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Prevalence of maxillary sinus pneumatization in partially or totally edentulous patients according to the Carl Misch classification, diagnosed by CBCT in a private radiology center in the city of Cuenca, 2021 - 2022

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Abstract

The maxillary sinus is the largest of the paranasal sinuses, located in the body of the maxillary bone. Its pneumatization process is part of its growth and development. After tooth loss, osteoclastic activity begins in Schneider's membrane, which causes the maxillary sinuses to increase in size, a situation that complicates prosthetic rehabilitation and implant placement.

Objective: To determine the degree of pneumatic sinus pneumatization based on Carl Misch's classification in partial or edentulous patients treated in a private radiology center in the city of Cuenca diagnosed by CBCT in 2021-2022.

Methodology: Study of observational, descriptive, and cross-sectional types. Seventy-three cone-beam tomographic studies of total and partially edentulous patients considering the area from canines to second molars were examined, based on Carl Misch's classification, to determine the degree of pneumatization and the depth of the maxillary sinus.

Results: grade III pneumatization was the most prevalent in 43.41% of the total 129 maxillary sinuses evaluated, a grade IV was mostly in total edentulous (17.05%), and partial edentulous a grade III was more predominant (27.13%).

Conclusion: The relationship between the degree of pneumatization and the depth of the maxillary sinus was evident, determining that there is a relationship between the loss of dental pieces and the pneumatization of the maxillary sinus, and these results can help plan surgical procedures and to take into account possible complications in patients with a higher degree of pneumatization.

Keywords: Pneumatization; Maxillary sinus; Totally edentulous; Partially edentulous

1. Introduction

The maxillary sinus or Highmore antrum is the largest of the paranasal sinuses. It is located in the body of the maxillary bone, has the shape of a horizontal pyramid and is internally lined by respiratory epithelium 1. It performs multiple functions such as air thermoregulation, phonation and acts as a barrier since the cells it contains allow the elimination of microorganisms 2.

Its pneumatization process is part of its growth and development, which is a normal and physiological process, closely related to dental development; therefore, after tooth loss in the posterior region and the absence of prosthetic rehabilitation, bone loss occurs due to osteoclastic activity that begins in the sinus membrane; in response, the maxillary

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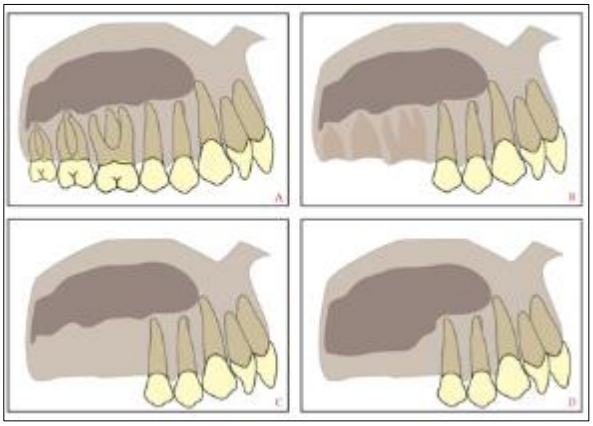
sinuses increase in size due to the lack of resistance at this site, added also to the increase in positive pressure and the decrease in occlusal stimulus that contribute to the atrophy of the alveolar process 1, 3, 4, 5. Therefore, it is said that there is an inverse relationship between sinus pneumatization and the remaining alveolar bone after tooth loss 6, 7 .

Its pneumatization process begins between birth and 12 months 8, continuing to pneumatized as permanent teeth erupt 9. From ten years onwards, variations in size occur until the apical closure of the third molar, indicating the cessation of growth 10, thus reaching an average volume of 15 ml in adults 11.

Due to the relationship between the development of the maxillary sinus and dental development, the sinus volume evolves over time and changes depending on the local dental situation. Indeed, after tooth loss in the posterior region and bone resorption after extraction, the maxillary sinuses increase in size (Figure 1) 12. In these cases, the rehabilitation of edentulous patients in the upper posterior maxilla area is a challenge due to the poor quality and quantity of alveolar bone, added to the lowering of the maxillary sinus, which limits the placement of implants or prosthetic rehabilitation. 13, 14. The extent of irregular sinus pneumatization remains unclear, but it is suspected that in addition to premature tooth loss and lack of rehabilitative treatment, it may also be caused by heredity, craniofacial configuration, bone density, growth hormones, or air pressure in the sinus cavity.15.



Source: Sager Ramseyer, Neumatización del seno maxilar. Una propuesta de clasificación 2016.

Figure 1 Pneumatization process after extractions in the maxillary sinus of an adult. A. Lateral view of the right upper jaw. B. Post-extraction dental alveoli. C. Regularization of the upper ridge. D. Pneumatization of the right maxillary sinus

It has also been suggested that conditions such as tooth location, sinus floor configuration, position of the sinus floor relative to the root apices, and the number of teeth extracted favor the susceptibility and degree of pneumatization after an extraction 15. Sinus expansion is greater in cases of loss of second molars compared to first molars and in cases of loss of 2 or more adjacent posterior teeth 12, 14. Irregular pneumatization of the sinus due to tooth loss may also give rise to the appearance of secondary septa in the maxillary sinus. Lee WJ et al, in their study observed that secondary septa may develop more frequently in the area above the lost teeth due to pneumatization, they described that the prevalence of septa in the edentulous atrophic group was higher than in the dentate non-atrophic group 10.

For this reason, the present study on the prevalence of maxillary sinus pneumatization in partially or totally edentulous patients is proposed, since the antral cavity is an anatomical structure that is not excluded from the oral cavity, since the maxillary sinuses and the roots of the posterior teeth are close and in close relationship. It is important for professionals to be able to establish clear criteria about the condition of maxillary sinus pneumatization, and thus be able to establish rehabilitation strategies in accordance with the anatomical and functional characteristics of the site to be treated.

The aim of this study was to determine the degree of pneumatization of the maxillary sinus based on the Carl Misch classification in partially or totally edentulous patients, its relationship based on age, sex and depth of the maxillary sinus; in order to improve therapeutic behavior in cases of pneumatization of the maxillary sinus.

2. Material and methods

This is an observational, descriptive and cross-sectional study. The study population consisted of 111 tomographic studies. For the sample calculation, the formula for a finite universe was used, resulting in a sample of 73 cone beam tomographic studies of partially or totally edentulous maxillary patients, obtained using an Orthophos SL 3D Sirona equipment, treated at the private radiology center in the city of Cuenca "Medimagen" in the years 2021-2022.

The CT studies were selected in a simple random manner and based on the inclusion criteria: CBCT of partially edentulous patients with an edentulous area ranging from the canine area to the second molars or totally edentulous patients of both sexes, CBCTs with a large and medium field of view (FOV) and CT scans that reflect clear images without distortion. And among the exclusion criteria: patients under 20 years of age, patients with radiographic signs of nasal or sinus pathologies.

The degree of pneumatization of the maxillary sinus was evaluated using the Carl Misch classification (1984), which evaluates the residual bone height between the floor of the maxillary sinus and the alveolar crest, suggesting four degrees of pneumatization (Table 1). Sagittal sections were used for measurements, in which the height of the residual alveolar ridge was determined and based on this, they could be classified based on the four degrees.

Table 1 Degree of pneumatization of the maxillary sinus based on the Carl Misch classification

Degree of pneumatization	Description	Treatment
Grade I	The remaining maxillary bone is > 10 mm	Conventional implant insertion without sinus lift.
Grade II	The remaining maxillary bone is between 8 and 10 mm.	a) Placement of implants with atraumatic elevation of the maxillary sinus. b) Placement of implants with a wide diameter and adequate length, without breaking the sinus cortex. c) In some cases, with residual height between 7-8 mm. We can resort to atraumatic elevation of the maxillary sinus, especially if the remaining maxillary width allows us to place wide diameter implants.
Grade III	The residual bone height is between 4 and 8 mm.	Insertion of implants with maxillary sinus lift using a lateral approach in the same surgical procedure. The primary stability of the implants is provided by the remaining maxillary bone.
Grade IV	The remaining maxillary bone is less than 4 mm.	Maxillary sinus elevation via lateral approach and delayed placement of implants in a second surgical procedure, after maturation of the antral graft.

Source: Vara de la Fuente, Tratamiento de las atrofias óseas maxilares: cirugía del seno maxilar 2006.

The depth of the maxillary sinus was measured in the coronal sections by drawing a horizontal line through the deepest part of the hard palate and from this a vertical line to the floor of the maxillary sinus. Based on the measurement obtained, the depth of the sinus was classified into three classes, this evaluation being of great relevance to check if the sinus has become pneumatized below the hard palate [16].

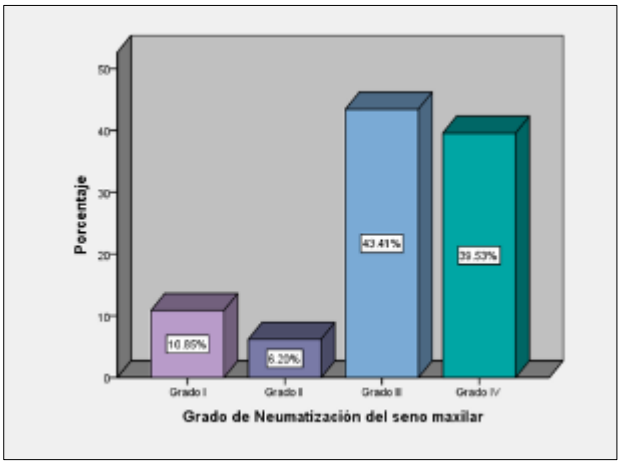
- Class I: above the hard palate.
- Class II: 0-6 mm below the hard palate.
- Class III: > 6 mm below the hard palate.

The data were obtained from the measurement of the CT scans using the Sidexis 4 program. The measurements were made 1 by 1 in a personalized way in each of the CT scans. After obtaining all the data and compiling it in Excel, they were entered for statistical analysis using the SPSS statistical package version 21, through frequency tables and measures of central tendency and dispersion according to the nature of the study variables.

3. Results

A total of 73 tomographic studies were evaluated, 52.05% corresponds to tomographies of female patients (n=38) and 47.95% of male patients (n=35), with a minimum age of 24 years and a maximum of 94 years. 34.25% of the sample consisted of tomographic studies of totally edentulous maxillary patients (n=25) and 65.75% of partially edentulous posterior maxillary patients (n=48).

The respective measurements were performed in a total of 129 maxillary sinuses, distributed in 71 right sinuses and 58 left sinuses among totally and partially edentulous patients. When evaluating the residual bone height to estimate the degree of pneumatization of the sinus based on the Carl Misch classification, a minimum of 0.61 mm, a maximum of 14.78 mm and a mean of 5.39 mm were obtained. Grade III pneumatization of the maxillary sinus was more prevalent in the study population, representing 43.41% (n=59) (Figure 2), with a mean of 5.87 mm, a minimum value corresponding to the bone height of 4.22 mm and a maximum of 7.81 mm (Table 2). This prevalence of grade III could also be seen for both sexes 20.93% (female) and 22.48% (male), grade IV was mostly seen in the age groups between 39-58 and 59-78 years at 18.60% (n=24) each.



Sorce: Ortiz D, Quizhpe K

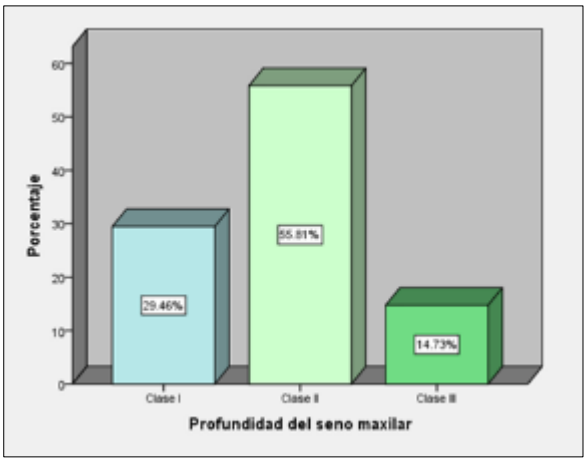
Figure 2 Degree of pneumatization of the maxillary sinus.

Table 2 Residual ridge values to assess the degree of pneumatization based on the Carl Misch classification

	Grado I	Grado II	Grado III	Grado IV
Máximo	16,55	9,03	7,81	3,94
Mínimo	11,12	9,91	4,22	0,76
Mediana	12,35	8,66	5,76	2,75
Media	12,80	8,56	5,87	2,59

The most prevalent degree of pneumatization in right maxillary sinuses was grade III and IV in 40.85% (n=29). While, in the left maxillary sinuses, grade III was more predominant with 46.55%. In totally edentulous patients, grade IV was mostly evident in 17.05% (n=22), compared to partially edentulous patients, in which grade III was predominant in 27.13% (n=35).

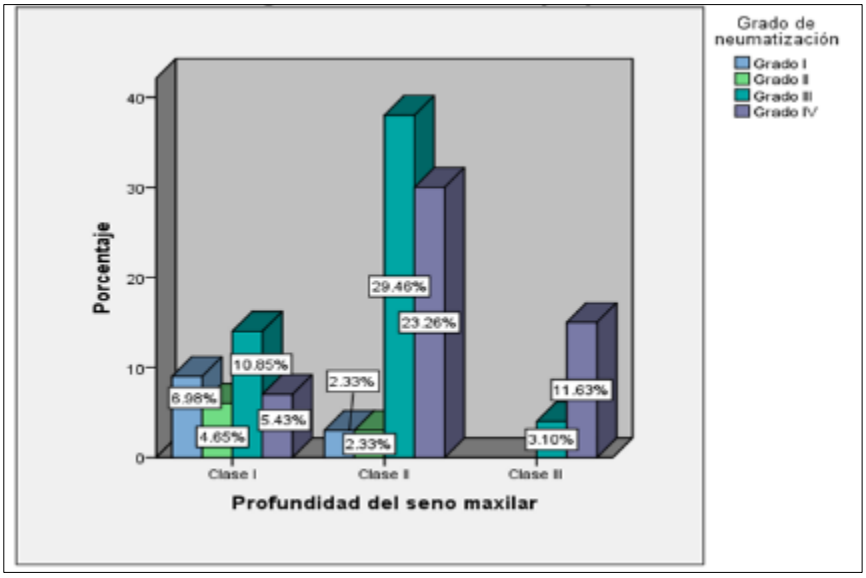
When evaluating the depth of the maxillary sinus, class II was obtained as the most prevalent in 55.81% (n=72) (Figure 3), occurring in 56.34% (n=40) on the right side and 58.62% (n=34) on the left side.



Source: Ortiz D, Quizhpe K.

Figure 3 Depth f the maxillary sinus

Class II was found mostly in tomographic studies that presented a pneumatization grade III with 29.46% (n=38), while class III was present mostly in maxillary sinuses with a pneumatization grade IV with 11.63% (n=15) (Figure 4).



Source: Ortiz D, Quizhpe K

Figure 4 Relationship between the degree of pneumatization and the depth of the maxillary sinus

4. Discussion

The present study maintains a similarity with the study by Cisneros Aliaga 3 (2021) and García Linares et al 17 (2017), which sought to determine the relationship and prevalence of pneumatization of the maxillary sinus with the absence of the upper posterior teeth, respectively. A grade III pneumatization was found more frequently at 43.79% in the study by Cisneros Aliaga as well as in the study by García Linares et al [17] by 33.3%. It is worth mentioning that the study carried out by García used panoramic radiographs and a standardized millimetric template, concluding that the loss of teeth affects the pneumatization of the maxillary sinus.

In the Ponce studio [18] (2023) 29 tomographic images of patients over 50 years of age were analyzed, in which 38% presented grade III, 27% grade IV, 21% grade II and 14% grade I. While in the present study, 73 tomographic studies were analyzed, presenting 43.41% grade III, 39.53% grade IV, 10.85% Grade I and 6.20% grade II. Comparing these two studies, the most prevalent degree of pneumatization was grade III, however, the different size of the study population and the age range must be considered since the Ponce study was conducted on patients over 50 years of age. Based on sex, both studies determine that grade III occurs more frequently in both females and males.

In contrast, in the study by *Barzola Ampuero et al*.[5] (Guayaquil,2022) they obtained a prevalence of grade IV in 64% of the left maxillary sinuses and 66% in the right maxillary sinuses. This research differs from the results of the present study since the most predominant grade was grade III and IV in the right sinuses 40.85%, while in the left maxillary sinuses grade III with 46.55%. Barzola also evaluates the depth of the maxillary sinus, obtaining mostly a class III, while in the present study a class II was mostly found for both the right and left sinuses.

When evaluating the degree of pneumatization based on sex, in the present study a pneumatization grade III was the most predominant, both in the female and male sex. In the studies by *Cisneros and Ponce*, similar results were obtained since the degree of pneumatization most frequently in the female sex was Grade III and in the male sex Grade III and IV in both studies.

When comparing the degree of pneumatization in totally edentulous and partially edentulous maxillary posterior patients, in the present study a higher prevalence of grade IV was found in totally edentulous patients at 17.05% and grade III in partially edentulous patients at 27.13%. While *Vélez Terán* [2] (2021) which sought to compare the volume of the maxillary sinus between the edentulous and non-edentulous population, in the 23 edentulous patients evaluated, found mostly a grade III and the same in partially edentulous patients; which coincides with the present study. Concluding that there is a greater volume of the maxillary sinus in the edentulous population than in the non-edentulous population, this difference in volume being statistically significant.

Finally, based on age, in the present study a pneumatization of 44.19% was observed in patients between 59 and 78 years old, while in the study by Barzola & Gómez a pneumatization of 29% was found in patients between 68 and 78 years old and 24% in patients between 58 and 68 years old, these results demonstrate that according to age, a higher degree of pneumatization occurs.

5. Conclusions

The present study sought to evaluate the relationship between pneumatization and maxillary sinus depth with tooth loss in a total of 129 maxillary sinuses of totally and partially edentulous patients based on the Carl Misch classification.

The tomographic studies of totally edentulous patients showed a higher prevalence of grade IV pneumatization, corresponding to a residual bone height of less than 4 mm compared to partially edentulous patients, where grade III was the predominant one. The results show that with the loss of teeth, resorption of the maxillary bone occurs and consequently, pneumatization of the maxillary sinus due to the loss of occlusal stimulus added to an increase in positive pressure that contributes to atrophy of the alveolar process and pneumatization. We can also conclude that there tends to be a greater volume of the maxillary sinus in the edentulous population than in the non-edentulous population.

Based on the depth of the maxillary sinus, class II corresponding to a location of the maxillary sinus floor below the hard palate of 0-6 mm was mostly present in tomographic studies that presented a pneumatization degree III, while a class III corresponding to a location of the maxillary sinus floor below the hard palate greater than 6 mm was present in maxillary sinuses with a pneumatization degree IV; results that establish the relationship that exists between the degree of pneumatization and the depth of the maxillary sinus; that is, with greater pneumatization, the maxillary sinus floor tends to be found below the hard palate, a factor that must be considered when planning a surgical or rehabilitative treatment.

In summary, the study shows that there is a relationship between pneumatization and tooth loss, and at the same time the degree of pneumatization increases the depth of the maxillary sinus. Therefore, its prior evaluation before rehabilitation of a totally or partially edentulous patient is important in planning their treatment, guiding us to the most appropriate rehabilitation options for these patients, such as the need for lifting the floor of the maxillary sinus, placement of bone grafts, short or zygomatic implants.

Compliance with ethical standards

Disclosure of conflict of interest

The authors declare that they have no conflicts of interest.

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