Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 4, 2021, Pages. 5041 - 5049
Received 05 March 2021; Accepted 01 April 2021.

A Systematic Study On The Lateral Wall Thickness Of The Maxillary Sinuses

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Abstract:
Background: The maxillary sinus is one the most Important anatomical structure in the head and neck region. Some surgical procedures are complicated and require separate surgical access to the sinus. Since the internal anatomical structures vary, understanding of them has become mandatory.
Aim of this systematic review is to compare and analyse so far (until February 2021) published articles on maxillary sinus lateral wall thickness and to identify similarities and differences in their research results.
Materials & methods: Based on the principles of PRISMA and CRD statements, a computerized systematic search of literature was carried out in Medline (via PubMed), Cochrane, ISI Web of Information, Embase, Scopus and a limited gray literature search was conducted with the help of Google. The search of published articles extended until February 2021.
Results: The search in the electronic databases yielded 142 articles. It detected conflicting data between the databases and eliminated duplicates, after which 102 papers were screened. A total of 63 irrelevant articles were omitted, leaving 34 articles for full-article review. The application of the inclusion and exclusion criteria was specified by eleven relevant publications that were included in the qualitative analysis.
Conclusion: Based on the current review it can be concluded that dentists should thoroughly evaluate the lateral wall thickness before performing surgeries related to maxillary sinuses.
Keywords: CBCT, Implants, Maxillary sinus, Lateral wall.

Introduction

The maxillary sinus is an anatomical structure that is significant in both medicine and dentistry (otorhinolaryngology). The Caldwell-Luc approach, as well as other forms of maxillary sinus procedures performed by oral and maxillofacial surgeons, is used to extract retained roots, small cysts, or tumors in dentistry.[1] Some surgical procedures are complicated and require separate surgical access to the sinus, such as reducing and repairing a Le Fort or Zygomatic complex bone fracture or sinus floor augmentation to support implant placement. The advent of dental implants has dramatically changed the post extraction course of care in dentistry.[2,3]

It has become a common approach to dentition restoration in patients with partial or complete tooth loss and now it has been widely acknowledged as the most effective method of replacing missing teeth over a long period. Since the maxillary sinus is situated in the posterior part of the arch, implant placement in the posterior maxilla can be difficult. The inadequate height and width of the alveolar bone ridge renders dental implant therapy of the posterior maxilla difficult.[4,5] The presence of a low-lying maxillary sinus, combined with lower alveolar bone height due to natural bone resorption after dental extraction, can reduce the amount of vertical bone available for implant placement. The amount of bone resorption and the degree of maxillary sinus pneumatization differs from person to person. To address this issue, dentists have resorted to either placing short implants or performing maxillary sinus augmentation with bone grafting (sinus lift) to increase the amount of bone available to help implant placement.[1,6]

The lateral window approach and the crystal approach are two surgical approaches used to augment the maxillary sinuses. Both strategies have yielded satisfactory results; however, the lateral window method is still thought to be more predictable in terms of outcome and protection, especially in cases with low bone height. Furthermore, the thickness of the lateral sinus wall must be precisely determined, and a lateral wall osteotomy must be performed to open a window to the maxillary sinus.[3,7]

Dentists must have a detailed understanding of the buccofacial wall of the maxillary sinus to conduct lateral sinus window osteotomy, an anatomical location that is seldom covered in detail in dental schools. Because

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of the fragility of the structures and anatomical variations associated with the sinus, maxillary sinus floor elevation through lateral window is a difficult procedure. The most common intraoperative complication during a sinus elevation procedure is perforation of the Schneiderian membrane. The risk of membrane perforation is increased when the lateral wall is thin or thick. The thickness of the lateral wall should be assessed prior to surgical care because it may affect the sinus membrane's integrity during the operation. The use of CBCT imaging has helped clinicians to accurately assess soft and hard tissues, as well as to remove distortion and superposition associated with teeth and their surrounding structures. Periodontal disease, for example, may affect lateral wall thickness due to a variety of local or systemic causes.[2,5]
Aim of this systematic review is to compare and analyse so far (until February 2021) published articles on maxillary sinus lateral wall thickness and to identify similarities and differences in their research results.

Materials and Methods
Based on the principles of Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) and CRD (Centre for Reviews and Dissemination, University of York) statements, the current review was conducted.

Search strategies
In the following electronic databases, a computerized systematic search of literature was carried out: Medline (via PubMed), Cochrane, ISI Web of Information, Embase, Scopus and a limited gray literature search was conducted with the help of Google. By using words such as maxillary sinus thickness, maxillary sinus wall thickness, maxillary sinus lateral wall thickness or thickness of maxillary sinus and only articles published in English language were included in the search. The search of published articles extended until February 2021 that answered the oriented research question using with both medical subject headings (MeSH) and free text words. The reference lists of articles were scanned and relevant references were searched.

Inclusion criteria
Research that involved prospective and retrospective original studies on human subjects, original case reports with analysis, studies that had detailed explanations of the methods and original case reports of implants and surgical care were included in only publications published in the English language.

Exclusion criteria
Radiographic studies performed for suspected sinus pathology or syndromes, abstracts, discussions, post-mortem findings, used mixed samples (living and cadaveric specimens) and incomplete presentation-related case studies were exclusion criteria. The investigator independently collected data from the selected papers that addressed the clinical research questions.

Data extraction
The name of the author, year of publication, origin of the population studied, and findings were among the pertinent data extracted from each of the selected studies. The Newcastle-Ottawa Scale (NOS) was used to measure the quality of the reviewed papers, and the quality of the selected articles was independently assessed.

Results
The methodology used for the article selection has been shown in PRISMA flow diagram (**Figure 1**). The search in the electronic databases yielded 142 articles. It detected conflicting data between the databases and eliminated duplicates, after which 102 papers were screened. A total of 63 irrelevant articles were omitted, leaving 34 articles for full-article review. The application of the inclusion and exclusion criteria was specified by eleven relevant publications that were included in the qualitative analysis (**Table:1**).

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Figure 1: Prisma Flow Chart

Figure: 1PRISMA flow Chart

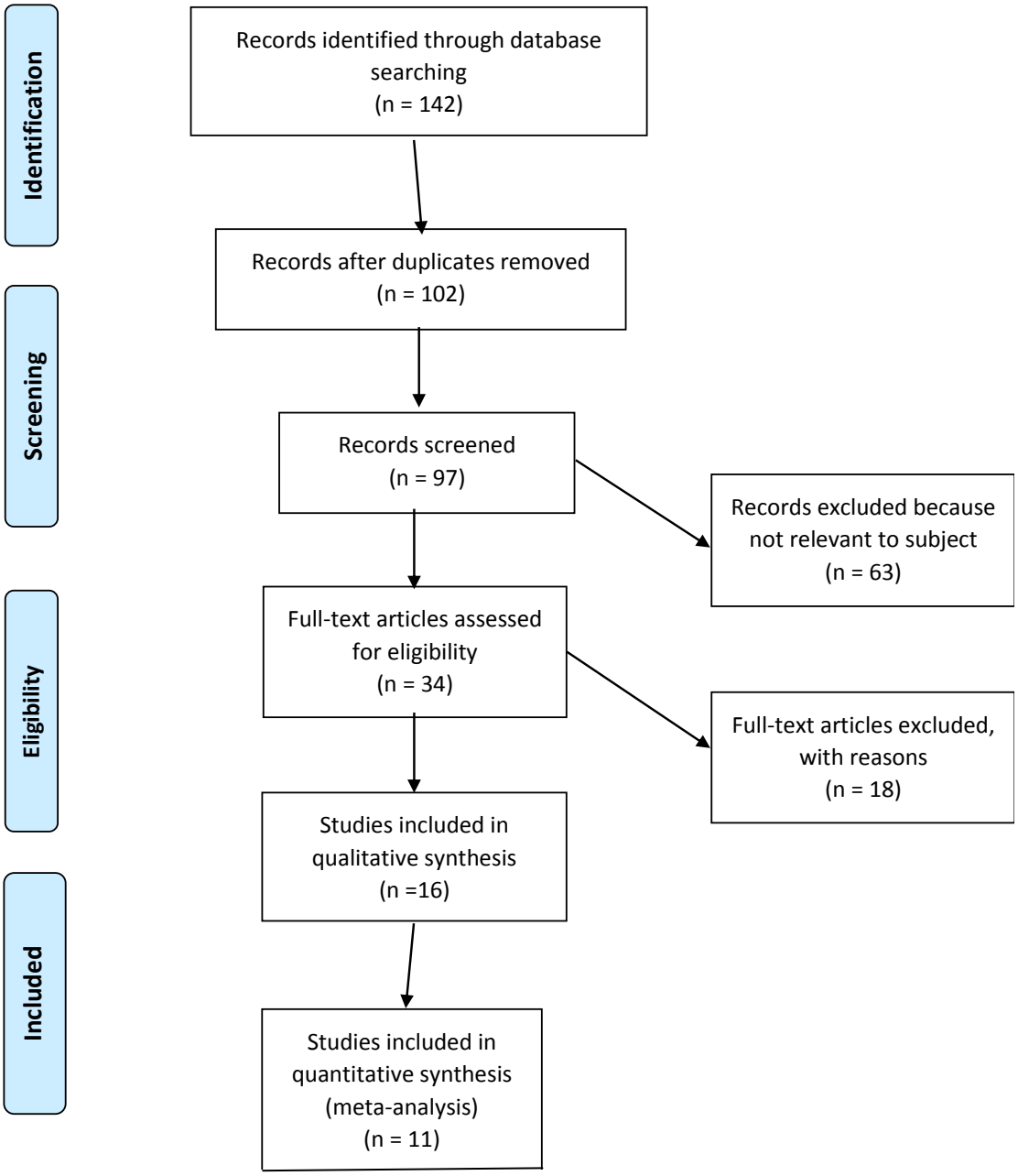

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Table: 1 Authors finding about Maxillary Sinus LWT

	Author	Country	Year	Max Sin Lat Wall mean thickness(mm)				Findings	Journal's details
				Positions					
				1	2	3	4		
1	Yang SM et al.,	South Korea	2012	1·69mm	1·50 mm	1·77mm	1·89mm	--The thickness of the lateral wall of the maxillary sinus tended to increase from the P2 to M2. --The mean thickness of the lateral wall of the sinuses differed significantly at the R2 and R3 reference points --The thickness differed significantly between M1 and P2, M2 and P2 and M1 and M2 --At the premolars thickness differed significantly by sex --At molar region there was no significant thickness difference -The presence or absence of periodontitis did not have any effects on the thickness of the lateral wall of the maxillary sinus	J Oral Rehabil 39(6):421-8.
2	Li J et al.,	China	2013	P_2	M_1		M_2	--The thickness of maxillary sinus lateral wall on the left side were significantly different from that on the right side at P2 -- Significant gender differences on the thickness of maxillary sinus lateral wall were demonstrated at P2 and M2 -- The thickness in men were thicker than that in women -- The thickness of maxillary sinus lateral wall at M1 and M2 were significantly different among different age groups -- There was no significant difference on the lateral wall thickness with respect to presence or absence of tooth	Shanghai Kou Qiang Yi Xue. 22(5):537-41
				2.23mm	2.19mm		1.41mm		
3	Khajehahmadi S et al.,	Iran	2014	Edentulous			Dentulous	--The mean of the wall thickness in each of these points was lower in patients with edentulous spaces --There was no association between gender and the thickness of the lateral wall of the maxillary sinus	Iran J Radiol 11(1):e6675
				P_2	M_1	M_2	P_2 M_1 M_2		
				1.47mm	2.87mm	0.85mm	1.56 mm 3.0 mm 1.8 mm		
4	Monje A et al.,	USA	2014	Partial edentulous maxilla (PEM)			Complete edentulous maxilla (EM)	--The maxillary sinus lateral wall tends to increase in thickness from the second premolar to the second molar --Significant difference in mean LWT between sexes only in the premolar region -- Lateral pneumatisation does not increase with age -- less RH, the thinner the lateral maxillary sinus wall -- the longer the	J.Periodontol 85(5):676-82
				P_2	M_1	M_2	P_2 M_1 M_2		
				1.94mm	1.93mm	1.27mm	1.61 mm 1.77 mm 1.35 mm		

										edentulous span, the thinner the lateral wall	
5	Danesh Sani S,et al.,	USA	2017	P1	P2		M1	M2		--the mean thickness of the lateral wall was higher in patients with teeth in all the measured areas; however the difference between the dentate and edentulous cases was not statistically significant -- a significant difference in the mean lateral wall thickness between males and females at the P1, P2, and M2 locations --thicker lateral wall in men in comparison to women --the thickness did not vary with age	Clin Implant Dent Relat Res 19(1):151-60
				2.16mm	2.02mm		1.98mm	1.21mm			
6	Kiakojori A, et al.,	Iran	2017	PM1	Edentulous					-- no relationship between gender and age with the sinus lateral wall thickness -- The maximum thickness was found in the first molar and the minimum values were in the second premolar and the second molar -- RH showed a significant relationship with LWT so that the higher the RH, the greater the LWT	Electron Physician 9(12):5948-53
					Partial		1.43mm				
					complete		0.96mm				
				PM2	Partial		1.24mm				
					Complete		0.82mm				
				M1	Partial		1.43mm				
					Complete		1.20mm				
				M2	Partial		1.16mm				
					complete		0.82mm				
7	Lim EL et al.,	Malaysia	2017		H10	H20	H30	H40		-- The mean thickness of the buccofacial maxillary sinus wall at every point of measurement in our patients was found to be more than 2.0 mm. --This is higher than the values that have been reported for Caucasians and Koreans. -- The buccofacial wall gradually became thinner from the region of the second premolar towards the region of the second molar	Braz. Oral Res 31:e97
				Malay	7.13mm	5.3mm	3.4mm	3.02mm			
				Chinese	7.52mm	5.7mm	3.1mm	2.61mm			
				Indian	6.66mm	4.8mm	3.4mm	3.60mm			
8	TaloYildirim T et al.,	Turkey	2019	From sinus floor		Male	Female			-- there was a statistical difference at 3 and 13 mm between age groups -- no significant differences between gender for lateral wall thickness -- PBL is an important factor for lateral wall thickness.	Med PrincPract 28:109-14
				3mm		2.30mm	2.27mm				
				13mm		4.36mm	4.55				
				15mm		2.96mm	2.91mm				
9	AsiehMozaffari ,et al.,	Iran	2019	LWT		Male	Female			-- There is a significant relationship between age and LWT of the maxillary sinuses -- The thickness of the lateral wall significantly decreased as the age increased -- No significant difference was observed in the LWT of the maxillary sinus in terms of gender --The mean thickness of lateral sinus wall is significantly smaller in patients with complete edentulism compared to partially edentulous patients	Dental Hypotheses 10 (4) : 91-96
				Right		1.59mm	1.65mm				
				Left		1.60mm	1.64mm				

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10	Shun-Jen Yu	Taiwan	2019	LWT 2.08±0.94 mm		--- no significant difference between the tooth position and lateral wall thickness --- the lateral wall thickness increased from the premolar to molar region at 3-mm coronal to the sinus floor	J Periodontal Implant Sci. 2019;49(4): 237-247
11	NazanKocakTopbas	Turkey	2021	LWT at 3mm 1.72mm	LWT at 5mm 1.64mm	-- LWT-5-mm averages were significantly different in favor of male partially edentulous patients --- the measurements were compared by age, not statistically different	MeandrosMed Dent J 2021;22 (Suppl):50-61.

---LWT=Lateral Wall Thickness
---mm= millimeter

Discussion

The maxillary sinus lateral wall has been identified as a thin bone plate that can be easily penetrated by any rotating or sharp instrument. Schneiderian membrane, which normally measures around 1 mm in thickness, is critical for keeping the implanted bone graft contained and it should be kept intact for the success of grafts and implants.[3]According to reports, Schneiderian membrane perforation is one of the most common complications in sinus augmentation and Schneiderian membrane's integrity tends to be influenced by the thickness of the lateral maxillary sinus wall.[4,7] Anatomical variations related to the maxillary sinus, on the other hand, have been found to increase the risk of Schneiderian membrane perforation. Surgery becomes more complex and time-consuming as the thickness of the lateral sinus wall increases. Examining the thickness of the lateral sinus wall before surgery will help the surgeon choose the best places to avoid surgical complications including membrane perforation. As a result, dentists must do detailed preoperative 3D radiographic assessment for understanding of the anatomy of the maxillary sinus walls to perform sinus bone augmentation effectively.[2,3]

In a few studies, thickness of the buccofacial wall of the maxillary sinus has only been done by using skulls or cadavers such as Neiva et al., who did so using white people's skulls, reported that the mean thickness of the lateral wall of the maxillary sinus was 0.91 ± 0.43 mm and Yang et al., who did so using Korean hemiface cadavers, reported that the mean thickness of the lateral wall of the maxillary sinus was from 1.23 mm to 1.86 mm at different points.[8,9] The mean LWT in females is substantially lower than the corresponding value in males, according to Neiva et al. Arman et al., measured the thickness of the anterior wall of the maxillary sinus in 30 dry skulls and found little difference between the right and left sides in terms of wall thickness.[10] Since availability of 3D digital radiographs in this systetamatic review these kinds of studies were excluded.

Based online database search only eleven studies were identified that are specifically related to the LWT. On basis of analysis it has been noted that these studies are not showing uniformity in their results and varying on identified thickness of LW according to the age, gender, locations and relationship with the status of the dentition.

LWT thickness

The thickness LW in dentulous patients found in the P_2 region by Khajehahmadi S et al., was 1.57mm, DaneshSani S et al., 2.02mm and Li J et al.,2.23mm.[11,12,13] The study conducted by Lim EL et al., in Malaysia showed that LWT was not uniform between Chinese, Malay and Indian people.[14] According to Lim EL et al., the mean thickness of the buccofacial maxillary sinus wall was found to be more than 2.0 mm at any point of measurement in the patients. This is, on average, higher than the values recorded for Caucasians and Koreans. According to Lim EL et al., findings the buccofacial wall of the maxillary sinus becomes thicker anteroposteriorly, except in the region of the second molar, and thinner superior-inferiorly.[14]

Danesh-Sani et al., Li et al., and Monje et al., were recorded that the buccofacial wall gradually becomes thinner from the region of the second premolar towards the region of the second molar.[12,13,15] Tuba TaloYildirim et al., noticed that sinus lateral wall thickness was significantly associated with PBL.[16] In the study of Khajehahmadi et al., the thickest wall was observed in the bone above the first molar and the least thickness was documented in the second molar.[11] The presence of the buttress of the zygoma tends to be responsible for the increased thickness of the lateral wall of the maxillary sinus in the bone above the first molar. According to Yang et al., the mean thickness of the lateral wall of the maxillary sinus was 1.69mm at the first premolar (P1), 1.50 mm at the second premolar (P2), 1.77 mm at the first molar (M1) and 1.89 mm at the second molar (M2).[17] The thickness of the lateral wall of the maxillary sinus tended to increase from the P2 to M2. The thickness differed significantly between M1 and P2, M2 and P2 and M1 and M2. According to Monje, et al. mean LWT for partially edentulous region was 1.71 mm, and for completely edentulous region, 1.57 mm.[15] Danesh-Sani et al**.,** the average thickness of the lateral wall of the maxillary sinus was 1.216 mm at the second molar (M2), 1.986 mm at the first molar (M1), 2.026 mm at the second premolar (P2) and 2.166 mm at the first premolar (P1).[12] The bone above the P1 area has the thickest wall and the least thickness of the lateral wall was documented in the M2 area.
Kang et al., has found that the maxillary sinus LW thicker in the premolar region than the molar.[18] In contradiction to this finding, Shun-Jen Yu et al., mentioned that the average thickness of the lateral wall of the maxillary sinus was 2.08 mm and the lateral wall thickness increased from the premolar to molar region at 3-mm coronal to the sinus floor.[19]

Influence of dentitions status on LWT

Monje et al., showed that the nature of edentulism (either partial or complete) having impact on the lateral wall thickness and with increasing the length of the edentulous span, the lateral wall becomes thinner.[15] Li et al., their study couldn't notice any effect of edentulism on the thickness of the lateral wall.[13] Danesh-Sani et al., and TubaTaloYildirim et al., found that significant difference between the left and right sides of the maxillary sinus.[12,16] But on the other hand Yang et al., found no significant difference between the left and right sides and noticed a higher LW thickness in completely edentulous patients than partially edentulous patients.[17] AsiehMozaffari et al., the average thickness of lateral sinus wall is significantly less in patients with complete edentulism than partially edentulous patients.[20] Khajehahmadi et al., reported that there is no significant difference between dentate and edentulous cases, but a trend of thicker lateral wall for dentate patients.[11] According to Danesh-Sani et al.,neither edentulous nor non-edentulous influencing the lateral wall thickness.[12] Shun-Jen Yu et al., concluded that there was no significant difference between the dentition status and lateral wall thickness.[19]

Influences of age

Li et al., &Monje et al., reported that maxillary sinus wall thickness was indirectly proportional to patient age.[13,15] According to Tuba TaloYildirim et al., there is a connection between lateral wall thickness at 3 and 13 mm and age.[16] At a vertical level measurement of 13 mm from the sinus floor, Kang et al. discovered an important association between age and lateral wall thickness.[18] Yang et al., suggested that lateral wall thickness did not vary with age.[17] AsiehMozaffari et al., found that there is a significant relationship between age and LWT of the maxillary sinuses and mentioned that LWT decreases as the age increases.[20] TubaTaloYildirim et al., there was a significant association between lateral wall thickness at 3 and 13 mm and age.[16]
On contradiction to above mentioned findings Danesh-Sani et al., Lim EL et al.,Yang et al.,NazanKocakTopbas et al., and Kiakojori et al.,found that the age of the patients was not influencing the thickness of the lateral wall and there was no significant differences in the mean thickness of the lateral wall with respect to age.[12,14,17,21,22]

Impact of gender on LWT

Khajehahmadi et al., Lim EL et al., Monje et al., Tuba TaloYildirim et al., AsiehMozaffari et al., NazanKocakTopbas., and Kiakojori et al., found in their studies that there is no positive correlation between

the gender and the thickness of the LW and found that there no significant difference among the genders.[11,14,15,16,20,21,22]
On the other hand Li et al., Yang et al., and Kang et al., based in their findings reported that females had a thinner mean lateral wall thickness than their male counterpart.[13,17,18] Danesh-Sani et al., reported that women are having a thinner lateral wall at P_1,P_2 and M_2 than men. There was no statistically significant difference between men and women at M1.[12]
These studies are showing that there are some differences among their findings about lateral wall of the maxillary sinus. This may be due to the selected landmarks used for measurements or ethnic group of patients. But clearly imply that the maxillary sinus lateral wall thickness is not uniform and changes subject to subject. To avoid possible complications, priorly knowing the thickness of the maxillary sinus wall would help the surgeon to select locations for surgery according to the surgical procedure. This can be done with help of CBCT imaging technique.

Conclusion

Based on this review the following conclusions had been drawn

- LWT varies between the genders and different age groups
- Depends on subject's dental status such as dentulous, partially or completely edentulous and periodontal conditions LWT varies
- Since different studies showing different LWT and they have been conducted in different population, it can be concluded that ethnicity, race and demographic factors also having influence on LWT.

These findings indicates that LWT not static and varies among the persons and the dental surgeons before performing surgical procedure such as implant procedures, sinus lift or grafting should perform proper evaluation in case by case with the help of 3D imaging techniques. It will prevent unnecessary complications.

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