Clinics of Surgery

Research Article ISSN: 2638-1451 | Volume 10

Analysis of Maxillary Sinus Septa using Cone Beam Computed Tomography: A Novel Classification and Clinical Management Proposals

Chen J[1,2,3,4†], Yang Q[1,2,3,4†], Li Y[1,4,5,6*], Li Y[1] and Xu G[1,3,4*]

[1]Department of Oral Surgery, Shanghai Ninth People's Hospital, Shanghai Jiao Tong University School Of Medicine, Shanghai 200011, PR. China

[2]College of Stomatology, Shanghai Jiao Tong University, Shanghai 200011, PR. China

[3]National Center for Stomatology, Shanghai 200011, PR. China

[4]National clinical Research Center for Oral Diseases, Shanghai 200011, PR. China

[5]Shanghai Key Laboratory of Stomatology, Shanghai 200011, PR. China

[6]Shanghai Research Institute of Stomatology, Shanghai 200011, PR. China

†These authors contributed equally to this work.

***Corresponding author:**

Guangzhou Xu and Yan Li,
Department of Oral Surgery, Shanghai Ninth People's Hospital, Shanghai Jiao Tong University School of Medicine, 500, Qu xi Road, Shanghai 200011, PR. China

Received: 16 Nov 2023
Accepted: 22 Dec 2023
Published: 29 Dec 2023
J Short Name: COS

Citation:

Li Y, Xu G. Analysis of Maxillary Sinus Septa using Cone Beam Computed Tomography: A Novel Classification and Clinical Management Proposals. Clin Surg. 2023; 10(7): 1-10

Keywords:

Maxillary sinus septa; Classification; Clinical management proposals; Anatomical structures; Cone-Beam Computed Tomography

1. Abstract:

1.1. Purpose: To propose a new classification for maxillary sinus septa with evaluating the distribution and investigat the appropriate management proposals for clinical reference.

1.2. Material and Methods: A retrospective study of CBCT images from 292 patients was carried out. Sinus septa were first divided into Classes I–III, IV, and V based on the orientation of maxillary septa. Class II and III are classified separately as specific bucco-palatal septa. Class I, IV, and V septa are further subdivided into subclasses based on the completeness and the connected internal sinus walls of septa. Class VI refers to combination of various classes. CBCT images were analyzed to summarize the distribution of septa in patients under the new classification by Mimics21.

1.3. Results: The septa were present in 124 of 584 sinuses (21.2%). The majority of maxillary sinus septa were observed in the bucco-palatal direction (52.4%). Septa connected only to the medial wall were significantly more than those connected only to the lateral wall. Complete septa were prevalent, accounting for a total of 46.7% in all orientations. Moreover, relative management proposals were discussed.

1.4. Conclusion: The new classification of the maxillary sinus septa and relative management proposals were developed, exhibiting wider coverage, visual clarity, and practicality.

2. Introduction

Due to resorption of the alveolar bone and pneumatization of the maxillary sinus, patients with maxillary posterior teeth loss usually lack sufficient vertical bone volume for implants. When residual alveolar ridge height≤6mm, the prevalent treatment plan is lateral sinus floor elevation (LSFE) combined with simultaneous/delayed implantation. In the basic procedure of LSFE [1], a full-thickness flap on the edentulous area is reflected to fully expose the antero-lateral wall of the maxillary sinus. Then a bone window is created and removed by penetrating only the bone wall without hurting the sinus membrane (also called the Schneiderian membrane). The osteotomy can be prepared using a high-speed handpiece or piezoelectric instruments. After that, the Schneiderian membrane is visible and lifted gently by the specialized lifting tool. Then bone graft material is placed between the elevated Schneiderian membrane

and the maxillary sinus floor to achieve the elevation effect. The key to the success of LSFE is to ensure the integrity of the Schneiderian membrane. Perforated Schneiderian membranes can lead to graft displacement or inflammation, ultimately leading to surgical failure. As a common complication during LSFE, its incidence has ranged from 5.76% to 41.8%, with the majority of reported incidence rates ranging between 15% and 25% [2].

Sinus septa were bony projections from the maxillary sinus walls with a high incidence. Recent literature shows that the frequency of sinus septa is 33.2% per side and the prevalence is 41% to 45.9% [3, 4]. The current literature indicates that the presence of sinus septa, located in the lower 2/3 of the maxillary sinus region, is a major risk factor for perforation of the Schneiderian membrane during LSFE [2, 5-8]. The sharp turns of the maxillary sinus septa can easily cause perforations when lifting the mucosa to the peak of the septa [9]. In a retrospective study of LSFE procedures by Schwarz8, it was found that 77.1% of perforations occurred at sites where septa were present, and the difficulty of mucosal detachment increased the risk of perforation.

Several studies have demonstrated that there are significant anatomical variations in the maxillary sinus septa of different individuals, like location, orientation, morphology, quantity and so on [10-12]. These variant structures of the maxillary sinus septa have been discovered to significantly increase the difficulty of management.

For intraoperative management of the maxillary sinus septa. The dominant approach is the classical double/multiple windows technique [13]. In the double/multiple windows technique, the Schneiderian membrane is lifted through the bone window on the either side of the septum. After that, the septum can optionally be removed/not removed. Recently, Jung proposed the floating septum technique [9]. The technique floats the septum together with the lifted Schneiderian membrane instead of removing it, which avoids crossing the tip of the septum. It significantly lowers the risk of perforation and offers a fresh direction to managing the maxillary sinus septa. However, current management proposals are mainly for bucco-palatal septa. There are no clear management guidelines for other complex septa [14, 15].

The use of cone-beam computed tomography (CBCT) to examine the maxillary sinus septa in detail before surgery is recommended in recent guidelines to prevent complications during LSFE [11, 16]. By cone-beam computed tomography (CBCT), variant anatomical structures of the maxillary septa would show more details. It is beneficial to understand the variant anatomical structures of the maxillary sinus septa preoperatively [3, 17].

The objectives of the study were to propose a new classification system of the maxillary sinus septa based on the variant anatomical structures comprehensively and summarize the regularity in clinical distribution of the septa referring to the new classification by analyzing CBCT images from patients. The relative management proposals according to the classification were discussed for clinical reference.

By CBCT, we analyzed the variant anatomical structures of the sinus septa and proposed a novel classification. According to the new classification, distribution of the septa in patients was evaluated and the relative management proposals were discussed for clinical reference.

3. Material and Methods

3.1. Study Design and Population

The research project was approved by the Institutional Review Board of the College of Stomatology, Shanghai Jiao Tong University (Ethical Approval No.: SH9H-2023-T117-1). Images are selected from the database at Shanghai Ninth People's Hospital, Shanghai Jiao Tong University School of Medicine.

In this retrospective study, the following inclusion criteria were:

(1) Patients who were referred to the department of Oral Surgery, Shanghai Ninth People's Hospital between September 2018 and March 2022 for CBCT radiographic examination of the maxillary sinuses; (2) No previous surgeries performed on the maxillary sinus. In total, 392 patients were evaluated for eligibility to participate in the study.

The following exclusion criteria were considered:

(1) Patients younger than 18 years old (N = 47). As shown in the literature, the width and length (antero-posterior diameter) of the sinus come up to adult proportions by the age of 12 years, while the height of the sinus increases steadily until the age of 18. This study only included patients >18 years old in order to minimize the influence of age on the development of the sinus by age as much as possible [18]; (2) Patients with severe pathology in the sinus, such as oroantral fistula (Oral-maxillary sinus fistula) and severe bone hypoplasia of the sinus, benign and malignant neoplasms, etc., affecting the sinus region (N = 25); (3) Any partial or incomplete images involving sinus (N = 28).

Therefore, the final study consists of 292 patients.

3.2. Cone-Beam Computed Tomography

CBCT images were scanned and recorded with the following parameters: 120 kV, 4 mA, 15 s exposure, a field of view of 10 * 10 cm, and a 0.0125 mm3 voxel size. The data were reconstructed in slices of 0.25 mm intervals. Analysis was completed by Mimics21 (Materialise, Belgium) software.

3.3. Data Collection

The analysis was performed by two observers, one a maxillofacial expert and the other a second-year dental student. In cases of disagreement between the observers, the cases were discussed until consensus was reached. Then the classification of these septa was determined based on sagittal, coronal, and cross-sectional images at 0.25 mm intervals.

3.4. Proposed New Classification

Based on our years of clinical experience and abundant CBCT analysis of sinus septal anatomical structures, we propose the following classification :

Firstly, we classify maxillary sinus septa into Classes I–III, IV, and V based on their direction (bucco-palatal, antero-posterior, and horizontal).

Class II and III are classified separately. as specific bucco-palatal septa. Class II refers to multiple bucco-palatal septa on sinus floor. Class III refers to complete bucco-palatal septa on sinus floor.

Subsequently, Class I, IV, and V septa are further subdivided into subclasses based on the completeness (whether they cross from one wall of the sinus to the other) and the connected internal sinus walls of septa. When several septa of various classes are seen in the maxillary sinus, we recommend classifying them as Class VI. (Table 1)

Typical CBCT sections (coronal, sagittal, and cross-sectional) for septa in each subclass were showed (Figure 1).

The height of the septum should be greater than 2.5 mm. According to the literature, some authors believe that septa should be higher than 2.5 mm in length; shorter septa are better described as ridges. 10, 19

3.5. Data Analysis

Data were captured and imported using Microsoft Excel and then analyzed on IBM SPSS Statistics for Windows, version 19 (IBM Corp., Armonk, NY, USA). The chi-square test was used to compare the categorical variable (lateral side of the sinus). P values < 0.05 were considered statistically significant.

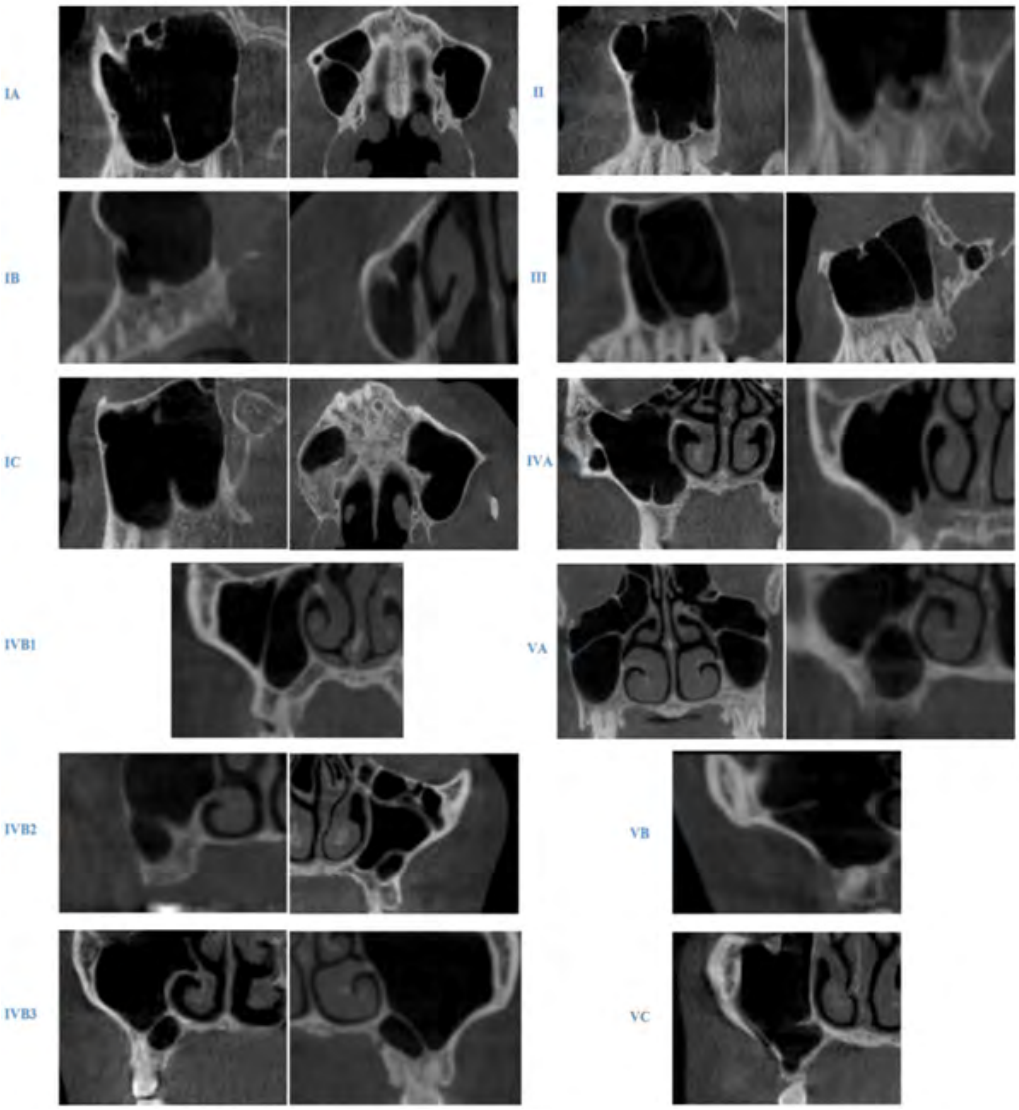

Figure 1: Typical CBCT sections for septa in each subclass on sagittal, coronal or cross-sectional plane.

Table 1: Proposed classification of the maxillary sinus septa

Class I: Single bucco-palatal septum of maxillary sinus floor	**SubclassA**	**The septum connected to both the lateral and medial walls**
	SubclassB	The septum connected to the lateral wall without connection to the medial wall
	SubclassC	The septum connected to the medial wall without connection to the lateral wall
Class II	Multiple bucco-palatal septa of the maxillary sinus floor	
Class III	Complete bucco-palatal septum of maxillary sinus floor	
Class IV: Antero-posterior septum of maxillary sinus floor	SubclassA	Pure antero-posterior partial septum of maxillary sinus floor
	SubclassB1	Complete septum connected to the sinus floor and the superior wall of the maxillary sinus.
	SubclassB2	Complete septum connected to the sinus floor and the lateral wall of the maxillary sinus.
	SubclassB3	Complete septum connected to the sinus floor and the medial wall of the maxillary sinus.
	SubclassA	A complete horizontal septum, connected to both lateral and medial walls of sinus
Class V: The horizontal septum	SubclassB	Horizontal septum connected to lateral sinus wall
	SubclassC	Horizontal septum connected to medial sinus wall
Class VI	Combination of two or more of the above septa	

4. Result

4.1. Population in research and basic character of the Septa

In total, CBCT images from 292 patients with 584 sinuses were evaluated. In the population, 150 patients were men (51.4%) and 142 patients were women (48.6%), with a mean age of 43.7 years old (range: 18–84 years). The septa were present in 80 of 292 patients (27.4%) and in 124 of 584 sinuses (21.2%). Of the 80 patients, 29 were male and 51 were female. Of 126 septa, 58 (49.8%) were right-sided and 60 (50.2%) were left-sided, while 79 (66.9%) sinuses had a single septum and 39 (33.1%) had two or even more septa. In addition, no significant differences were found in the quantity of septa per sinus with different lateral side of sinuses (P = 0.474).

4.2. Distribution of Septa based on the new classification

Through the analysis of CBCT images from 292 patients, we summarize the distribution of septa based on the proposed classification. The bucco-palatal direction was the most common for maxillary sinus septa, accounting for 52.4% of all types of septa, followed by the septa in the antero-postero direction (15.3%) and the horizontal direction (4.8%) in order. Among all subclasses, Class I septa were the most frequently observed, accounting for 44.4%. Class III and class VB septa were the least, with only one example detected, accounting for 0.8%. Besides, septa of Class VI accounted for 27.4% in 124 sinuses (Table 2). Of the septa in three orientations, those connected only to the medial wall were significantly more common than those connected only to the lateral wall (Table 3). Complete septa were found to be quite prevalent in all three orientations (total 46.7%), with percentages of 52.3%, 31.6%, and 33.3% in the bucco-palatal, anterior-posterior, and superior-inferior orientations, respectively (Table 4).

Table 2: Distribution of the maxillary septa in unilateral sinus

Oritention (No. & %)	Class	Right sinus (No.of septa)	Left sinus(No.of septa)	Total No. of septa (%)
Bucco-palatal (65, 52.4)	**I**	**29**	**26**	**55 (44.4)**
	IA	17	16	33 (26.6)
	IB	2	2	4 (3.2)
	IC	10	8	18 (14.5)
	II	**5**	**4**	**9 (7.3)**
	III	**0**	**1**	**1(03)**
Antero-posterior (19, 15.3)	**IV**	**8**	**11**	**19 (15.3)**
	IVA	0	4	4 (3.2)
	IVB1	4	2	6 (4.8)
	IVB2	2	**0**	2 (1.6)
	IVB3	2	5	7 (5.6)
Horizontal (6, 4.8)	**V**	**2**	**4**	**6 (4.8)**
	VA	1	1	2 (1.6)
	VB	1	0	1 (0.8)
	VC	0	3	3 (2.4)
Combination (34, 27.4)	**VI**	**16**	**18**	**34 (27.4)**
Total		**60**	**64**	**124 (100)**

Table 3: The distribution of septa connected to medial or lateral wall only

The connected sinus wall of septa		
Class	Medial sinus wall only (No. & Subclass)	Lateral sinus wall only (No. & Subclass)
I	18 (IC)	4 (IB)
IV	7 (IVB3)	2 (IVB2)
V	3 (VC)	1 (VB)
Total	28	7

Table 4: The distribution of complete septa in three orientations

Orientation	No. of ICS (%)	No. of CS (%)	Total (%)
Bucco-palatal	31(47.7)	34 (52.3)	65 (100)
Antero-posterior	13(68.4)	6 (31.6)	19 (100)
Horizontal	4 (66.7)	2 (33.3)	6 (100)
Total	48 (53.3)	42 (46.7)	90 (100)

ICS= Incomplete sinus septa, CS= Complete sinus septa

5. Discussion

5.1. The anatomical structures of the maxillary sinus septa in relation to clinical management

Anatomical factors considered in the classification suggested in this study include orientation, completeness, connected sinus walls and quantity of the sinus septa. These anatomical structures would influence the difficulty and specific operation in clinical management.

5.1.1. Orientation: The maxillary sinus septa can be classified into three main directions: bucco-palatal, anterior-posterior, and horizontal. Previous studies have reported the highest proportion of septa in the bucco-palatal direction, followed by the anterior-posterior direction, and the lowest proportion in the horizontal direction. Bernhard Pommer 15conducted a meta-analysis of 33 retrospective studies involving 2038 patients and found that the proportion of bucco-palatal septa was 87.6%, anterior-posterior septa was 11.1%, and horizontal septa were 1.3%. More recently, a study conducted by Mohammad S.12 involving 505 patients indicated a similar regularity.

Septa oriented in the anterior-posterior direction can impede proper access and significantly reduce the operator's visibility on the medial side, thereby increasing the difficulty of the operation. Wen and Irinakis classified the management of septa located in the antero-posterier direction as moderately difficult, higher than that of the typical bucco-palatal septa. Horizontal septa and multi-directional septa are considered to be the most difficult to manage. 13, 20

5.1.2. Complete septa: Schriber M.11classified the maxillary sinus into complete septa (septa crossing from one wall of the sinus to the other) and incomplete septa. The CS (complete septa) were further classified into septa with or without compartmentalization of the maxillary sinus into two separate spaces. CSC (complete septa with compartmentalization) was not observed in any of the 60 samples of maxillary sinus septa in their study. Likewise, Krennmair21 found only one complete sagittal septum in 200 maxillary sinuses (0.5%), comparting the sinus into two separate spaces.

CS would hinder the luxation of the bony window due to their connection with multiple sinus walls; when peeling off the mucosa, it is easier to encounter sharp turns on the septa and increase the risk of perforation [15].

5.1.3. Connected sinus walls of septa: The studies involving connected sinus walls of septa are rare. To the best of our knowledge, only Bornstein et al [22]. Studies the original sinus wall of septa without considering the septa connecting to multiple sinus walls.

But the sinus walls connected by the maxillary sinus septum affects the specific management approach. When connected to the lateral wall, window design and luxation of the bone window need a presurgical plan to bypass the connection. If connected to the medial wall, the direct detachment of the maxillary sinus mucosa is impossible.

5.1.4. Quantity of septa in unilateral sinus: In a CBCT study of 100 sinuses, Schriber, M. found that 9(9%) sinuses had more than two septa. Similarly, Al-Zahrani, M. S.12 found that multiple septa were present in 11.9% of sinuses (60 of 505). Furthermore, the patients were separated into four age groups (below 25, 25–35, 35–45, and above 45), and there was a positive association between age and number of septa (P<.001). This may be relative to the occurrence of secondary septa. It was also found that multiple septa are more common in males.

The presence of multiple septa requires the application of the multi-window technique which is difficult. In modified AI-Faraje's classification, multiple high partial septa are accessed as high risk and a relative contradiction for LSFE, but multiple basal septa are low risk [11].

5.2. Distribution features of the maxillary septa in patients

In this study, the proportion of bucco-palatal septum was 55 and

Class IA septa were the most common among all subclasses. This finding is consistent with the researches mentioned above: the highest proportion of septa is in the bucco-palatal direction. Except the bucco-palatal septum, the rest of the septum accounts for 45% relatively. Current management proposals for the bucco-palatal septa alone are insufficient.

Furthermore, in all three orientations, the frequency of the septum connected to the medial wall alone was significantly higher than that of the septum connected to the lateral wall alone (Table 2). AI-faraje13 also mentioned that the partial horizontal septum attached to the medial wall is caused by an overdeveloped maxillary process of the inferior turbinate. This could imply that the development of the maxillary sinus septum is associated with the maxillary sinus medial wall. It's interesting, but the concrete developmental mechanism of the primary maxillary sinus septa remains to be explored.

As for CSC, only one case (type III septa) was found, accounting for 0.8%. Similar to the study conducted by Schriber.M. and Krennmair6, 11, CSC is extremely rare. Complete septa were found to be quite prevalent in all three orientations in 124 septa. To our best acknowledgement, there are few studies on CBCT measurements regarding the completeness of the maxillary sinus septum. In the only study by Schriber M.11, the proportion of CS even reached 98.3% in 60 septa. This proportion is significantly higher than that encountered in our clinical work. This can be the result of bias due to a small sample size of 60 septa. However, both results reflect the high proportion of CS and the necessity to consider completeness as a classification criterion.

5.3. Comparison with existing classifications

So far, there are three prevailing classifications of maxillary sinus septa by Wen, Irinakis, and Sigaroudi, respectively [14, 20, 23]. In AI-Faraje's classification [13], maxillary sinus septa were classified into classes I-VI according to their height, completeness and quantity, and the classification was modified by Sigaroudi [23] by adding complete horizontal septa as Class VII. Wen et al [14], classified the maxillary sinus septa mainly according to their corresponding difficulty of surgical management while Irinakis' classification [20] is based on the orientation of sinus septa. The three classifications have their own classification criteria and clinical sinificance.

But these classifications also have their own shortcomings due to the highly variant structures of the maxillary sinus septa. Modified AI-Faraje's classification does not consider septa in the antero-posterier direction which accounts for 15.3% in our study. Wen's and Irinakis' classifications do not consider the impact of complete septa which accounts for 46.7% in our study. We found that the sinus walls connected to the septa is variant in patients, which is not taken into account to any of the three classifications. This classification provides a comprehensive coverage of sinus septa encountered in clinical work by preoperative CBCT.

5.4. Relative management proposals

Several approaches have been proposed for the intraoperative management of the maxillary sinus septum. AI-Faraje proposed the classic double/multiple windows technique for the bucco-palatal septa.13 Jung [9] proposed the floating septum technique to specifically address small bucco-palatal septa located on the palatal side. For antero-posterior septa, only Wen et al. proposed a theoretical option that creating bone window on the crest to get the approach. Currently, there are no clear management proposals on the treatment of other complex septa.

The piezoelectric instrument allows for adequate bone resection while maintaining the integrity of the surrounding soft tissue. In the last decade, the selective cutting action of piezoelectric instruments has created a new trend in the application of LSFE to significantly reduce membrane perforation [24, 25].

Based on our 20 years of experience in LSFE, a synthesis of the management proposed by previous scholars and the emerging trend of piezoelectric instruments, we proposed relative management proposals for the new classification. (Table 5)

Table 5: Management proposals relative to the new classification

Orientation	Class	Proposed Management
Bucco-palatal	**I**	
	IA	Double window technique
	IB	Septum removal technique; Double window technique
	IC	Floating septum technique
	II	Multi-window technique; Direct implant by digital assistance
	III	Double window technique
Antero-posterior	**IV**	Modified floating septum technique for IVA, IVB1, IVB2 ForIVB3, membrane reflection from crestal approach could be tried.
	IVA	
	IVB1	
	IVB2	
	IVB3	
Horizontal	**V**	
	VA	Generally, no treatment is required.
	VB	If septum is too low, it is the contradiction of sinus lift.
	VC	
Complex	**VI**	A combination of the above considerations

If sometimes the management is impossible in clinical practice, removal of the septa with reentry sinus lift is recommended.

Class I (Single septum on sinus floor located in bucco-palatal direction):

For Class IA septa, due to their connection to both the medial and lateral sinus walls, the "Double Window Technique" is recommended. (Figure 2A) 13 From the two windows, located mesial or distal to the middle of the septum, the Schneiderian membrane is lifted from both sides and finally reaches the top of the septum together.

For Class IB septa, the "Double window technique" is also suitable similarly. In addition, the disconnection from the medial wall makes it possible to move the Class IB septum from the lateral window directly. Therefore, we proposed the "Modified septum removal technique". (Figure 2B, 3) In the procedure, a lateral window is created at the middle of the septum, then the connection between the septum and sinus lateral wall is dissected by the piezoelectric instrument until the bony window is removable. The inferior edge of the bone window should be lower than the sinus floor to ensure entire exposure of the base of the septum. After the osteotomy, the sinus membrane is lifted from the bilateral sides of the septum and a linear cutting by the piezoelectric instrument is made at the base of the septum. The septum was then separated from the sinus floor and removed, followed by a macroscopic examination of the Schneiderian membrane and insertion of the graft material. To avoid tearing the membrane, the dissection should be performed gently.

For Class IC septa, due to the connection to the medial wall, it is difficult to elevate the membrane around the septum directly. The floating septum technique proposed by Jung is suitable [9] (Figure 2C). The steps are as follows:

1) Create a single small window. The distal margin of the window is positioned anterior to the septum or extended distally to include the septum.

2) Release the membrane on the mesial side of the septum through the window to expose the base of the septum.

3) A linear cut by the piezoelectric instrument is made at the base of the septum and mobilization of the septum is achieved.

4) Gently lift the membrane behind the septum subsequently until the septum is floating along with the membrane, then perform a macroscopical inspection and insert the graft material.

Class II (Multi-septa on sinus floor located in bucco-palatal direction):

Class II septa can be regarded as a combination of multiple ClassIsepta and can be managed by multi-window technology similarly. However, the multi-window technique is much more difficult than the double-window technique due to the limitations in scope and precision of the surgery. Furthermore, if Class II septum is short with a wide base, direct implantation by preoperative computerized design is workable (Figure 2D).

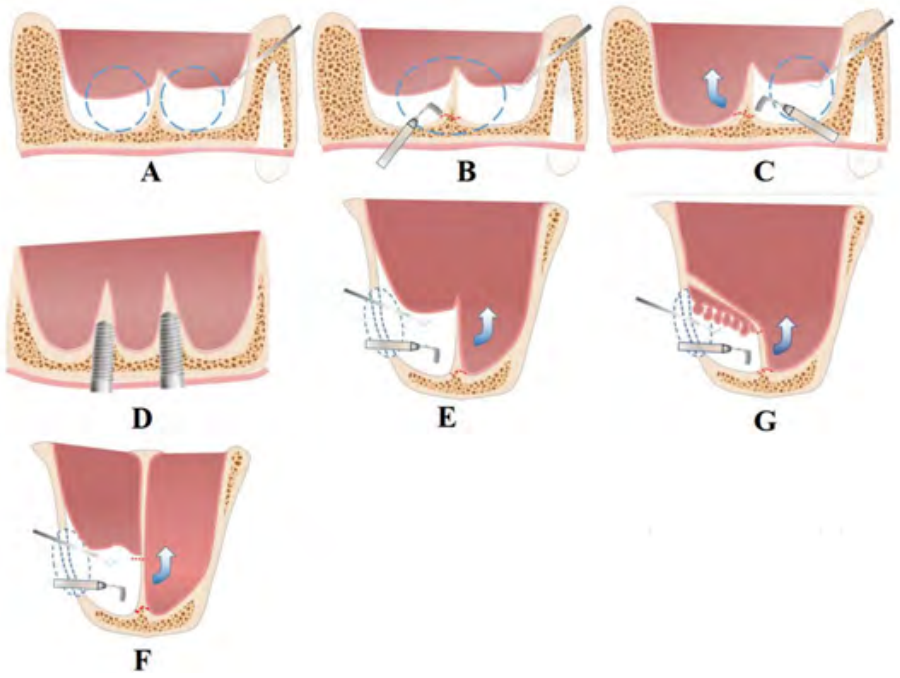

Figure 2: Schematic images of the proposed management: the blue oval dotted line indicates the window and the red oval dotted line indicates the dissection by a piezoelectric instrument. (A)The double window technique in the class lA septum in sagittal perspective. (B)The septum removal technique in the class IB septum in sagittal perspective. (C)The floating septum technique in the class IC septum in sagittal perspective. (D)Direct implantation in the Class II septum in sagittal perspective. (E) The modified floating septum technique in class VIA septum in coronal perspective. (F) The modified floating septum technique in class VIB1 septum in coronal perspective. (G)The modified floating septum technique in class VIB2 septum in coronal perspective

Class III (a single complete septum on sinus floor located in bucco-palatal direction):

Since Class III septa connect to the mesial and superior walls of the sinus, it is impossible to move the whole septum with the piezoelectric instrument. “Double window technique” is recommended (Figure 3).

Class VI (Septum in antero-posterior direction):

Class VIA septa refers to incomplete septa located in antero-posterior direction. If the septum is located so palatally that it does not interfere with the implant site, the septum can be used as the medial wall of the original maxillary sinus for maxillary sinus elevation without management (Figure 4). The approach not only simplifies management but also provides bone wall contact for the graft, providing osteoblasts and a blood supply for new bone formation. 26Alternatively, if the septum is less than 6 mm, direct reflection of the Schneiderian membrane can be attempted.14The following discussions are all about the septa in antero-posterior orientation affecting the implant site:

For class VIA septum >6 mm, the membrane on the medial wall of the septum cannot be released directly. No specific management of this type of septum has been found in the literature so far. The theoretical option was mentioned only in the literature of Wen. A crestal osteotomy is applied and the border of the window needs to be beyond the extent of the septum anteroposteriorly. After removing the window wall, the septum is separated from the alveolar ridge and the Schneiderian membrane is lifted to the planned height in crestal approach [14, 27]. However, the osteotomy on the alveolar ridge may do harm to bone formation and increase the risk of oroantral communication [27].

Influenced by the idea of the “Floating Septum Technique” above, we proposed a modified floating septum technique for septa in antero-posterior direction (Figure 2E): The basic procedure is similar to the former, except that the septum is cut from the lateral side of the septum instead of the mesial side.

The management of Class VIB1 septum is similar to Class VIA septum. The difference is that an additional cut is required at the end of the membrane reflection using the piezoelectric instrument to make a portion of the septum movable since the Class VIB1 septum is also attached to the superior wall of the maxillary sinus. portion of the septum movable (Figurer 2F).

The management of Class VIB2 septum is similar to that of Class VIB1, as shown (Figure 2G).

The management of Class VIB3 is significantly difficult because the membrane on its medial wall is obstructed by the septum in two directions (lateral and superior). For this subclass, a membrane reflection through the alveolar crest approach mentioned above is a possible idea [27].

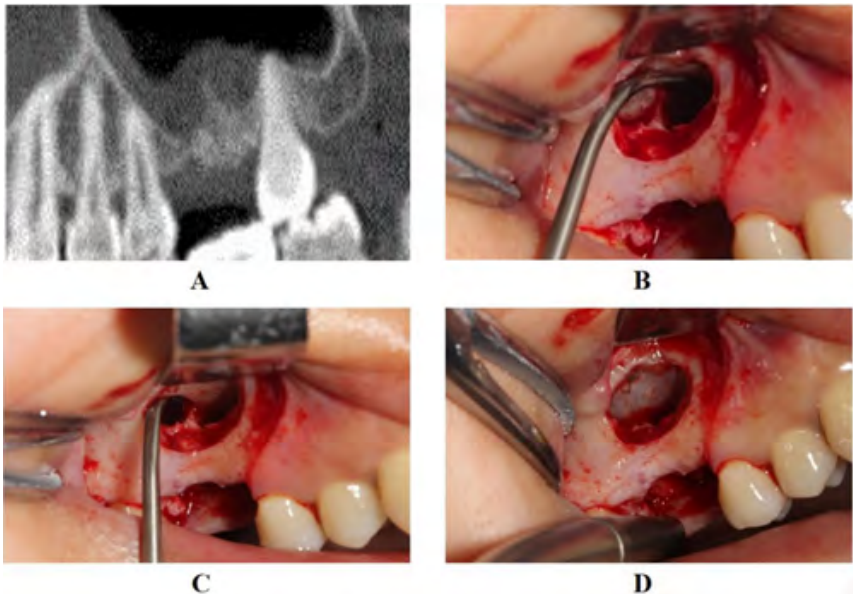

Figure 3: (A) A CBCT image in sagittal plane, showing the IB septum located in the first molar region. (B-D) Clinical photographs showing the septum removal technique, the base of the septum is exposed.

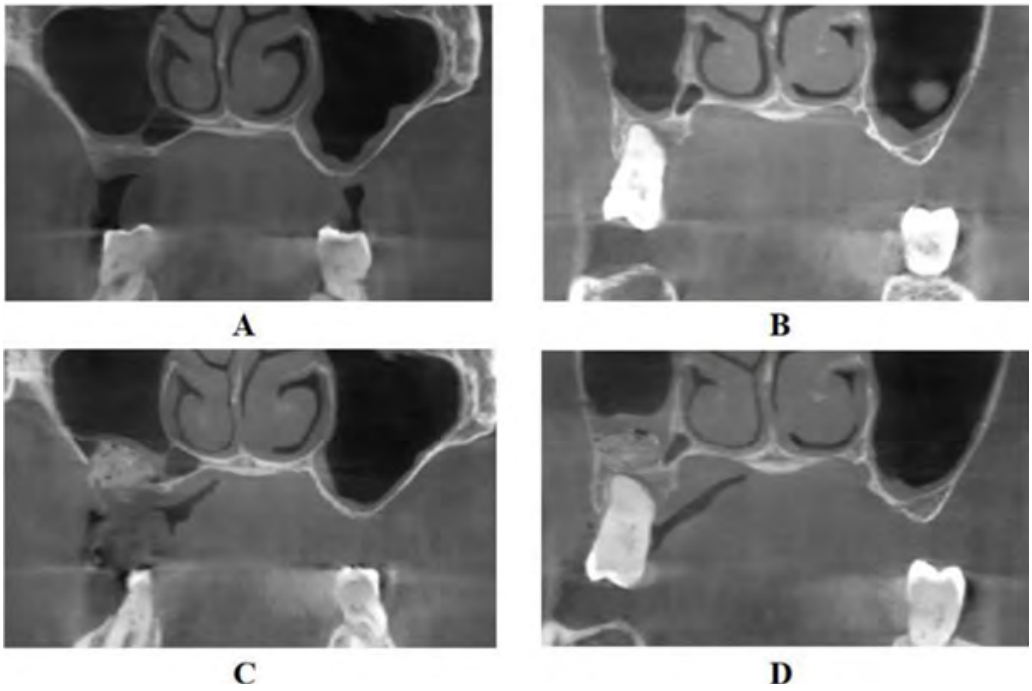

Figure 4: A, B. CBCT images of a patient with the Class IVB septum in Coronal plane, in first and second molar areas respectively. Theseptum positioned palatally without interfering with the implant site. C, D. CBCT images of the patient after lateral window sinus floor elevation.

Class V (Septum in horizontal):

Class V septum generally does not affect the surgical procedure of maxillary sinus floor lift. However, if the maxillary sinus septum is too low, it may affect the internal drainage of the sinus after surgery. And this situation is described as contraindication in sinus lift by AI-Faraje [28]. However, the exact distance from the sinus floor that increases the risk has not been further studied.

Class VI (Combination of two or more of the above septum):

The management of Class VI septum requires a combination of the above considerations.

Sometimes, if the management proposals above are too difficult to carry out in clinical practice, it is possible to remove the septum first, and then the reflected mucoperiosteal flap is repositioned and sutured. After 3-6 mouths, the perforation would be healed by scar tissue and a reentry lateral sinus floor elevation could be carried out. Long-term predictable results can also be achieved, as shown in the literature [29].

6. Conclusion

Our classification is proposed based on orientation, quantity, completeness, and the connected sinus walls of the maxillary septa comprehensively, with clear definition and good visualization. We evaluated and analyzed the distribution of different kinds of septa in the population in detail and got the following findings:

1) The bucco-palatal direction accounts for the most, followed by the antero-posterior direction, and the horizontal direction is the least.

2) Complete septa without compartmentalization are quite prevalent while complete septa with compartmentalization are rare.

3) Sinus septa manifest great variability and the development of maxillary sinus septa may be closely linked to the maxillary sinus medial wall or nasal turbinates.

Management proposals are discussed for each subclass, making the classification a valuable tool for clinicians.

References

1. Danesh-Sani SA, Loomer PM, Wallace SS. A comprehensive clinical review of maxillary sinus floor elevation: anatomy, techniques, biomaterials and complications. Br J Oral Maxillofac Surg. 2016; 54(7): 724-30.
2. Molina A, Sanz-Sánchez I, Sanz-Martín I, Ortiz-Vigón A, Sanz M. Complications in sinus lifting procedures: Classification and management. Periodontol 2000. 2022; 88(1): 103-15.
3. Henriques I, Caramês J, Francisco H, Caramês G, Hernández-Alfaro F, Marques D. Prevalence of maxillary sinus septa: systematic review and meta-analysis. Int J Oral Maxillofac Surg. 2022; 51(6): 823-31.
4. Alhumaidan G, Eltahir MA, Shaikh SS. Retrospective analysis of maxillary sinus septa - A cone beam computed tomography study. Saudi Dent J. 2021; 33(7): 467-73.
5. Shao Q, Li J, Pu R, Feng Y, Jiang Z, Yang G. Risk factors for sinus membrane perforation during lateral window maxillary sinus floor elevation surgery: A retrospective study. Clin Implant Dent Relat Res. 2021; 23(6): 812-20.
6. Krennmair S, Malek M, Forstner T, Krennmair G, Weinländer M, Hunger S. Risk Factor Analysis Affecting Sinus Membrane Perforation During Lateral Window Maxillary Sinus Elevation Surgery. Int J Oral Maxillofac Implants. 2020; 35(4): 789-98.

7. von Arx T, Fodich I, Bornstein MM, Jensen SS. Perforation of the sinus membrane during sinus floor elevation: a retrospective study of frequency and possible risk factors. Int J Oral Maxillofac Implants. 2014; 29(3): 718-26.
8. Schwarz L, Schiebel V, Hof M, Ulm C, Watzek G, Pommer B. Risk Factors of Membrane Perforation and Postoperative Complications in Sinus Floor Elevation Surgery: Review of 407 Augmentation Procedures. J Oral Maxillofac Surg. 2015; 73(7): 1275-82.
9. Jung J, Hwang BY, Kim BS, Lee JW. Floating septum technique: easy and safe method maxillary sinus septa in sinus lifting procedure. Maxillofac Plast Reconstr Surg. 2019; 41(1): 54.
10. Kim MJ, Jung UW, Kim CS, Kim KD, Choi SH, Kim CK, et al. Maxillary sinus septa: prevalence, height, location, and morphology. A reformatted computed tomography scan analysis. J Periodontol. 2006; 77(5): 903-8.
11. Schriber M, von Arx T, Sendi P, Jacobs R, Suter VG, Bornstein MM. Evaluating Maxillary Sinus Septa Using Cone Beam Computed Tomography: Is There a Difference in Frequency and Type Between the Dentate and Edentulous Posterior Maxilla? Int J Oral Maxillofac Implants. 2017; 32(6): 1324-32.
12. Al-Zahrani MS, Al-Ahmari MM, Al-Zahrani AA, Al-Mutairi KD, Zawawi KH. Prevalence and morphological variations of maxillary sinus septa in different age groups: a CBCT analysis. Ann Saudi Med. 2020; 40(3): 200-6.
13. Al-Faraje. Surgical Complications in Oral Implantology, First. ed. 2011: 153-60.
14. Wen SC, Chan HL, Wang HL. Classification and management of antral septa for maxillary sinus augmentation. Int J Periodontics Restorative Dent. 2013; 33(4): 509-17.
15. Schiller LA, Barbu HM, Iancu SA, Brad S. Incidence, Size and Orientation of Maxillary Sinus Septa-A Retrospective Clinical Study. J Clin Med. 2022; 11(9).
16. Harris D, Horner K, Gröndahl K, Jacobs R, Helmrot E, Benic GI, et al. E.A.O. guidelines for the use of diagnostic imaging in implant dentistry 2011. A consensus workshop organized by the European Association for Osseointegration at the Medical University of Warsaw. Clin Oral Implants Res. 2012; 23(11): 1243-53.
17. Zijderveld SA, van den Bergh JP, Schulten EA, ten Bruggenkate CM. Anatomical and surgical findings and complications in 100 consecutive maxillary sinus floor elevation procedures. J Oral Maxillofac Surg. 2008; 66(7): 1426-38.
18. Bhushan B, Rychlik K, Schroeder JW, Jr. Development of the maxillary sinus in infants and children. Int J Pediatr Otorhinolaryngol. 2016; 91: 146-51.
19. Whyte A, Boeddinghaus R. The maxillary sinus: physiology, development and imaging anatomy. Dentomaxillofac Radiol. 2019; 48(8): 20190205.
20. Irinakis T, Dabuleanu V, Aldahlawi S. Complications During Maxillary Sinus Augmentation Associated with Interfering Septa: A New Classification of Septa. Open Dent J. 2017; 11: 140-50.
21. 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(6): 667-671.
22. Bornstein MM, Seiffert C, Maestre-Ferrín L, Fodich I, Jacobs R, Buser D,. An Analysis of Frequency, Morphology, and Locations of Maxillary Sinus Septa Using Cone Beam Computed Tomography. Int J Oral Maxillofac Implants. 2016; 31(2): 280-7.
23. Khalighi Sigaroudi A, Dalili Kajan Z, Rastgar S, Neshandar Asli H. Frequency of different maxillary sinus septal patterns found on cone-beam computed tomography and predicting the associated risk of sinus membrane perforation during sinus lifting. Imaging Sci Dent. 2017; 47(4): 261-7.
24. Geminiani A, Weitz DS, Ercoli C, Feng C, Caton JG, Papadimitriou DE. A comparative study of the incidence of Schneiderian membrane perforations during maxillary sinus augmentation with a sonic oscillating handpiece versus a conventional turbine handpiece. Clin Implant Dent Relat Res. 2015; 17(2): 327-34.
25. Rickert D, Vissink A, Slater JJ, Meijer HJ, Raghoebar GM. Comparison between conventional and piezoelectric surgical tools for maxillary sinus floor elevation. A randomized controlled clinical trial. Clin Implant Dent Relat Res. 2013; 15(2): 297-302.
26. Stacchi C, Lombardi T, Ottonelli R, Berton F, Perinetti G, Traini T. New bone formation after transcrestal sinus floor elevation was influenced by sinus cavity dimensions: A prospective histologic and histomorphometric study. Clin Oral Implants Res. 2018; 29(5): 465-79.
27. Soardi C WH. New crestal approach for lifting sinus in the extremely atrophic upper maxillae. Clin Adv Periodontics. 2012: 179–185.
28. AI-Faraje. Surgical and Radiologic Anatomy for Oral Implantology. 2013.
29. Wang D, Tian J, Wang Y, Wei D, Lin Y. Clinical and radiographic outcomes of reentry lateral sinus floor elevation after a complete membrane perforation. Clin Implant Dent Relat Res. 2020; 22(5): 574-81.