# The Buccofacial Wall of Maxillary Sinus: An Anatomical Consideration for Sinus Augmentation

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### ABSTRACT

*Purpose*: This study aimed to quantify the thickness of the buccofacial wall of the maxillary sinus where sinus augmentations are often performed.

*Materials and Methods:* Fourteen sites located 15 and 20 mm superior to the anatomical cervical line (named as groups H15 and H20, respectively) and along the long axes of the mid and the interproximal of two premolars and two molars were measured from 74 Korean hemiface cadavers.

*Results:* The buccofacial wall of the maxillary sinus was thinnest at the area between the maxillary second premolar and first molar in groups H15 and H20. The lowest mean thickness was 1.2 mm in both groups. The walls were thicker in males than in females, with statistically significant gender differences found at four and two sites on the anterior horizontal reference in groups H15 and H20, respectively. However, the thickness did not differ significantly with age or laterality. Incomplete septa were found in seven of the 74 specimens, and they were present in the area between the first and second molars in six (86%) of these cases.

*Conclusions:* These observations indicate that anatomical characteristics of the buccofacial wall thickness of the maxillary sinus need to be considered when performing a window opening procedure for sinus augmentation.

KEY WORDS: anatomy, bone thickness, buccofacial sinus wall, dental implant, maxilla, maxillary sinus, sinus augmentation

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# INTRODUCTION

The presence of a maxillary sinus with severe pneumatization and alveolar bone loss often makes it difficult to install implant fixtures at the optimal length, diameter, and shape, requiring further surgical intervention. When maxillary sinus augmentation is considered, there are two choices for the surgical procedure: window opening and osteotome technique.

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When performing the window opening procedure, the mucoperiosteum of the maxillary sinus floor is carefully elevated to create a space between the membrane and the sinus floor to allow the bone grafting material of choice to be placed.<sup>1</sup> The mucoperiosteum of the buccofacial sinus wall plays an important role in containing the bone graft. However, the vulnerability of the mucoperiosteum to damage during this procedure means that it has to be managed cautiously while considering the thickness of the buccofacial wall of the maxillary sinus.<sup>2,3</sup> A few studies have described the topography and thickness of the buccofacial sinus wall, but positional variations in the bone thickness have not been reported.<sup>4,5</sup>

Therefore, the objective of this study was to elucidate the topographic thickness of the lateral wall of the maxillary sinus, which is a critical information when performing the window opening procedure prior to sinus augmentation.

# MATERIALS AND METHODS

Measurements were made on the buccofacial wall of the maxillary sinus in eight nonembalmed hemifaces (six males and two females) and 66 embalmed hemifaces (34 males and 32 females) with a dentate or partial edentate state obtained from Korean cadavers (mean age 69.3 years). The soft tissues overlying the cortical bone of the buccofacial wall of the maxillary sinus were removed entirely to reveal the bony surface in the region of interest.

Sites for the measurements were established as follows. On the exposed maxillae, vertical lines were drawn through the long axes at the center of teeth from the maxillary first premolar (PM1) to the second molar (M2) as well as the interproximal lines parallel to the long axes of the adjacent teeth. An anatomical cervical line of each tooth and the imaginary lines connecting the cervical lines adjacent to the remaining teeth were drawn and the two horizontal references were established 15 and 20 mm superior to the cervical line of the maxillary teeth, designated as H15 and H20, respectively. The intersecting points of the vertical lines and the two horizontal references were drawn with an oilbased marker pen (Figure 1).

After marking the points on the surface of the maxillae, the entire buccofacial walls confined within the maxillary sinus were gently removed. The sinus wall thickness at each location was measured with a bone depth gauge (CAT No. 1730-4, Schwert, Germany).



**Figure 1** Simplified illustration showing the mean thicknesses of the buccofacial wall of the left maxilla. H15 and H20 are the regions 15 and 20 mm superior to the cervical line, respectively. All values expressed are mean thicknesses in millimeter. Shaded areas in green and blue color indicate the thinnest and the thickest area of the buccofacial wall, respectively. M1 = first molar; M2 = second molar; M1 | M2 = interproximal region between first molar and second molar; PM1 = first premolar; PM2 = second premolar; PM2 | M1 = interproximal region between second premolar and first molar; PM1 | PM2 = interproximal region between first and second premolar.

#### Statistical Analysis

Mean and standard deviation values were calculated using Microsoft Excel software (version 2007, Microsoft, Redmond, WA, USA). The thicknesses in each group according to sex (male and female groups), age, horizontal location (15 and 20 mm superior to the cervical line), and vertical location were compared using *t*-tests. Statistical differences in buccofacial wall thickness in various regions were assessed using analysis of variance with a 5% confidence level. The 67 specimens without a septum were selected for statistical analysis according to sex, age, and laterality. To identify tendencies according to age, specimens were classified into three age categories: (1) 19 specimens aged 30 to 59 years; (2) 40 specimens aged 60 to 79 years; and (3) eight specimens aged 80 to 99 years.

# RESULTS

The buccofacial wall thickness differed significantly between groups H15 and H20 with varying tooth position (p < 0.05) (Table 1). The wall was thinnest between the secondary premolar and the first molar (area PM2 | M1) in groups H15 and H20. Generally, the

TABLE 1 Thickness of the Buccofacial Wall of the Maxillary Sinus in the Two Study Groups (in Millimeters)									
	Group H15			Group H20					
Region	Ν	Mean	SD	N	Mean	SD			
*First premolar area (area PM1)	56	1.83	1.20	48	1.67	1.02			
*Interproximal region between first and second premolar (area PM1   PM2)	62	1.80	1.17	51	1.52	1.07			
*Second premolar (area PM2)	62	1.45	0.96	54	1.47	1.17			
Interproximal region between second premolar and first molar (area PM2   M1)	62	1.23	0.78	56	1.24	0.82			
*First molar area (area M1)	66	1.54	0.89	58	1.45	0.79			
Interproximal region between first and second molar (area M1   M2)	65	1.86	1.11	56	1.70	0.91			
Second molar area (area M2)	67	1.45	0.99	56	1.39	0.84			

H15 and H20 are the regions 15 and 20 mm superior to the cervical line, respectively.

\*Statistically significant in the thicknesses between H15 and H20 groups (p < 0.05).

N = number of specimens; SD = standard deviation.

buccofacial wall of the maxillary sinus emerged as a thick cortical plate (1.7–1.8 mm thick) at the first premolar area (area PM1), thinned in the posterior direction to become thinnest at area PM2 | M1, and then increased in thickness to the area between the first and second molars (area M1 | M2), which was the thickest area in both groups. The wall was thinner in the second molar area (area M2) than in area M1 | M2. The lowest mean thickness of the walls was 1.2 mm in both groups, and the highest mean thicknesses were 1.9 and 1.7 mm in groups H15 and H20, respectively.

In most cases, the buccofacial walls were thicker in males than in females, especially from area PM1 to area PM2 | M1 in group H15 (p < 0.05) (Table 2), and from area PM1 | PM2 to area PM2 in group H20. There were no significant differences among the three age categories in groups H15 and H20 (p > 0.05) or between the right and left sides. Incomplete septa were observed in seven

of the 74 specimens (9.5%), and they were present in area M1 | M2 in six (86%) of these cases (Table 3).

#### DISCUSSION

The maxillary sinus has a pyramidal shape and its buccofacial wall is often chosen as an access site for the window opening procedure in sinus augmentation.<sup>4,6</sup> The buccofacial wall is a very thin bony plate that is easily penetrated by rotating or sharp instruments during the surgical procedure.

An ideal osteotomy involves virtually the complete buccofacial wall of the maxilla. Intact mucoperiosteum of the sinus wall is important in sinus augmentation procedure and extra precautions are required on thick buccofacial wall. From our results, in most areas, the buccofacial wall was slightly thicker in group H15 (0.06– 0.28 mm) than in group H20, but has the same thickness in areas PM2 and PM2 | M1 (see Figure 1). These

TABLE 2 Comparison of the Thickness of the Buccofacial Wall between Males and Females (in Millimeters)									
	Group H15			Group H20					
Region	Males	Females	р	Males	Females	р			
First premolar area (area PM1)	2.13	1.51	0.049	1.83	1.16	0.262			
Interproximal region between first and second premolar (area PM1   PM2)	2.12	1.43	0.019	1.78	1.03	0.040			
Second premolar (area PM2)	1.80	1.10	0.003	1.40	1.04	0.015			
Interproximal region between second premolar and first molar (area PM2   M1)	1.45	1.00	0.020	1.37	1.54	0.105			
First molar area (area M1)	1.63	1.45	0.408	1.52	1.89	0.422			
Interproximal region between first and second molar (area M1   M2)	1.82	1.90	0.768	1.23	1.57	0.126			
Second molar area (area M2)	1.52	1.38	0.555	1.61	1.49	0.139			

H15 and H20 are the regions 15 and 20 mm superior to the cervical line, respectively.

N = number of specimens; SD = standard deviation.

# TABLE 3 Comparison of Mean Thickness of the Buccofacial Wall among the Three Age Categories (in Millimeters)

	Group H15				Group H20				
	30–59	60–79	80–99		30–59	60–79	80–99		
Region	years	years	years	р	years	years	years	р	
First premolar area (area PM1)	1.64	2.02	1.36	0.303	1.43	1.81	1.62	0.402	
Interproximal region between first and second premolar	1.74	1.94	1.31	0.385	1.55	1.52	1.36	0.826	
(area PM1   PM2)									
Second premolar (area PM2)	1.29	1.63	0.94	0.134	1.53	1.52	0.94	0.373	
Interproximal region between second premolar and first molar	1.32	1.27	0.90	0.423	1.24	1.34	0.56	0.049	
(area PM2   M1)									
First molar area (area M1)	1.71	1.54	1.15	0.321	1.60	1.47	0.76	0.042	
Interproximal region between first and second molar	1.81	1.88	1.90	0.969	1.41	1.76	1.42	0.562	
(area M1   M2)									
Second molar area (area M2)	1.48	1.48	1.28	0.866	1.56	1.38	1.38	0.993	

H15 and H20 are the regions 15 and 20 mm superior to the cervical line, respectively.

N = number of specimens; P = probability; SD = standard deviation.

measurements indicate that a mucoperiosteal perforation can occur in most areas when making the hinge (superior margin of the window) during the window opening procedure if the superior marginal osteotomy of the window is made deeper than the inferior margin.

Neiva and colleagues reported that the thickness of the buccofacial wall varied widely, from 0.5 to 2.0 mm. We similarly found that the thickness of the wall varied significantly among individuals around the mean values (see Figure 1), indicating that careful consideration of individual cases is needed.<sup>5</sup> We also showed statistically significant variations between specific regions, as described previously. It has been described that the wall is thinnest above the M1 area.<sup>4</sup> However, we found that the thinnest area in both groups H15 and H20 was area PM2 | M1, with a mean thickness of 1.2 mm, whereas the wall was thickest in areas PM1, PM1 | PM2, and M1 | M2 in both groups. Neighboring structures such as the zygomatic buttress, the canine eminence, and the maxillary tuberosity might influence topographic differences in the thicknesses in the vertical and horizontal directions, and hence, these anatomical sites - which can be easily detected - deserve special attention during surgery.

There were no significant differences between the left and right side, but the wall was thicker in males than in females. There appeared to be similar patterns in the maxillary sinus wall and the bone thickness. However, further investigations of the relationship between the maxillary wall and general bone thickness are needed. McGowan and colleagues described that resorption of the alveolar process with continued sinus pneumatization in an older edentulous maxilla can result in only a thin layer of cortical bone.<sup>4</sup> However, the thickness did not vary with age in groups H15 and H20 regardless of the presence of teeth in the present study (p > 0.05), and hence, there was no evidence that older patients have a thinner buccofacial wall of the maxillary sinus, or that pneumatization makes the wall thinner.

It is important to consider the anatomy of the maxillary sinus septa during sinus augmentation. Krennmair and colleagues observed 17 sinus septa in 61 patients (27.8%), and concluded that most septa within the maxillary sinus appear in the premolar region in the case of atrophy-related resorption of the alveolar process.<sup>7</sup> However, we observed seven cases (9.5%) with incomplete septa in our 74 Korean specimens, with six of them located in the M2 area. However, the presence of septa in this region would not be problematic since it is not generally chosen for window opening. Nevertheless, the presence of septa needs to be confirmed in surgical procedures involving the area posterior to the M1.

In conclusion, the data obtained in the present study should be considered when performing the window opening procedure prior to sinus augmentation in Korean population. It is possible to estimate the thickness of the buccofacial wall of the maxillary sinus to minimize the occurrence of a mucoperiosteal perforation during an osteotomy.

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# CONFLICTS OF INTEREST STATEMENT

The authors have declared no conflicts of interest. [Correction added after online publication 23 October 2009: Conflicts of Interest Statement added.]

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