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VOLUME OF THE UPPER AIRWAY IN DIFFERENT FACIAL SKELETAL PATTERNS OF A POPULATION OF PALASTUDENTS FROM THE UNIVERSITY OF CUENCA USING CONE BEAM COMPUTED TOMOGRAPHY

VOLUME DA VIA AÉREA SUPERIOR EM DIFERENTES PADRÕES ESQUELÉTICOS FACIAIS DE UMA POPULAÇÃO DE ESTUDANTES DA UNIVERSIDADE DE CUENCA EM TOMOGRAFIA COMPUTADORIZADA DE FEIXE CÔNICO

VOLUMEN DE LA VÍA AÉREA SUPERIOR EN DIFERENTES PATRONES ESQUELÉTICOS FACIALES DE UNA POBLACIÓN ESTUDIANTIL DE LA UNIVERSIDAD DE CUENCA EN TOMOGRAFÍA COMPUTARIZADA DE HAZ CÓNICO

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ABSTRACT
In the context of diagnosing and planning treatment for patients with dentofacial deformities, it is crucial to examine the upper airway, as its function may be compromised by the facial skeletal pattern or impacted by planned surgical intervention. Cone Beam Computed Tomography (CBCT) is positioned as the preferred option for evaluation due to its precision and ability to predict possible changes. Objective: to evaluate the volume of the upper airway in different facial skeletal patterns of a population of students from the University of Cuenca at TCHC. Materials and methods: 33 tomographies were evaluated through the Sidexis 4 program, where the volume of the nasopharynx, oropharynx, and hypopharynx was measured according to facial skeletal pattern and sex. Results: Of the 33 CBCT analyzed, 10 (30%) belonged to males and 23 (70%) to females. Within the population of patients with skeletal class I, it was found that the volume of the oropharynx was greater compared to the nasopharynx and hypopharynx, thus obtaining an average of 21.87 cm3, with a standard deviation of 5.09. Conclusions: The average volume of the upper airway in subjects with Class I facial skeletal patterns is higher than in Class II, thus being statistically significant in the oropharynx. It is recommended to conduct studies with a larger population involving Class III skeletal patterns.

KEYWORDS: Cone beam computed tomography. CBCT. Upper airway. Pharyngeal airway.

RESUMO
No contexto do diagnóstico e plano de tratamento de pacientes com deformidades dentofaciais, é crucial examinar a via aérea superior, uma vez que sua função pode ser comprometida pelo padrão esquelético facial ou impactada pela intervenção cirúrgica planejada. A Tomografia Computadorizada de Feixe Cônico (TCCT) posiciona-se como a opção preferida para avaliá-la, graças à sua precisão e capacidade de prever possíveis alterações. Objetivo: avaliar o volume da via aérea superior em diferentes padrões esqueléticos faciais de uma população de estudantes da Universidade de Cuenca em CCT. Materiais e métodos: Foram avaliadas 33 tomografias através do programa Sidexis 4, onde o volume da nasofaringe, orofaringe e hipofaringe foi medido de acordo com o padrão esquelético facial e sexo. Resultados: Das 33 TCFC analisadas, 10 (30%) pertenciam ao sexo masculino e 23 (70%) ao feminino. Dentro da população de pacientes com classe I esquelética, verificou-se que o volume da orofaringe foi maior em relação à nasofaringe e hipofaringe, obtendo-se assim uma média de 21,87cm3, com desvio padrão de 5,09. Conclusões: O volume médio da via aérea superior em indivíduos com padrão esquelético facial Classe I é maior do que no Classe II, sendo estatisticamente

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RECISATEC – REVISTA CIENTÍFICA SAÚDE E TECNOLOGIA
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significante na orofaringe. Recomenda-se a realização de estudos com uma população maior envolvendo padrões esqueléticos de classe III.

PALAVRAS-CHAVE: Tomografia computadorizada de feixe cônico. TCFC. Via aérea superior. Via aérea faríngea.

RESUMEN
En el contexto del diagnóstico y la planificación del tratamiento de los pacientes con deformidades dentofaciales, es crucial examinar la vía aérea superior, ya que su función puede verse comprometida por el patrón esquelético facial o afectada por la intervención quirúrgica planificada. La Tomografía Computarizada de Haz Cónico (TCCT) se posiciona como la opción preferida para evaluarla, gracias a su precisión y capacidad para predecir posibles cambios. Objetivo: Evaluar el volumen de la vía aérea superior en diferentes patrones esqueléticos faciales de una población de estudiantes de la Universidad de Cuenca en CCT. Materiales y métodos: Se evaluaron un total de 33 tomografías computarizadas mediante el programa Sidexis 4, donde se midió el volumen de nasofaringe, orofaringe e hipofaringe según patrón esquelético facial y sexo. Resultados: De los 33 CBCT analizados, 10 (30%) eran hombres y 23 (70%) mujeres. Dentro de la población de pacientes con clase esquelética I, se encontró que el volumen orofaríngeo fue mayor en relación a la nasofaringe e hipofaringe, obteniéndose así una media de 21,87 cm3, con una desviación estándar de 5,09. Conclusiones: El volumen medio de la vía aérea superior en individuos con patrón esquelético facial de clase I es mayor que en clase II, siendo estadísticamente significativo en la orofaringe. Se recomienda realizar estudios con una población más grande que involucre patrones esqueléticos de clase III.

PALABRAS CLAVE: Tomografía computarizada de haz cónico. CBCT. Vía aérea superior. Vía aérea faríngea.

OBJECTIVE

To evaluate the volume of the upper airway in different facial skeletal patterns of a population of students from the University of Cuenca through the study and analysis of CBCT.

INTRODUCTION

In the diagnosis and treatment planning for patients with dentofacial deformities, it is essential to consider the analysis of the airway and its functioning because it can be influenced by skeletal pattern and impacted by planned surgical interventions. In this sense, research has been carried out to examine the measurement of the upper airway using Cone Beam Computed Tomography (CBCT), exploring its relationship with facial biotype, facial skeletal pattern, gender, age, and other relevant variables.

The upper airway plays a crucial role in the human respiratory system; its shape and size are determined by anatomical structures such as the soft tissues and craniofacial skeleton surrounding the pharynx.

In our area, the amount of research that uses Cone Beam Computed Tomography (CBCT) to measure the upper airway is limited, especially when considering a population as diverse as those from Cuenca.

RECISATEC – REVISTA CIENTÍFICA SAÚDE E TECNOLOGIA
ISSN 2763-8405

The purpose of this study was to analyze the volume of the upper airway in various facial skeletal profiles within a university population from the University of Cuenca using CBCT.

MATERIALS AND METHODS

A cross-sectional, retrospective, descriptive, and observational study was conducted by analyzing 33 Cone Beam Computed Tomography (CBCT) scans in a population of students from the University of Cuenca's Faculty of Dentistry during the academic period 2023-2024. These students volunteered to participate in order to determine the volume of the upper airway.

Inclusion criteria for the study required participants to be part of the university population, have permanent dentition, a history of orthodontic treatment, students without a history of orthodontic treatment, and students undergoing orthodontic treatment, with a history of maxillofacial surgery, and ages between 21 and 29 years. Exclusion criteria included students with congenital and acquired deformities, as well as a history of airway-related pathologies.

All CBCT images were captured using the Morita Veraview x800 tomograph. Measurements were taken using the SIDEXIS and NEMOSTUDIO viewers, where anatomical boundaries were determined according to the specifications of Guijarro Martinez and Swennen. Additionally, images were obtained in a natural position and in maximum intercuspation.

Each structure had its demarcation; the nasopharynx was delimited at the top by the contour of the soft tissue of the pharyngeal wall up to the Horizontal Frankfort Plane (HF) as its lower limit, which runs through the Posterior Nasal Spine (PNS) and extends to the posterior wall of the pharynx. The lower limit of the oropharynx approaches the HF parallel plane, running through C3ai (the most anteroinferior point of the body of the third cervical vertebra). The hypopharynx is delimited by the inferior HF parallel plane and joins the base of the epiglottis or the entrance to the esophagus.

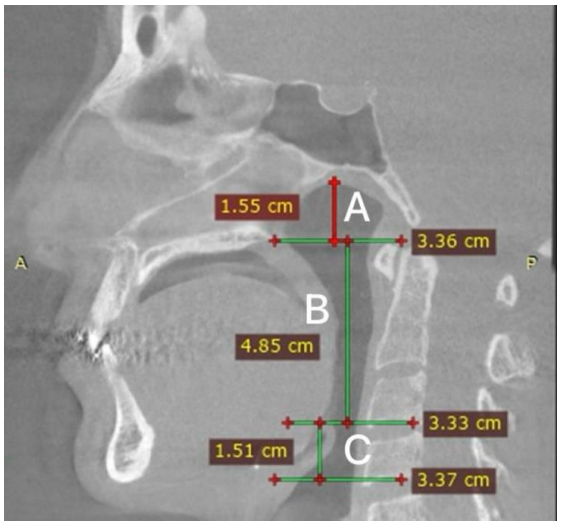

Figure 1. Limits of the upper airway (5): A. Nasopharynx; B. Oropharynx; C. Hypopharynx

RECISATEC – REVISTA CIENTÍFICA SAÚDE E TECNOLOGIA
ISSN 2763-8405

The study sample consisted of 33 students from the Faculty of Dentistry at the University of Cuenca, divided into three groups based on the molar class each student presented. In this regard, the data were examined using Excel, where tables were created to obtain the mean, standard deviation, minimum, and maximum values. Two tests, Student's t-test and ANOVA, were employed to differentiate between two independent means and more than two means, respectively.

RESULTS

Out of the 33 analyzed CBCT scans, 10 (30%) belonged to male students, and 23 (70%) belonged to female students.

Within the population of patients with skeletal class I, it was found that the volume of the oropharynx was greater compared to the nasopharynx and hypopharynx, resulting in an average of 21.87 cm3, with a standard deviation of 5.09. (Table 1).

Table 1. Upper airway volume in Facial Skeletal Pattern I

Variable	N	Media	D.S.	Mín.	Máx.
Nasopharyngeal volume	21	6,83	2,05	3,8	10,71
Oropharyngeal volume	21	21,87	5,09	13,3	29,93
Hypopharyngeal volume	21	7,28	1,71	3,63	9,98

On the other hand, in patients with class II, it was found that the oropharynx had the highest average volume, specifically 19.30cm3 with a standard deviation of 4.63. (Table 2).

Table 2. Upper airway volume in Facial Skeletal Pattern II

Variable	N	Media	D.S.	Mín.	Máx.
Nasopharyngeal volume	12	5,44	2,19	1,56	10,15
Oropharyngeal volume	12	19,30	4,63	11,59	25,19
Hypopharyngeal volume	12	6,25	2,39	3,4	9,87

When analyzing the upper airway in the nasopharynx across different skeletal patterns based on gender, a higher average was observed in men within Class I (6.99 ± 2.71 in men and 6.67 ± 1.84 in women), while in Class II a higher average was found in women (5.76 ± 2.62 in women and 4.79 ± 0.84). In the oropharynx, the average volume is greater in men compared to women in Class I, with an average of 24.36 ± 3.85. In Class II, the average is slightly higher in women with an average of 21.58 ± 3.75 and in men an average of 14.75 ± 2.12.

RECISATEC – REVISTA CIENTÍFICA SAÚDE E TECNOLOGIA
ISSN 2763-8405

In the hypopharynx, the average volume is slightly greater in women than men (7.39 ± 1.88 in women and 7.15 ± 1.65 cm3 in men) in Class I; in Class II, a higher average was found in women (7 ± 2.61 in women and 4.73 ± 0.63 in men).

Table 3. Airway volume according to the different Facial Skeletal Patterns

Vía aérea superior	I		II		F	P
	Media	D.S	Media	D.S		
Nasofaringe	6.83	2.05	5.44	2.19	3,08	0,0712
Orofaringe	21.87	5.09	19.30	4.63	10,29	0,0001
Hipofaringe	7.28	1.71	6.25	2.39	3,38	0,0823

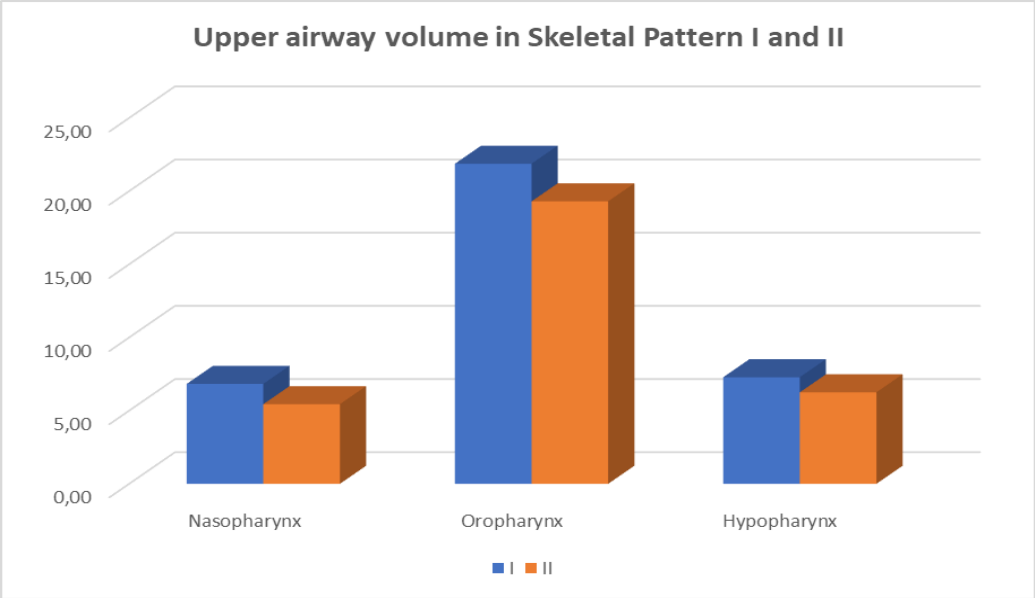

Figure 2. Upper airway volume in Skeletal Pattern I and II

When evaluating the upper airway based on the skeletal pattern, in the nasopharyngeal region, the highest average volume is found in individuals of Class I (6.83 cm3) and in Class II (5.44 cm3); in the oropharynx, it was greater in Class I (21.87 cm3) and in Class II (19.30 cm3). The average volume in the hypopharynx was high in Class I (7.28 cm3) and in Class II (6.25 cm3). The correlation between the two groups according to the skeletal pattern is statistically significant in the oropharynx ($p<0.05$) (Table 1).

DISCUSSIONS

Currently, the analysis of the upper airway in different facial skeletal patterns is highly significant, as it can be modified by orthognathic surgery. Cone-beam computed tomography (CBCT), in this case, is one of the best tools for diagnosis through 3D evaluation. There is limited information

RECISATEC – REVISTA CIENTÍFICA SAÚDE E TECNOLOGIA
ISSN 2763-8405

on the assessment of the airway in mestizo populations in Latin America, such as Ecuador, and specifically in a higher education institution. Therefore, the objective of this research was to examine the volume of the upper airway in different facial skeletal patterns in an Ecuadorian university population using CBCT. However, further studies with a larger sample size and over different time periods are needed to validate the results obtained in this study.

In order to determine the volume of the upper airway, anatomical boundaries were defined according to the specifications of Guijarro Martínez and Swennen. In their study, anatomical boundaries were established in the nasopharynx, oropharynx, and hypopharynx, allowing for potential reproducibility in other studies within the Latin American population. This establishes the standardization of the proposed anatomical boundaries, with the potential to homogenize the analysis of upper respiratory airway areas and enable comparisons between future studies.

In this descriptive cross-sectional study, 33 tomographies were analyzed, collected over a period of approximately 2 months. All of them were selected for the present study as they met the inclusion criteria. They were analyzed by two properly trained observers using Sidexis software version 4.2 on the same computer and under the calibration method by direct comparison.

The results of the study showed that the majority were female, and these data are consistent with the descriptions by Paredes et al. (1), Zheng et al., and Castro Silva et al. (10). The explanation for this is that the greater attendance for dental cosmetic treatment is from the female community. According to Dos Santos et al.'s study, the female population seeks to improve facial aesthetics through occlusion correction (11).

The average volume found in relation to the nasopharyngeal volume in Class I and II patients was 6.83 cm3 and 5.44 cm3 respectively; the values determined by Paredes et al, 5.9 cm3, 6.4 cm3 and 7.3 cm3 with respect to Class I, II and III, Zheng et al with 5.4 cm3, 4.05 cm3 and 6.05 cm3; concluded values not very similar to our study. Claudio et al., (3) specified the oropharyngeal and hypopharyngeal volume, in addition to the lower pharyngeal region, with values for Class I, II and III of 20.5 cm3, 21.1 cm3 and 29.9 cm3, respectively; having the mean in the present study of 21.87 cm3 and 19.30 cm3. The ethnic origin of the populations and the sample examined are determinants factors for differences between studies, however, the results coincide with those proposed by Claudio, et al. In the data collection, patients with Class III were not evaluated, despite this, this type of patients in other studies presented a high average value of upper airway volume, since in those patients a greater volume in oropharyngeal and hypopharyngeal was identified due to protrusion of the mandible with respect to the upper jaw; which coincides with the study by Kikuchi et al., it explains that the increase in volume is due to the anteroposterior position of the lower jaw (12).

The determinant of sex did not have significant differences in the nasopharyngeal region as identified in the article proposed by Zheng et al. However, higher average values were manifested in the hypopharyngeal area in male subjects of Class II and III being statistically significant ($p<0.05$). There was no comparison for Class III due to its absence in the study population. These results is due

to the sexual dimorphism observed in the laryngeal region. Mohsein et al., (13) mentioned in their study that there is a limitation of the upper airway in female due to the local anatomy of the cricoid cartilage.

In the study by Castro-Silva et al., (10) it was determined that in the Class III population, the mean volume of the airway was greater than in Class I and II, which is consistente with the description by Iwasaki et al., who indicates that Class III is related to the oropharyngeal zone, which is larger than Class I (14). In the present study, the volumes of subjects with Class III were not observed; therefore, the volumes in relation to nasopharyngeal, oropharyngeal, and hypopharyngeal were not analyzed. Through the study conducted by Hong et al. (15 where the pharyngeal airway is correlated with the anterior position of the lower jaw, it is mentioned that the posterior position of the lower jaw can displace the tongue and soft palate to decrease the volume of the upper airway, which contradicts the previously stated (8).

When compared with other authors, it could be established that the upper airway will vary in size depending on different variables such as biotype, facial skeletal pattern, sex, age etc. For example, Humaní in his study recorded that subjects with a dolichofacial biotype will register a lower oropharyngeal volume than mesofacial and brachyfacial subjects, but no significant difference was found (2).

It is important to take into account the role of measuring the upper airway when planning surgery, as evidenced by the different studies conducted; this measurement can increase or decrease depending on the different procedures performed, as in the case of Bimaxillary surgery for correcting a Class III malocclusion, which will result in a decrease in airway volume (16). On the other hand, in the study conducted by Wiedemeyer et al., an increased measurement of airway volume will be found in patients with a Class II malocclusion undergoing mandibular advancement surgery (17). Similarly, studies conducted by ChengHui Lin (18) and Faur (19) demonstrated that procedures such as Bimaxillary advancement and counterclockwise maxillomandibular rotation can be performed in patients with decreased airway volume, resulting in a decrease in apnea indices.

CONCLUSIONS

The volume measurements in the nasopharyngeal, oropharyngeal, and hypopharyngeal in the Ecuadorian population are variable depending on the skeletal pattern of each patient.

It was found that upper airway volume in different skeletal patterns according to sex is greater in females in the hypopharyngeal with significant differences for Class I and II patients. Additionally, a relationship was found between upper airway volume according to skeletal pattern, being statistically significant in oropharyngeal, where Class I was greater, followed by Class II respectively. Within the analyzed data, there were no Class III skeletal patterns; therefore, no significant differences were recorded when compared to other studies. It is recommended to conduct a study with a larger population that can evaluate different skeletal patterns.

RECISATEC – REVISTA CIENTÍFICA SAÚDE E TECNOLOGIA
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