship among Schneiderian Membrane, Underwood's Septa, and the Maxillary Sinus Inferior Border

Binali Çakur, DDS, PhD; Muhammed Akif Sümbüllü, DDS, PhD; Doğan Durna, DDS

ABSTRACT

Background: Osseo-integrated implants are increasingly being used to restore functional dentition; however, in the posterior region, implant placement can be problematic because of inadequate bone height. In this condition, maxillary sinus floor elevation surgery has become the treatment of choice. The presence of anatomic variations within the maxillary sinus such as Underwood's septa and thin schneiderian membrane decreases the success of the sinus floor elevation.

Purpose: In this study, we tried to determine the relationship between the anatomic variations of the maxillary sinus: Underwood's septa, schneiderian membrane thickness, and the cortical thickness of the inferior border of the maxillary sinus.

Material and Methods: The left and right maxillary sinus images of 74 patients were obtained by using dental computed tomography (CT). The schneiderian membrane and the cortical thickness of the inferior border of the maxillary sinus were measured on the coronal images of dental CT scans at the deepest portion of the sinus cavity. The presence of Underwood's septa was identified on the axial images. The correlations between these variables were assessed.

Results: We found that there was only a negative correlation between the schneiderian membrane thickness and the presence of Underwood's septa ($r = -0.168$ $p = .042$).

Conclusion: It is suggested that Underwood's septa may be the reason for the thinness of the schneiderian membrane. However, future studies among larger groups are necessary for confirming the finding by using well-designed clinical studies.

KEY WORDS: dental computed tomography, maxillary sinus floor, maxillary sinuses, schneiderian membrane, Underwood's septa

INTRODUCTION

Anatomic variations within the sinus, such as Underwood's septa, schneiderian membrane thinness increase the risk of the schneiderian membrane perforation during the sinus elevation procedure.[1–6] The success of this operation depends on the evaluation of the inner aspect of the maxillary sinus. For this reason, the radiological assessment of the sinus is performed exactly and definitively.[1,7,8] Maxillary sinus septa were first described by Underwood in 1910. Hence, they are sometimes referred to as Underwood's septa.[9] Thirteen and 35.3% of the maxillary sinuses have septa.[10] They can be located in any region of the maxillary sinus.[10] A perforation of the schneiderian membrane forms a frequent complication and always threatens the coverage of the bone graft.[5,11] The normal schneiderian membrane is approximately 1 mm in thickness.[11] However, mucosal thickening of the maxillary sinus is common in asymptomatic patients; therefore, the mucosal lining is considered to be normal when less than 4 mm.[12] It is reported that the membrane perforation rate is inversely related to the schneiderian membrane thickness.[11] The cortical thickness of the inferior border of the sinus and its relationship with the anatomic structures are important in determining the topography of a spreading dental

Department of Oral Diagnosis and Oral Radiology, Faculty of Dentistry, Atatürk University, Erzurum, Turkey

Reprint requests: Dr. Binali Çakur, Department of Oral Diagnosis and Radiology, Faculty of Dentistry, Ataturk University, 25240 Erzurum, Turkey; e-mail: bcakur@atauni.edu.tr

DOI 10.1111/j.1708-8208.2011.00336.x

infection into the maxillary sinus and essential to diagnose and plan dental implantation, endodontic procedures, and orthodontic treatment.[13]

Although there are many studies regarding the prevalence of anatomic variations of the maxillary sinus, there is no study evaluating whether or not a relation exists among the anatomic variations of the maxillary sinus. The aim of this study was to determine if there were correlations among the anatomic variations of the maxillary sinus; the thickness of schneiderian membrane, the presence of Underwood's septa, and the cortical thickness of the inferior border of the maxillary sinus.

MATERIALS AND METHODS

The material of the study consisted of 148 images of the maxillary sinus of dental computed tomography (CT) scans of 74 patients (28 female patients, 46 male patients). Their ages ranged from 20 to 75 years, with mean age of 34 years 9 months ± 13 years 9 months. All patients required treatment with dental implants in the posterior maxilla. The patients who had no history of systemic diseases impacting on bone such as thyroid disease, hyperparathyroidism, diabetes, chronic renal disease, or osteoporosis, and no developmental or acquired craniofacial or neuromuscular deformities were included in this study. This study was approved by an ethical committee and informed consent was obtained from all patients.

Dental CT Examination

The maxillary sinus images were obtained by using cone beam CT (NewTom-FP; Quantitative Radiology, Verona, Italy) scans with 0.2-mm slices in the axial planes, 2-mm slices in the coronal planes, and 2-mm slices in the sagittal planes. The dental CT scanning was done on patients positioned supinely and the head position of those patients was adjusted in such a way that the hard palate was parallel to the floor, while sagittal plane was perpendicular to the floor. Imaging parameters were kV = 110, mA = 15, and FOV = 140 × 170 mm. The dental CT images were evaluated with respect to inferior border thickness of the maxillary sinus, the presence of Underwood's septa, and the schneiderian membrane thickness. The axial images were used for identification of presence of Underwood's septa (Figure 1). On the coronal images, the presence of the schneiderian membrane thickness was evaluated. The deepest point of the convex sinus inferior border was used as a reference point on the coronal images (Figure 2). At the reference point, the membrane lining was considered to be thickening when more than 3 mm (Figure 2), and the cortical thickness of the inferior border of the maxillary sinus was measured (Figure 3). The measurements of these parameters were made separately on the right and left maxillary sinuses. All dates were recorded and correlations between these variables were assessed. To ensure consistency, the first author was responsible for selecting all the images and performing the measurements of the schneiderian membrane thickness and the maxillary sinus inferior border thickness. Of these images, 50% (74 images) were randomly selected, re-marked, and remeasured. In order to determine the accuracy and reproducibility of the measurements, an analysis of the coefficient of variance (CV %) was performed. For this purpose, the first author's remeasurement was made 2 weeks after the first measurements, and the first and second measurements on 74 randomly selected images of the dental CT scans were analyzed.

Figure 1 On the axial image; the presence of Underwood's septa (white arrows).

Statistics. Descriptive statistics (means ± SD) and correlation were calculated using the SPSS® statistics program (SPSS® v11.0; SPSS Inc., Chicago, IL, USA). Correlations among the variables (schneiderian membrane thickness, Underwood's septa, and inferior border

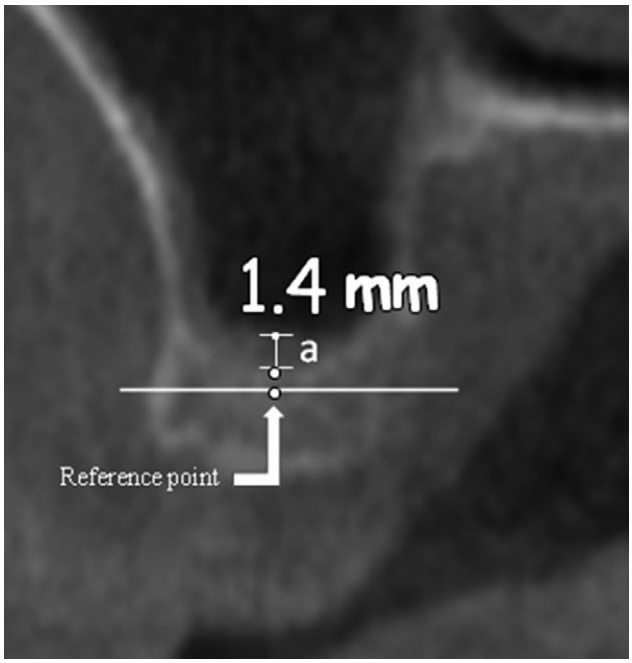

Figure 2 On the coronal image; the measurement of the schneiderian membrane thickness at the reference point. The deepest point of the convex sinus inferior border was used as a reference point. The deepest point was determined by tracing a line on the coronal images tangential to the inferior cortex of the convex sinus inferior border. At the reference point, the membrane lining (a) was considered to be thickening when more than 3 mm.

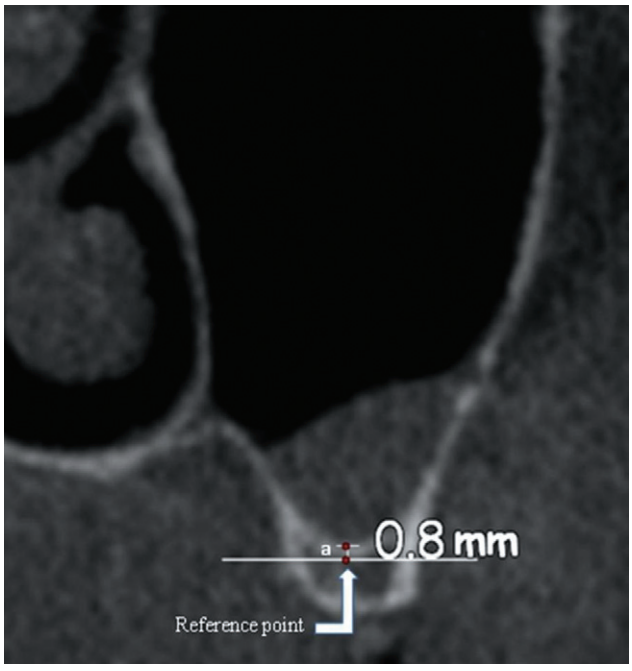

Figure 3 On the coronal images; it showed the measurement of the cortical thickness of the inferior border of the maxillary sinus. The thickness (a) was measured as the cortical width between the superior and inferior cortex of the convex sinus inferior border at the reference point.

TABLE 1 Descriptive Statistics of Age, Underwood's Septa, the Schneiderian Membrane Thickness, and the Maxillary Sinus Inferior Border Thickness

	n	Minimum	Maximum	Mean	SD
Age	72	20	75	34.9	13.9
US	144	0	1	0.26	0.44
SMT	144	0	1	0.5	0.49
IBT	144	0.6	1.4	0.86	0.21

IBT = the maxillary sinus inferior border thickness; SMT = the schneiderian membrane thickness; US = Underwood's septa.

thickness of the maxillary sinus) were established using the Pearson's correlation coefficient with the significance set at $p < .05$. *t*-Test was used to compare means of female and male.

RESULTS

Table 1 shows the age- and the sinus-related characteristics and Table 2 shows the results of the correlation analyses. Consequent to the performed analyses, it was found that there was only a negative correlation between Underwood's septa and the schneiderian membrane thickness ($r = –0.168$, $p = .042$). CV was found to be 0.84 and 0.25%, respectively, for the measurements (the schneiderian membrane thickness and the cortical thickness of the inferior border of the maxillary sinus). The schneiderian membrane thickness only showed a statistically significant difference between males and females ($p < .001$). In other

TABLE 2 The Results of Correlation Analysis among US, SMT, IBT

	US	SMT	IBT	Age
US	1	–0.168*	–0.048	–0.037
		$p = .042$	$p = .565$	$p = .653$
SMT	–0.168*	1	–0.048	0.154
	$p = .042$		$p = .566$	$p = .061$
IBT	–0.048	–0.048	1	0.121
	$p = .565$	$p = .566$		$p = 0142$
Age	–0.037	0.154	0.121	1
	$p = .653$	$p = .061$	$p = 0142$	

*Correlation is significant at the 0.05 level.
IBT = the maxillary sinus inferior border thickness; SMT = the schneiderian membrane thickness; US = Underwood's septa.

TABLE 3 The Results of *t*-Test

	Male		Female		
Parameters	Mean	SD	Mean	SD	Significance
SMT	0.74	0.44	0.34	0.48	0.000
IBT	0.86	0.22	0.86	0.21	0.986
US	0.33	0.60	0.34	0.64	0.899
Age	36.52	13.02	32.25	15.05	0.070

IBT = the maxillary sinus inferior border thickness; SMT = the schneiderian membrane thickness; US = Underwood's septa.

words, mean value of the schneiderian membrane thickness was higher in males than that in females (Table 3).

DISCUSSION

The relationship among the schneiderian membrane, Underwood's septa, and the maxillary sinus inferior border is critical element for the success of the sinus floor elevation.[14] While previous studies have evaluated the anatomical structures and variations of the maxillary sinus, to our knowledge this is the first study evaluating whether or not a relation exists among the anatomical variations of the maxillary sinus; Underwood's septa, schneiderian membrane thickness, and the cortical thickness of the inferior border of the maxillary sinus. The presence of anatomic variations within the maxillary sinus has been reported to increase the risk of sinus membrane perforation during the sinus elevation procedure.[1,4,5,15,16] It is reported that the prevalence of antral septa varies between 13 and 35.3% in studies based on the number of sinuses, and between 21.6 and 66.7% in studies based on the number of patients.[3] The most common intraoperative complication of sinus floor elevation surgery is reported to be perforation of the schneiderian membrane, with reported complication rates as high as 44% and always threatens the coverage of the bone graft.[17–20] According to Vlasiss and Fugazzotto,[21] perforation occurs more frequently during osteotomy than during the reflection of the membrane. If a sinus lift is conducted in the presence of Underwood's septa, it may be necessary to modify the design of the lateral window in order to avoid fracturing the septa and perforating the schneiderian membrane.[3] In the present study, we found a negative relationship between the schneiderian membrane thickening and Underwood's septa ($r = -0.168$, $p = .042$). In a study it was reported that the incidence of membrane perforation was found to be greater when the schneiderian membrane thickness was less than 1.5 mm.[11] Consequently, according to our result it was suggested that because Underwood's septa might be the reason for the thinness of the schneiderian membrane, the membrane perforation risk might be higher when Underwood's septa existed. In addition, we found that the mean value of the schneiderian membrane thickness was higher in male than that in female ($p < .001$). Therefore, the membrane perforation risk may be higher in female than that in male. However, more perforations have been referred among smoking patients,[22] presence of sharp and thin edges and ridges and at spines,[6,15] narrow maxillary sinus,[5] and presence of small residual bone height;[22] for all these parameters, there is a statistically significant relationship.[23] Harrison[24,25] reported that the inferior wall of the maxillary sinus had a minimum thickness of 0.5 mm over the first molar in 27% of cases, over the second molar in 46% of cases, and over the third molar in 30% of cases. Kwak and colleagues[13] measured the cortical thickness of the inferior wall of the maxillary sinus closest to the apex of the mesiobuccal root, the apex of the distobuccal root, and the furcation area of the maxillary first and second molar teeth. They reported that the cortical thickness over the distobuccal root of the second molar was the thinnest (average 0.37 mm), and the furcation area of the second premolar was the thickest (average 0.77 mm). In the present study, we found that the cortical thickness of the inferior border of the sinus averaged 0.86 mm in thickness in the deepest point of the convex floor of the maxillary sinus. Using a different technique for the same measurement could explain the discrepancy between Kwak and colleagues'[13] and Harrison's[24,25] results and ours.

CONCLUSION

The membrane perforation risk is more possible when the schneiderian membrane thickness decreases, and Underwood's septa may be the reason for the thinness of the schneiderian membrane. The schneiderian membrane thickness is higher in male than in female. However, future studies among larger groups are necessary for confirming the findings by using well-designed clinical studies. Dental CT scans can be utilized to

determine the thickness of the membrane and the inferior border of the maxillary sinus, and to identify the presence of Underwood's septa for preventing complications during presurgical planning.

REFERENCES

1. Kim MJ, Jung UW, Kim CS, et al. Maxillary sinus septa: prevalence, height, location and morphology. A reformatted computed tomography scan analysis. J Periodontol 2006; 5:903–908.
2. Cho SC, Wallece SS, Froum SJ, Tarnow DP. Influence of anatomy of Schneiderian membrane perforations during sinus elevation surgery: three-dimensional analysis. Pract Proced Aesthet Dent 2001; 13:160–163.
3. Maestre-Ferrín L, Galán-Gil S, Rubio-Serrano M, Peñarrocha-Diago M, Peñarrocha-Oltra D. Maxillary sinus septa: a systematic review. Med Oral Patol Oral Cir Bucal 2010; 15:e383–e386.
4. Tatum H Jr. Maxillary and sinus implant reconstructions. Dent Clin North Am 1986; 30:207–209.
5. van den Bergh JP, ten Bruggenkate CM, Disch FJ, Tuinzing DB. Anatomical aspects of sinus floor elevations. Clin Oral Implants Res 2000; 11:256–265.
6. Chanavaz M. Maxillary sinus: anatomy, physiology, surgery and bonegrafting related to implantology. Eleven years of surgical experience (1979–1990). J Oral Implantol 1990; 16:199–209.
7. Güler AU, Sumer M, Sumer P, Biçer I. The evaluation of vertical heights of maxillary and mandibular bones and the location of anatomic landmarks in panoramic radiographs of edentulous patients for implant dentistry. J Oral Rehabil 2005; 32:741–746.
8. Abrahams JJ. Dental CT imaging: a look at the jaw. Radiology 2001; 219:334–345.
9. Underwood AS. An inquiry into the anatomy and pathology of the maxillary sinus. J Anat Physiol 1910; 44(Pt 4):354–369.
10. Koymen R, Gocmen-Mas N, Karacayli U, Ortakoglu K, Ozen T, Yazici AC. Anatomic evaluation of maxillary sinus septa: surgery and radiology. Clin Anat 2009; 22:563–570.
11. Cho SC, Yoo SK, Moon DH, Elian N, Froum S, Tarnow D. Schneiderian membrane thickness and membrane perforation. AO Poster Presentation 2002.
12. Eggesbø HB. Radiological imaging of inflammatory lesions in the nasal cavity and paranasal sinuses. Eur Radiol 2006; 16:872–888.
13. Kwak HH, Park HD, Yoon HR, Kang MK, Koh KS, Kim HJ. Topographic anatomy of the inferior wall of the maxillary sinus in Koreans. Int J Oral Maxillofac Surg 2004; 33:382–388.
14. Vitkov L, Gellrich NC, Hannig M. Sinus floor elevation via hydraulic detachment and elevation of the Schneiderian membrane. Clin Oral Implants Res 2005; 16:615–621.
15. Betts NJ, Miloro M. Modification of the sinus lift procedure for septa in the maxillary antrum. J Oral Maxillofac Surg 1994; 52:332–333.
16. Krennmair G, Ulm CW, Lugmayr H, Solar P. The incidence, location, and height of maxillary sinus septa in the edentulous and dentate maxilla. J Oral Maxillofac Surg 1999; 57:667–671.
17. van Zyl AW, van Heerden WF. A retrospective analysis of maxillary sinus septa on reformatted computerised tomography scans. Clin Oral Implants Res 2009; 20:1398–1401.
18. Schwartz-Arad D, Herzberg R, Dolev E. The prevalence of surgical complications of the sinus graft procedure and their impact on implant survival. J Periodontol 2004; 75:511–516.
19. Shibli JA, Faveri M, Ferrari DS, et al. Prevalence of maxillary sinus septa in 1024 subjects with edentulous upper jaws: a retrospective study. J Oral Implantol 2007; 33:293–296.
20. Becker ST, Terheyden H, Steinriede A, Behrens E, Springer I, Wiltfang J. Prospective observation of 41 perforations of the Schneiderian membrane during sinus floor elevation. Clin Oral Implants Res 2008; 19:1285–1289.
21. Vlassis JM, Fugazzotto PA. A classification system for sinus membrane perforations during augmentation procedures with options for repair. J Periodontol 1999; 70:692–699.
22. Ardekian L, Oved-Peleg E, Mactei EE, Peled M. The clinical significance of sinus membrane perforation during augmentation of the maxillary sinus. J Oral Maxillofac Surg 2006; 64:277–282.
23. Viña-Almunia J, Peñarrocha-Diago M, Peñarrocha-Diago M. Influence of perforation of the sinus membrane on the survival rate of implants placed after direct sinus lift. Literature update. Med Oral Patol Oral Cir Bucal 2009; 14:e133–e136.
24. Harrison DFN. Oro-antral fistulae. Br J Clin Pract 1961; 15:169–174.
25. Harrison DFN. Surgical anatomy of maxillary and ethmoidal sinuses – a reappraisal. Laryngoscope 1971; 81:1658–1664.