

Evaluation of the Thickness of Lateral Wall of Maxillary Sinus According to Gender, Age and Ethnicity using Cone Beam Computed Tomography in a Tertiary Care Center of Nepal- an Analytical Cross-sectional Study

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ABSTRACT

Background

There is lack of studies in Nepalese population evaluating the lateral wall thickness of maxillary sinus. The lateral wall thickness of maxillary sinus is one of the crucial parameters for implant placement specially in the aged population for posterior maxilla.

Objective

To measure the lateral wall thickness of maxillary sinus and look for potential variations as per age, gender, and ethnicity in a tertiary care center of Nepal.

Method

A cross-sectional analytical study was conducted on 110 patients (57 males and 53 females) over a period of eight months (September 2024 to April 2025) who fulfilled the inclusion criteria using cone beam computed tomographic images. The sinus wall thickness was measured at 3 mm, 6 mm and 9 mm from the base of maxillary sinus in four different teeth i.e., maxillary right first molar, maxillary right second premolar, maxillary left first molar, and maxillary left second premolar which are generally near maxillary sinus. The calculated values were analyzed for variation among different age groups, gender, and ethnic groups as per the Health Management Information System of Nepal using the Mann Whitney U test and Kruskal Wallis test.

Result

The overall mean sinus lateral wall thickness (LWT) was found to be 1.52 ± 0.76 mm which was found to be greater in molar region (1.72 ± 0.82 mm) when compared with premolar region (1.32 ± 0.64 mm). The relation between the lateral wall thickness of maxillary sinus and age, gender and ethnicity were not statistically significant except for maxillary left premolar which was found to be increased with increasing age and in females.

Conclusion

Within the limitations of this study, the pattern of lateral wall thickness of maxillary sinus seems to be favorable for direct sinus lift in Nepalese population provided that other factors affecting the sinus lift procedure are well evaluated.

KEY WORDS

Dental implant, Edentulism, Lateral wall thickness, Maxillary sinus, Nepal

INTRODUCTION

The prevalence of edentulism in Nepal is around 8.58% which is similar to our neighboring countries like China 9% and India 16.3%.^{1,2} The most common cause for tooth loss leading to edentulism in our part of world is dental caries and periodontal disease.³ This often challenges for dental implant placement particularly in the posterior maxilla. This is mainly because of reduced sub antral bone height due to post extraction dimensional change and tendency of maxillary sinus pneumatization with age. The two surgical techniques namely direct and indirect sinus lift procedure are the generally the remaining option to be able to place an implant of adequate length in those areas. The preferred technique among the two is the direct sinus lift procedure as it can be employed even in challenging cases where remaining bone height from crest to sinus floor is < 5 mm.⁴ The direct technique involves the entry of maxillary and lifting the sinus membrane (Schneiderian membrane) from the lateral wall of maxillary sinus similar to Caldwell Luc surgery.

Cone beam computed tomography (CBCT) is a three-dimensional dental radiographic technique which is necessary for the evaluation of sinus and related anatomical landmarks prior to implant placement.⁵ As the lateral entry/direct technique is a method of choice one should be aware of the lateral wall thickness measurement and its possible variations as per age, gender, and ethnicity.^{6,7}

The CBCT study for evaluating the lateral wall thickness of maxillary sinus in Nepalese population hasn't been performed previously. Hence, this study was conducted to facilitate clinicians to provide reference regarding the lateral wall thickness of maxillary sinus for implant placement in posterior maxilla.

METHODS

A cross sectional analytical prospective study was planned within a period between September 2024 to April 2025. The study protocol was approved by institutional review committee (IRC) of KUSMS (Kathmandu University School of Medical Sciences). IRC approval number was 309/24. All the three-dimensional radiographs were taken using Dentium rainbow CT as per standard volume protocol:

- Scan time: 17 seconds
- Peak voltage: 80 kVp
- Tube current: 7 mA
- Voxel size: 300µm
- Patient position: Standing, incisors held on the bite fork

Inclusion criteria

- Nepalese nationals who are registered in the health insurance scheme of Nepal government.
- CBCT scan of both dentulous and edentulous maxilla with

at least 1 molar and 1 premolar near maxillary sinus

- Age ≥ 20 years

Exclusion criteria

- Presence of sinus pathology
- Unclear or incomplete scan images
- Previous sinus lift surgery or Caldwell Luc procedures

CBCT views were analyzed using rainbow™ Image Viewer (Dentium Korea) software. The measurement of the thickness of lateral wall was taken in three different points in every 3mm distance from the base of maxillary sinus.⁸ A pilot study was conducted prior to the commencement of the study where three examiners (SL, SA and AHR) measured the thickness of four teeth in three different area as mentioned above in 20 samples at a gap of 2 weeks period. The intra-class correlation coefficient (ICC) was calculated to assess intraobserver reliability. The measurement values in the second recording were compared among the observers to calculate interobserver reliability. The ICC values were greater than 0.90 for all the measured parameters indicating the excellent agreement.

Four teeth namely maxillary right 1st molar, maxillary right 2nd premolar, maxillary left 1st molar and maxillary left 2nd premolar were taken into considerations in this current study from a total of 110 patients. In each tooth, lateral wall thickness of maxillary sinus were measured linearly in millimeter (mm) units in three points at 3 mm, 6 mm and 9 mm from the floor of maxillary sinus (Fig. 1 and 2) in a transaxial section. So, a total of 440 teeth were evaluated at 3 different points in this radiographic study.

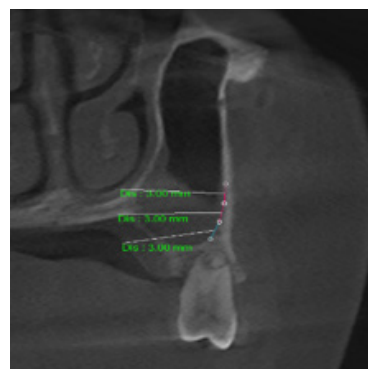


Figure 1. Measuring the lateral wall of maxillary sinus exactly at each 3 mm.

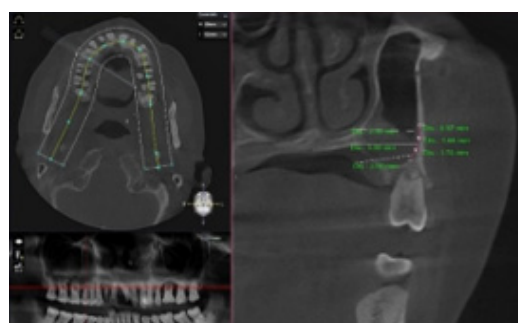


Figure 2. Measurement of thickness lateral wall of maxillary sinus of right maxillary premolar using rainbow™ viewer.

Data were entered in a Microsoft excel software in a password protected folder within a computer of Department of Oral Medicine and Radiology, KUSMS. Data analysis was done using Statistical Package for Social Sciences (SPSS) version 21 (IBM, Chicago, USA). Tests of normality was performed which showed the data were skewed. The statistical difference was set at p value < 0.05 . Mann Whitney test was employed to see the relation of sinus wall thickness with gender whereas Kruskal Wallis test was used to compare with age and ethnicity as per Health Management Information System (HMIS) of Nepal government.⁹

RESULTS

A total of 440 teeth and 1,320 points were evaluated from 110 patients for measuring the thickness of lateral wall of maxillary sinus in a linear direction. Among the subjects, male sample were 51.8% and female were 48.2%. Regarding the distribution of ethnic group, Janajati patients were the highest (25.5%) whereas Muslim patients were the least (2.7%). Frequency distribution of the patients is shown in figure 3.

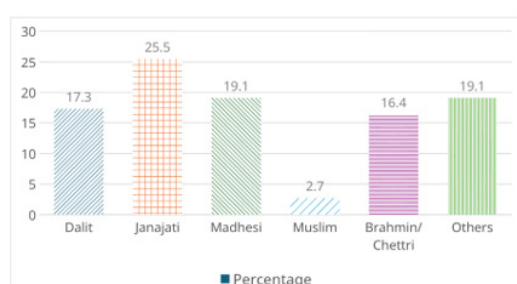


Figure 3. Percentage distribution of Ethnic group in current study

The mean overall lateral wall thickness of maxillary sinus in this study was found to be (1.52 ± 0.76) mm with a greatest dimension found at left maxillary molar area (1.77 ± 0.93) mm and least in the right maxillary premolar area (1.31 ± 0.64) mm (Table 1).

Table 1. Descriptive statistics for thickness of lateral wall as per different location

Teeth involved	n	%	Mean	Standard deviation	Minimum	Maximum
Overall thickness	440		1.52	0.76	0.39	7.23
Molar	220		1.72	0.82	0.47	7.23
Premolar	220		1.32	0.39	0.39	5.52
Maxillary Right 2 nd Premolar (15)	110		1.67	0.71	0.47	3.93
Maxillary Right 1 st Molar (16)	110		1.31	0.60	0.39	4.18
Maxillary Left 2 nd Premolar (25)	110		1.32	0.67	0.47	5.52
Maxillary Left 1 st Molar (26)	110		1.77	0.93	0.60	7.23

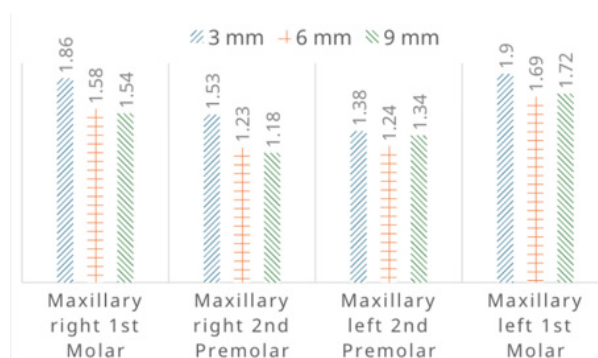


Figure 4. Mean lateral wall thickness on different points

The mean lateral thickness while going farther from base of sinus didn't seem to be present in this study. Test for normality was done for all the data which showed significant differences for all the dependent variables. Hence, non-parametric test was used for data analysis ($p < 0.05$).

Table 2. Comparison of lateral wall thickness based on gender

Tooth number	Gender	n	Median	Interquartile range (IQR)	p-value*
16	Male	57	1.51	1.19-2.32	0.475
	Female	53	1.5	1.10-1.97	
15	Male	57	1.18	0.98-1.54	0.841
	Female	53	1.22	0.89-1.50	
25	Male	57	1.34	1.11-1.51	< 0.001
	Female	53	1.63	1.42-1.79	
26	Male	57	1.46	1.15-1.68	0.299
	Female	53	1.51	1.22-1.72	

*Mann Whitney U Test, $p < 0.05$: statistically significant

The values were statistically insignificant for 16, 15 and 26 whereas with the gender whereas there was an increase in lateral wall thickness of maxillary sinus of upper left second premolar in females compared with males which was found to be statistically significant ($p < 0.05$).

The values were statistically insignificant for 16, 15 and 26 whereas with the increase in age there was an increase in lateral wall thickness of maxillary sinus of upper left second premolar which was found to be statistically significant ($p < 0.05$).

The values were statistically insignificant for all measured teeth with ethnic group as per Health Management Information System of Nepal government.

DISCUSSIONS

Most of the clinicians in the world are left out with limited options regarding the oral rehabilitation with dental implants in posterior maxilla. Clinicians in many instances must choose for more invasive treatment procedures such as zygomatic implants for compensating for availability of minimum bone height for placement of dental implants.¹⁰

Table 3. Comparison of lateral wall thickness based on age group

Tooth number	Age group	n	Median	Interquartile range (IQR)	p-value*
16	20-29	53	1.65	1.24-2.17	0.448
	30-39	36	1.35	1.16-1.91	
	40-49	14	1.54	1.15-2.6	
	50-59	7	1.05	0.95-1.58	
15	20-29	53	1.14	0.86-1.44	0.798
	30-39	36	1.24	0.91-1.55	
	40-49	14	1.39	1.11-1.91	
	50-59	7	1.33	0.80-1.46	
25	20-29	53	1.32	1.07-1.51	<0.001
	30-39	36	1.57	1.44-1.75	
	40-49	14	2.05	1.89-2.28	
	50-59	7	2.15	1.91-2.51	
26	20-29	53	1.43	1.09-1.68	0.131
	30-39	36	1.42	1.26-1.67	
	40-49	14	1.73	1.51-2.04	
	50-59	7	1.54	1.21-2.01	

*Kruskal Wallis Test, $p < 0.05$: statistically significant

Maxillary sinus being the largest paranasal sinus is located just beneath the orbit and in lateral direction to nose in the maxillary bone (cheek area). Two types of resorptions are seen whenever an individual loses his/her teeth in the maxillary posterior area, one being the bone resorption along with extraction of teeth and second is due to sinus pneumatization with age.¹¹ The remaining residual ridge height plays a significant role in decision making process for choosing the direct and indirect approach for sinus lift procedure. Residual height < 4 mm is managed with direct sinus lift procedure whereas in > 4 mm cases, indirect sinus lift technique can be used.⁴ Ridge height 2 mm or less is considered as unfavorable and most challenging case scenarios.¹²

There are different factors to consider for the placement of implant with direct sinus lift procedures like lateral wall thickness, LFM angle- an angle formed between the medial and lateral wall of sinus, residual bone height, presence of sinus septa, presence of alveolar antral artery, etc.^{13,14} The lateral wall thickness is considered as the foremost thing to consider in direct sinus lift surgery is first it is the main doorway for sinus entrance and its thickness is related to the major complication i.e. sinus membrane perforation. There was a greater chance of membrane perforation 38.3% when the lateral wall thickness was ≥ 1.5 mm whereas only 14% chances of membrane perforation was reported when lateral wall thickness was < 1.5 mm in a retrospective study done by Pizzini et al.¹³ The incidence of sinus membrane perforation associated with lateral wall thickness was also evaluated in another study through a multilevel regression analysis. The perforation rate was 56.4% when the lateral wall thickness at 4 mm coronal to the sinus floor was ≥ 2 mm and 12.1% when it was ≤ 1 mm.

Table 4. Comparison of lateral wall thickness based on ethnic group

Tooth number	Ethnicity	n	Median	Interquartile range (IQR)	p-value*
16	Dalit	19	1.41	1.16-1.96	0.05
	Janajati	28	1.71	1.3-2.20	
	Madhesi	21	1.70	1.2-2.20	
	Muslim	3	1.93	0.84-3.14	
15	Brahmin/Chhetri	18	1.64	1.13-2.20	0.345
	Others	21	1.10	0.79-1.42	
	Dalit	19	1.29	0.67-1.46	
	Janajati	28	1.39	1.03-1.99	
25	Madhesi	21	1.12	0.82-1.40	0.166
	Muslim	3	1.02	0.81-1.06	
	Brahmin/Chhetri	18	1.22	0.93-1.50	
	Others	21	1.13	1.01-1.60	
26	Dalit	19	1.16	0.89-1.60	0.274
	Janajati	28	1.40	1.15-1.85	
	Madhesi	21	1.23	0.83-1.44	
	Muslim	3	0.76	0.60-1.49	
26	Brahmin/Chhetri	18	1.27	0.89-1.55	0.274
	Others	21	1.07	0.84-1.35	
	Dalit	19	1.91	1.35-2.14	
	Janajati	28	1.90	1.33-2.48	
26	Madhesi	21	1.47	1.11-2.30	0.274
	Muslim	3	1.27	0.99-3.41	
	Brahmin/Chhetri	18	1.62	1.32-1.98	
	Others	21	1.31	0.89-1.73	

*Kruskal Wallis Test, $p < 0.05$: statistically significant

A comparable variation in perforation rate was noted for the wall thickness assessed at 6 mm coronal to the sinus floor (57.9% versus 13.4%). The authors concluded that the thickness of the maxillary sinus lateral wall was associated with the incidence of membrane perforation.

Overall, the lateral wall thickness of maxillary sinus plays an important role in guiding the clinicians for sinus lift procedure more importantly to prejudge for the possible complications during the sinus lift surgery in posterior maxilla. Different scientific literatures are available worldwide but to our best knowledge, there is a lack of studies regarding the current topic in Nepalese population.

Many studies have shown that human anatomy changes with age, gender, and race.^{15,16} So far, many studies have been done to measure the variation in lateral wall thickness according to age, gender, and location. However, though race has been highlighted to influence the lateral wall thickness literature related to race is none or limited.⁷

In our current study, the mean thickness was measured at 3 mm, 6 mm and 9 mm since < 2 mm residual height

is considered unfavorable and risky for sinus lifting and implant placement. The recent data shows the shorter implants (≤ 6 mm) are equally competitive to standard/longer length implants (≥ 10 mm) in terms of implant survival.¹⁷ Thus, measuring till 9 mm can be considered enough for measuring the lateral wall thickness and has been previously studied as well.⁸ The measurement previously taken in different studies are from 3 mm to 15 mm from the base of maxillary sinus floor.⁵⁻⁷ The mean thickness of lateral wall of maxillary sinus in the current study was 1.52 ± 0.76 mm which was similar to the results found in a retrospective study done in 2021 which was 1.59 ± 0.84 at 4 mm coronal to sinus floor and 1.58 ± 0.83 at 6 mm.¹⁸ The other studies done in different countries throughout the world yielded a similar mean thickness of 1.71 mm in Saudi Arabia, 1.79 mm in Iran, 1.85 mm in United States of America and 1.64 mm in Spain.^{7,8,19,20} There were somewhat different finding of mean thickness of 2.29 mm and 2.35 mm in a study conducted in Turkey and India.^{21,22} The mean lateral wall thickness seems to be favoring the direct sinus lifting procedures in Nepalese population as the membrane perforations chances are less.

There are conflicting results in different studies related to lateral wall thickness and age. Monje et al. stated that though it was hypothesized that the sinus pneumatization is related with the decreased thickness with increasing age, this is not true as the pneumatization doesn't occur in lateral direction.⁷ The authors claimed that there is an increase in lateral wall thickness with increasing age.^{7,8,23} The maxillary left 2nd premolar was only found to be affected by age in our present study. Other areas apart from the mentioned teeth were relatively unaffected which is in accordance with the study conducted in India by Giri et al.⁵

Regarding the gender, some studies claimed that the lateral wall thickness is greater in males compared to females where other found the opposite way.^{19,20} One of the studies found that gender and lateral wall thickness were completely unrelated.⁵ Our study findings also suggest that gender doesn't seem to affect lateral wall thickness. The only area where a statistically significant data appeared was for the maxillary left 2nd premolar.

The association of lateral wall thickness and race was highlighted by few studies but was never adjudged.^{6,7} In this study, we found no significant differences between the lateral wall thickness of maxillary sinus and ethnic groups. Further studies are required on this regard.

There are certain limitations in this study owing to a relatively small sample size, samples from ethnic group four were limited and a small range of error than can occur with cone beam computed tomography.²⁴ So, a multicenter study in large population in different provinces of Nepal would be required in future to further authenticate the current findings.

CONCLUSION

Pre-operative CBCT analysis is recommended for implant planning in maxillary posterior region. Within the limitations of this study, the pattern of lateral wall thickness of maxillary sinus seems to be favorable for direct sinus lift in Nepalese population provided that other factors affecting the sinus lift procedure are well evaluated.

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