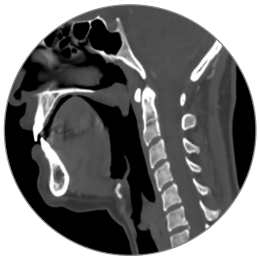

Pre-Surgical and Post-Surgical Assessment of the Upper Airway by Computed Tomography in Patients with Obstructive Sleep Apnea Hypopnea Syndrome Undergoing Maxillomandibular Advancement Surgery

Valoración pre y posquirúrgica de la vía aérea superior por tomografía computarizada, en pacientes con síndrome de apnea-hipopnea obstructiva del sueño sometidos a cirugía de avance maxilomandibular

Key words (MeSH)

Palate
Sleep apnea syndromes
Mandibular advancement
Tomography

Palabras clave (DeCS)

Paladar
Síndromes de la apnea del sueño
Avance mandibular
Tomografía

Luis Manuel Alejandro Acosta Rosas[1]
Félix Andrés Martínez Ballesteros[1]
Martín Fernando Orozco[2]
Claudia Patricia Dávila[3]
Germán Galvis[3]
Andrés Felipe Cáliz Cabrales[4]
Kelly Estrada-Orozco[5]

[1]Radiologist, specialist in Epidemiology. Fundación Universitaria Sanitas, Organización Sanitas Internacional. Bogotá, Colombia.

[2]Oral and maxillofacial surgeon. Chief of the Maxillofacial Surgery Service, Clínica Universitaria Colombia Department of Oral and Maxillofacial Surgery. Bogotá, Colombia.

[3]Physician radiologist, Department of Radiology and Diagnostic Imaging, Clínica Universitaria Colombia. Assistant Professor, Fundación Universitaria Sanitas. Bogotá, Colombia.

[4]Physician, resident of Radiology and Diagnostic Imaging, Fundación Universitaria Sanitas. Bogotá, Colombia.

[5]Doctor, MSc in Clinical Epidemiology, PhD (c) Epidemiology. Epidemiology, PhD (c) Clinical Epidemiology. Epidemiology. PhD (c) Public Health. Foundation Sanitas University Foundation. Bogotá, Bogotá, Colombia.

Department of Radiology and Diagnostic Imaging, Clínica Universitaria Colombia. Fundación Universitaria Sanitas. Bogotá, Colombia.

Summary

Introduction: Obstructive sleep apnea-hypopnea syndrome (OSAHS) secondary to craniofacial malformations increases morbidity and decreases quality of life of the patient. ***Objective:*** To describe the anatomical characteristics of the airway before and after surgery, in patients with OSAHS secondary to craniofacial malformations undergoing maxillo-mandibular advancement surgery. ***Methodology:*** This was a descriptive observational study in adults with OSAHS secondary to craniofacial malformations, attending the Clínica Universitaria Colombia, whom underwent maxillo-mandibular advancement surgery between December 2013 and October 2018. Pre-surgical and post-surgical measures at predefined anatomical repair points were analyzed, as well as the magnitude of the post-intervention change. ***Results:*** 57.17 % of the patients presented between 2 to 4 malformations, and the remaining 42.86 % presented 5 or more. The anatomical landmarks that presented significant changes in the post-surgical measures in subjects with 2 to 4 malformations were: The upper pharyngeal space 4.78 mm (SD 1.92), lower pharyngeal space 4.5 mm (SD 3.25), base of the epiglottis 3.21 mm (SD 2.80), the soft palate 4.92 mm (SD 2.84), the midpoint between the soft palate and the base of the epiglottis in its AP diameter 4.42 mm (SD 3.13) and transverse diameter 5.42 mm (SD 4.83). All patients with severe OSAHS presented post-surgical changes with statistically significant differences values that vary between 6.27 mm (p value 0.0011) and 4.72 mm (p value 0.0000). ***Conclusions:*** The changes in the pre- and post-surgical measures of airway anatomic landmark patients with OSAHS were characterized. These findings can be a guide for the radiologist at the time of reporting a study for this purpose, helping in the surgical planning and follow up of patients.

Resumen

Introducción: el SAHOS secundario a malformaciones craneofaciales conlleva aumento en la morbilidad y deterioro en la calidad de vida del paciente. ***Objetivo:*** describir las características prequirúrgicas y cambios posquirúrgicos en la vía aérea, en pacientes sometidos a cirugía de avance maxilomandibular por SAHOS secundario a malformaciones craneofaciales. ***Metodología:*** Estudio observacional descriptivo en adultos con SAHOS secundario a malformaciones craneofaciales sometidos a cirugía de avance maxilomandibular entre diciembre del 2013 y octubre del 2018. Se analizaron las medidas prequirúrgicas y posquirúrgicas, así como la magnitud del cambio postintervención. ***Resultados:*** En la muestra se encontró el 57,17 % de los pacientes con 2 a 4 malformaciones, seguido del 42,86 % con 5 o más. Los reparos anatómicos con cambios significativos en las medidas posquirúrgicas, en el primer grupo fueron: espacio faríngeo superior, 4,78 mm (DE 1,92); espacio faríngeo inferior, 4,5 mm (DE 3,25); base de la epiglotis, 3,21 mm (DE 2,80); paladar blando, 4,92 mm (DE 2,84); punto medio entre el paladar blando y la base de la epiglotis en su diámetro AP, 4,42 mm (DE 3,13); y transverso, 5,42 mm (DE 4,83). Todos los pacientes con un grado de SAHOS severo tuvieron cambios posquirúrgicos con valores de diferencias estadísticamente significativas que varían entre 6,27 mm (*p* 0,0011) y 4,72 mm (*p* 0,0000). ***Conclusiones:*** Se caracterizó el cambio en las medidas pre y posquirúrgicas de los puntos de reparo de la vía aérea en los pacientes con SAHOS. Estos hallazgos pueden ser una guía para el radiólogo al momento de escribir el informe de un estudio, para ayudar en la planeación quirúrgica y el seguimiento de los pacientes.

Introduction

Obstructive sleep apnea-hypopnea syndrome (OSAHS) is the most common disorder within the spectrum of sleep-related breathing disorders. This disease is important for patients, as it leads to impaired neurocognitive function, excessive sleepiness, decreased quality of life, and is associated with hypertension, insulin resistance, and cardiovascular disease (1, 2).

Retrognathia, micrognathia and transverse deficiencies of the maxilla are among the most frequently found anomalies in patients with OSAHS, since these facial alterations generate a decrease in the diameter of the airway; therefore, maxillo-mandibular advancement surgery (MMA) is performed in order to enlarge the diameter of the airway while maintaining an adequate dental occlusion pattern. MMA is a surgical procedure that increases the diameter and stabilizes the skeleton of the velorohypopharyngeal airway, improving the neuromuscular tone of the pharynx, as well as the soft palate and the base of the tongue (3).

Comparison of the pre and post-surgical results of the airway by direct visualization with nasopharyngoscopy and lateral radiography have shown that the procedure, in addition to increasing the diameter of the airway due to the anterior displacement of the maxillo-mandibular complex, also decreases the tensile forces that collapse the suprahyoid and velopharyngeal airway, which generates a decrease in the damage caused on the pharyngeal wall. Therefore, at the time of surgery, adequate fixation with osteosynthesis and stabilization of the segments with bone grafts, when indicated, should be performed (3).

Currently, the pre and post-surgical evaluation, as well as the surgical planning of these patients, is performed with cephalometry by means of lateral radiography, inferring an approximate volume of the airway only with its anteroposterior measurement in the repair points, which is not the best diagnostic method to evaluate the real diameter of the airway, since the radiography does not allow to evaluate the soft tissues or the muscular structures, besides providing only a two-dimensional and non-dynamic image (4). Although the gold standard for the treatment of OSAHS is positive air pressure therapy (PAP), surgical intervention is considered in patients with therapeutic failure and treatable craniofacial alterations, even considered in the guidelines recommended by the American College of Physicians (5). Some centers that use surgery as a treatment perform an analysis with radiography in conjunction with nasofibrolaryngoscopy to take into account the soft tissues that influence this pathology (6). Considering the limitations of simple radiographic evaluation of the airway in patients with OSAHS, the use of CT could be considered in surgical planning and post-surgery follow-up. In the tomographic evaluation, the following are evaluated: anteroposterior diameter of the airway at the level of the hard palate, at the base of the epiglottis, in the retropalatal region and in the retroglossal space; additionally, the anteroposterior and posterior diameters of the airway at the base of the epiglottis, in the retropalatal region and in the retroglossal space, the anteroposterior and lateral diameters of the airway, measurements that have been have been previously considered as predictors of OSAHS (7).

CT significantly improves the assessment of soft tissues and allows precise measurements of the anteroposterior, transverse and longitudinal diameter of the airway at different levels by means of axial acquisition and multiplanar reconstructions, allowing an adequate estimation of the airway volume (4). On the other hand, the three-dimensional reconstruction of the bony structures provides the surgeon with relevant anatomical relevant anatomical information that facilitates surgical planning, with adequate planning, with an adequate geometry and visualization of the airway caliber of the airway, which allows to offer the patient the best functional result of his airway and decreases functional outcome for the patient's airway and reduces the degree of intraoperative error, which leads to an improvement in the functional success of the surgery (4).

Little has been studied on the pre and post-surgical characteristics of patients with OSAHS secondary to altered airway patients with OSAHS secondary to craniofacial alterations by CT, who undergo MMA; neither have the changes in airway diameter, airway the diameter of the airway, for which reason, a study will be carried out in the Colombian population, describing Colombian population that describes these changes by CT and assesses changes in airway diameter in these patients.

Materials and Methods

A descriptive observational study was conducted on ambispective data of patient care between December 2013 and October 2018, in adult patients with a diagnosis of obstructive sleep apnea-hypopnea syndrome (OSAHS), secondary to malformations of the craniofacial architecture confirmed by polysomnography, who required surgical treatment with MMA surgery treated in the Oral and Maxillofacial Surgery service of the institution to which the authors of this article belong. Images of adults (over 18 years of age) with OSAHS diagnosed by a sleep medicine physician, oral and maxillofacial surgeon or otolaryngologist with obstructive sleep apnea-hypopnea syndrome and secondary to malformations of the craniofacial architecture with diagnosis confirmed by polysomnography and nasofibrolaryngoscopy were included. Exclusion criteria were tomographic studies with acquisition deficits (image artifacts) that prevented an adequate assessment of the airway or presented incomplete data in their medical records.

There was no sampling; the entire population of subjects who met the inclusion and exclusion criteria was analyzed.

The CT studies were filed in the IMPAX system. Eight landmarks, established in previous publications as predictors of OSAHS (7, 10), were defined as follows:

- **Upper pharyngeal space:** anteroposterior (AP) diameter of the airway. It is measured in the sagittal reconstruction at the level of the uppermost edge of the hard palate (Figure 1).
- **Lower pharyngeal space:** AP diameter of the airway measured on the sagittal reconstruction at the level of the most inferior border of the mandible. The AP diameter is measured from the anterior wall to the posterior wall of the airway (Figure 2).
- **Distance from the hyoid to the mandible:** The highest point of the hyoid bone is located at the height of the midline, then in the axial plane it slides to the end of the mandible and at this point it is referred to the sagittal plane and the distance to the inferior border of the mandibular body is measured (figure 3).
- **AP diameter of the airway at the base of the epiglottis:** In the sagittal reconstruction, in the midline the base of the epiglottis is identified and at this level the AP diameter from the anterior wall to the posterior wall of the airway is measured (Figure 4).
- **AP diameter at the soft palate:** In the sagittal reconstruction, in the midline the most distal part of the soft palate is identified (inferoposterior aspect) and at this point the AP diameter is measured from the anterior wall to the posterior wall of the airway (Figure 5).
- **AP diameter at the midpoint between the soft palate and the base of the epiglottis:** In the sagittal reconstruction at the height of the midline the most distal part of the soft palate and the base of the epiglottis are identified, a cephalocaudal line is drawn between these two points and in the middle of this value the AP diameter from the anterior wall to the posterior wall of the airway is measured (figure 6).
- **Transverse diameter of the airway at the midpoint between the soft palate and base of the epiglottis:** At the location of the previous item, in the axial acquisition the distance between the most lateral walls of the airway is measured (Figure 7).
- **Diameter for tongue position:** In the sagittal reconstruction at midline height, the cephalocaudal distance is measured at the point of greatest amplitude between the tongue and the palate (Figure 8).

The measurements acquired were included in a standardized data recording format and a pilot test was performed in order to verify that the recording instrument was suitable for use; the necessary adjustments were made after the application of the pilot test. The pre and post-surgical data obtained were systematized in Excel for subsequent analysis, as well as the different study variables.

For the analysis of the information, a database was created in Excel with the information collected from each patient, according to the codification of the established variables, with a descriptive and analytical component. The results were presented by means of absolute and relative frequencies, proportions, and measures of central tendency and dispersion. Differences in pre- and post-surgical diameters were established using non-parametric tests for paired data. The STATA® version 13 program was used.

The present study was approved by the research ethics committee of the Fundación Universitaria Sanitas, by act No. 002-18 of January 2018.

Results

Of the 19 patients collected between December 2013 and October 2018, 2 were excluded because the data of interest were not found to be complete in the clinical history and 3, due to lack of pre- or postsurgical CT images; finally, 14 patients were analyzed.

Of the total number of patients analyzed, 28.57 % were women and 71.43 % were men; the mean age of the sample was 42.07 years (standard deviation SD 8.5). The 78.75 % presented severe OSAHS (apnea events per hour > 40 or minimum SaO2 achieved in sleep [80-85 %]) and in smaller proportion mild OSAHS (5-15 apnea events per hour [7.14 %]), the number of apnea events per hour in these patients was on average 49.14 (SD 22.09). Regarding the type of craniofacial malformations (Table 1), 57.17 % of the patients presented between 2 to 4 malformations, followed by 42.86 %, with 5 or more; no patient presented a single malformation. Regarding family history of sleep apnea, 85.71 % of the patients reported no history (Table 2).

Table 1. Types of maxillo-mandibular malformations described

Anatomical structure	Type of malformation
Nasal cavity	Collapse of pyriform openings High nasal floor Septodeviation Hypertrophy of turbinates Polyps Masses Nasal adhesions
Soft palate and uvula	Excessive elongation or flexibility of the uvula
Adenoids and tonsils	Chronic adenoid hypertrophy Chronic hypertrophy of tonsils
Tongue	Macroglossia Retropositioning
Maxilla	Retrognathism Micrognathism Transverse collapse
Mandible	Retrognathism Micrognathism Transverse collapse
Pharynx	Pharyngeal muscle hypertrophy
Alterations in the position of the hyoid and epiglottis	Present/absent

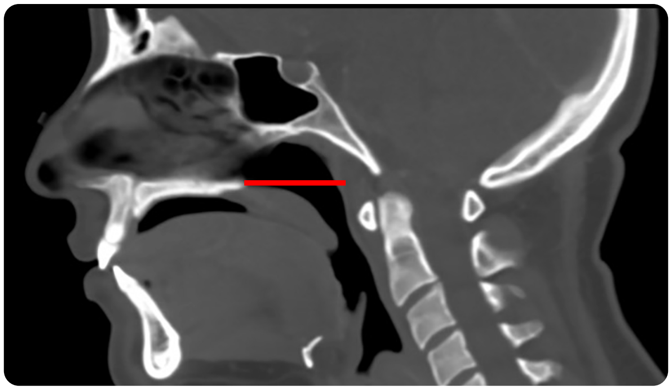

Figure 1. Upper pharyngeal space: sagittal reconstruction of scanography in the midline, the red line shows the anteroposterior (AP) diameter of the airway with the most superior border of the hard palate as reference.

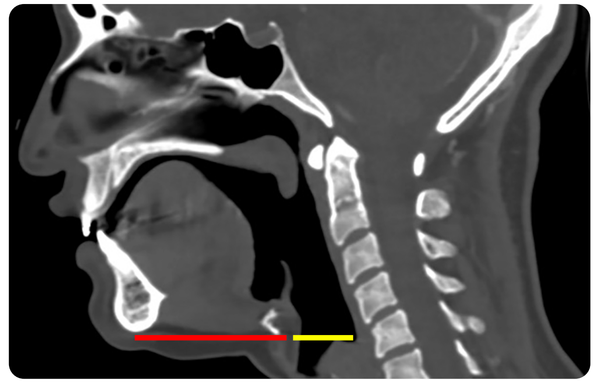

Figure 2. Lower pharyngeal space: sagittal scanning reconstruction: a line (red) is drawn at the level of the lower border of the mandible; the yellow line shows the anteroposterior (AP) diameter from the anterior wall to the posterior wall of the airway, at this level.

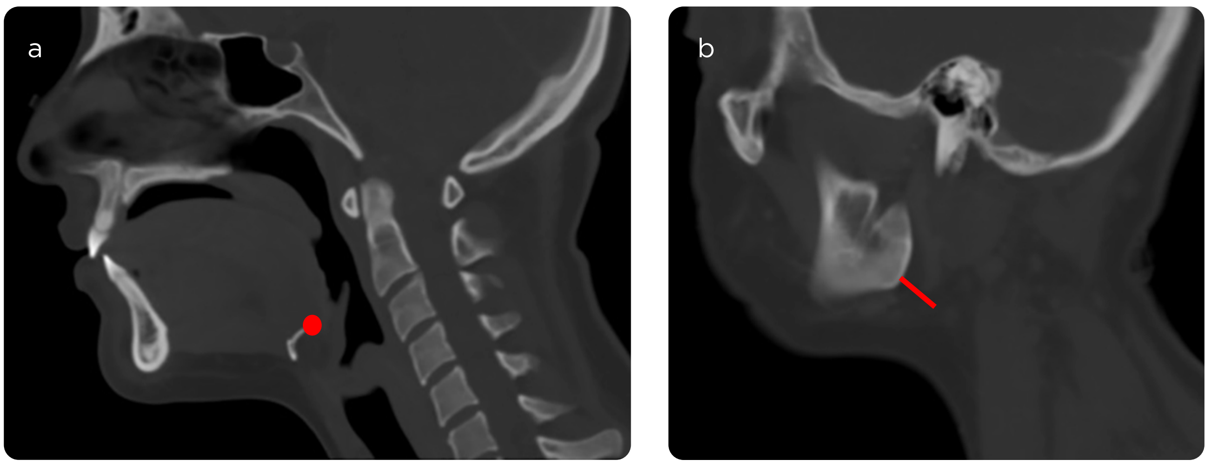

Figure 3. Distance from the hyoid to the mandible. a) Sagittal reconstruction of scanography. The highest point of the hyoid bone at this level is located in the midline, it slides to the end of the mandible. b) At this point the distance to the inferior border of the mandibular body is measured.

Figure 4. AP diameter at the base of the epiglottis: sagittal reconstruction of scanography. The base of the epiglottis is identified and at this height the AP diameter from the anterior wall to the posterior wall of the airway is measured.

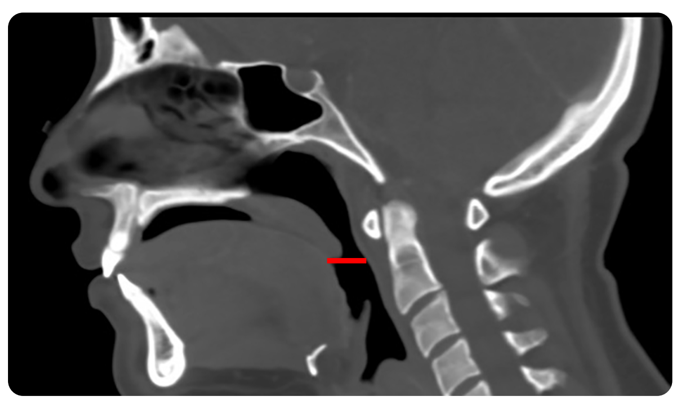

Figure 5. AP diameter in the soft palate: sagittal reconstruction of scan in the midline. The most distal part of the soft palate is identified (inferoposterior aspect) and at this point the AP diameter is measured from the anterior wall to the posterior wall of the airway.

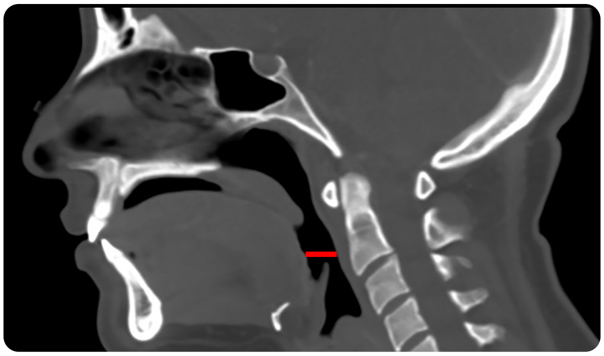

Figure 6. AP diameter at the midpoint between the soft palate and the base of the epiglottis: sagittal reconstruction of midline scan, measuring the AP diameter from the anterior wall to the posterior wall of the airway, at the midpoint between figures 4 and 5.

Figure 7. Transverse diameter of the airway at the midpoint between the soft palate and the base of the epiglottis: in axial acquisition of tomography, at the location of figure 6, the distance between the most lateral walls of the airway is measured.

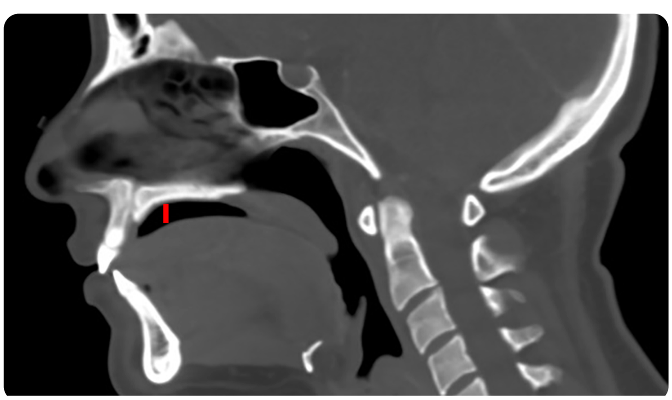

Figure 8. Diameter for tongue position: sagittal reconstruction of midline scan, the cephalo-caudal distance is measured at the point of greatest amplitude between the tongue and the palate.

Table 2. Characteristics of the sample

Sample characteristics n (%)		N: 14	
		95% CI	
Age*		42.07 (8.5)	37.2-46.9
Sex	Female	4 (28.57)	4.9-52.2
	Male	10 (71.43)	41.9-91.7
Degree of apnea	Mild	1 (7.14)	0.2-33.9
	Moderate	2 (14.29)	1.7-42.9
	Severe	11 (78.75)	49.2-95.4
Number of apnea events/hour*		49.14 (22.09)	36.3-61.9
Number of craniofacial malformations	Unique	0	
	2 a 4	8 (57.14)	31.2-83.1
	>5	6 (42.86)	16.9-68.8
Family history of sleep apnea	No	12 (85.71)	57.2-98.2
	Yes	2 (14.29)	1.7-42.9

* Mean (standard deviation)

All the patients analyzed had collapse of the piriform openings and maxillary retrognathism 100% (14 patients), 78.57% (11 patients), excessive lengthening or flexibility of the uvula and retropositioning of the tongue, followed by mandibular retrognathism 64.28% (9 patients) and micrognathism of the mandible 57.14% (8 patients). Regarding the other malformations related to the nasal cavity, it was found that 42.85 % (6 patients) had high nasal floor, followed by septum deviation with 35.75 % (5 patients) and turbinate hypertrophy in 28.57 % (4 patients) of the cases; similarly, micrognathia was observed in 28.57 % (4 patients) and 21.42 % (3 patients) had alterations in the position of the hyoid and epiglottis. Chronic hypertrophy of the adenoids and hypertrophy of the pharyngeal muscles were not found in any patient.

In the total sample it was observed that the average difference achieved in the upper pharyngeal space was 4.78 mm (SD 1.92) and in the lower pharyngeal space was 4.5 mm (SD 3.25). Regarding the average distance from the hyoid bone to the base of the mandible, an average decrease of 3.9 mm was observed after surgery. At the base of the epiglottis an average difference of 3.21 mm (SD 2.80) was observed, while at the soft palate the average difference reached was 4.92 mm (SD 2.84).

The average difference reached at the midpoint between the soft palate and the base of the epiglottis in its AP diameter was 4.42 mm (SD 3.13), while in its transverse diameter it was 5.42 mm (SD 4.83), and in the diameter for the tongue position, the average difference reached was 2.35 mm (SD 4.92) (Table 3)

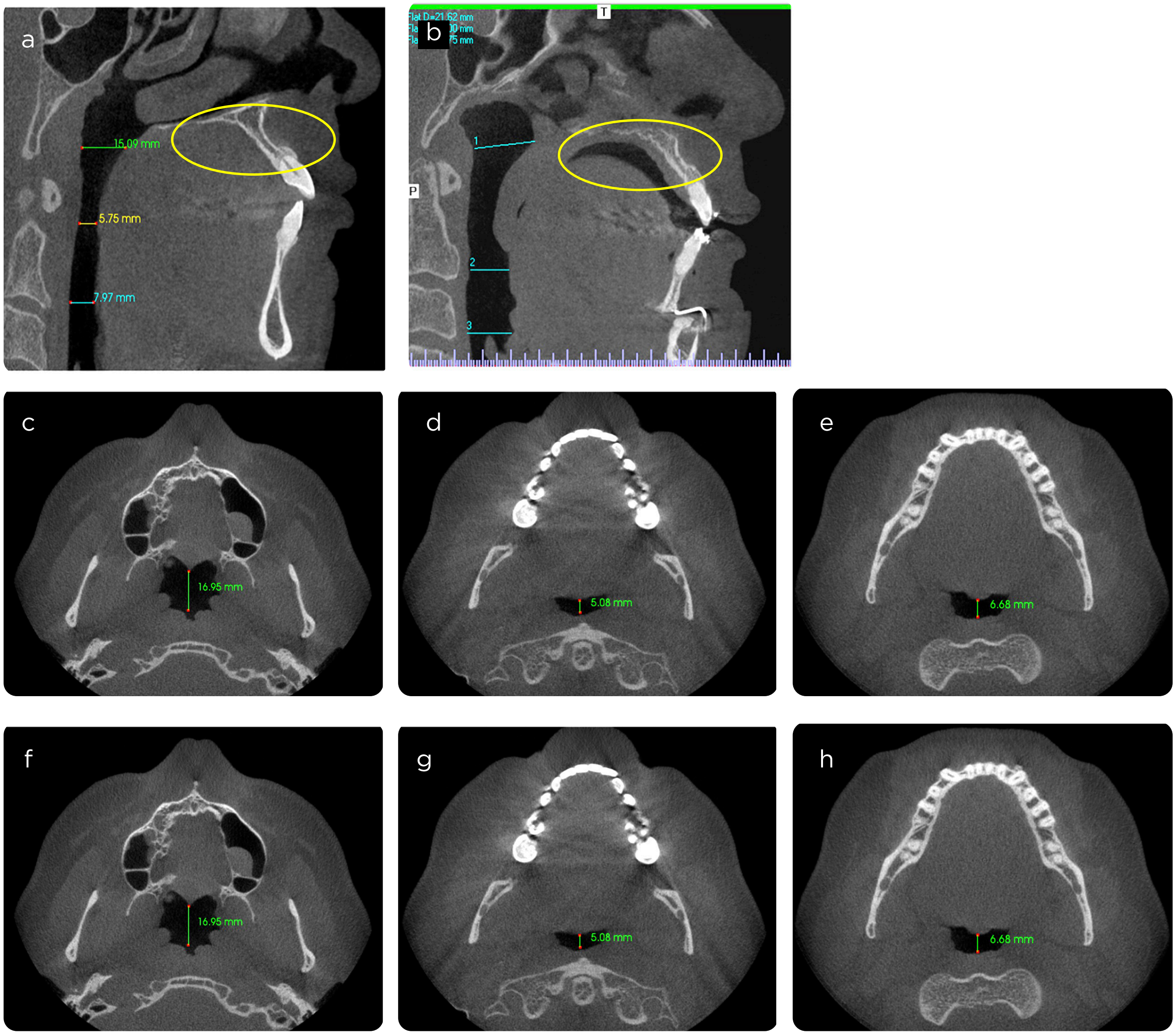

Figure 9. Patient undergoing MMA surgery. a) Pre-surgical patient, sagittal CT neck reconstruction, with airway measurements (green, yellow and blue lines). The space available for the position of the tongue is visualized (orange circle) where it is observed that the tongue, not having space due to the anatomical alteration, moves dorsally obstructing the airway. b) Post-surgical patient, sagittal CT neck reconstruction. There is an increase in the diameters of the airway and the space for the position of the tongue; the air column not previously visualized in this location can be seen (orange circle). c-e) Pre-surgical patient. Axial CT acquisition of the neck with airway measurements at three levels. f-h). Post-surgical patient. Axial acquisition of neck CT: increased airway diameters at different levels are observed.

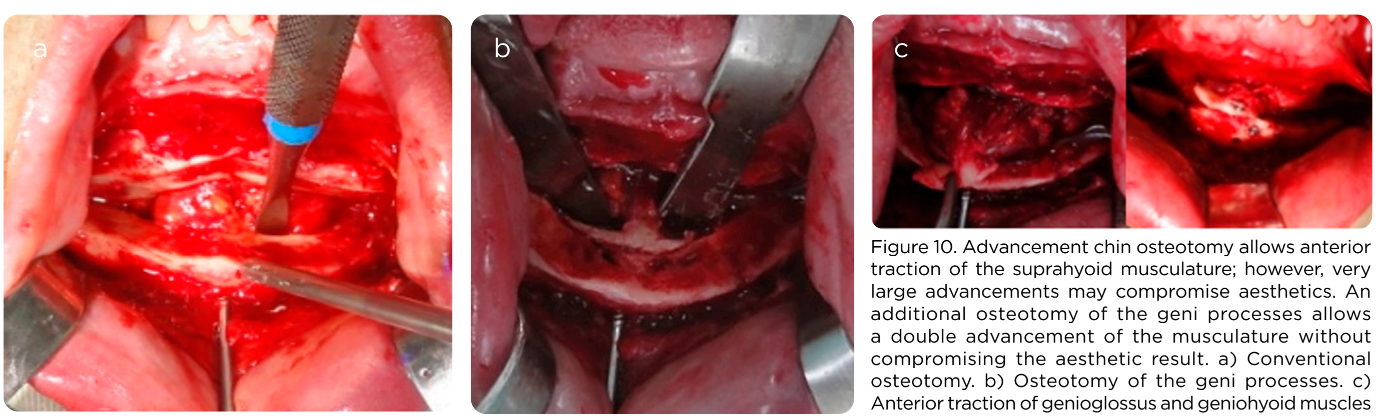

Figure 10. Advancement chin osteotomy allows anterior traction of the suprahyoid musculature; however, very large advancements may compromise aesthetics. An additional osteotomy of the geni processes allows a double advancement of the musculature without compromising the aesthetic result. a) Conventional osteotomy. b) Osteotomy of the geni processes. c) Anterior traction of genioglossus and geniohyoid muscles with fixation to the external cortex of the chin.

Table 3. Pre- and post-surgical airway measurements (repair points) by number of malformations*

	Anatomical repairs	Pre-qx. measurement [mean (sd)] [mean (sd)]		Post-qx. measure [mean (sd)] CI.95%	CI 95%	Difference [mean (sd)]	p-value
Number of malformations	Upper pharyngeal space (AP)	20.5 (6.3)	16.9-24.13	25.28 (5.6)	22.0-28.5	4.78 (1.92)	0.0009
	2 a 4	22.62 (5.82)	19.2-25.9	27 (6.18)	23.4-30.5	4.37 (1.30)	0.0000
	≥ 5	17.66 (6.25)	14.0-21.2	23 (4.19)	20.5-25.4	5.33 (2.58)	0.0020
Number of malformations	Lower pharyngeal space (AP)	13.78 (3.5)	11.8-15.9	18.28 (2.97)	16.5-19.9	4.5 (3.25)	0.0011
	2 a 4	14.62 (2.55)	13.1-16.1	18.5 (3.46)	16.5-20.5	3.87 (3.39)	0.0073
	≥ 5	12.66 (4.50)	10.1-12.2	18 (2.44)	16.5-19.4	5.33 (3.14)	0.0044
Number of malformations	Distance from the hyoid bone to the base of the mandible	16.28 (5.8)	12.9-19.7	12.35 (4.9)	9.5-15.1	- 3.9 (4.42)	0.0074
	2 a 4	15.12 (4.67)	12.4-17.9	11.37 (3.33)	9.4-13.2	- 3.75 (3.84)	0.9859
	≥ 5	17.83 (7.22)	13.7-21.2	13.66 (6.62)	9.8-17.4	- 4.16 (5.49)	0.9389
Number of malformations	Base of epiglottis (AP) airway measurements (pre and post-surgical repair points by number of malformations)	13.64 (3.7)	11.5-15.8	16.85 (3.5)	14.9-18.9	3.21 (2.80)	0.0018
	2 a 4	14.37 (3.33)	12.4-16.2	17.75 (3.73)	15.5-20.0	3.37 (2.61)	0.0041
	≥ 5	12.66 (4.41)	10.2-15.2	15.66 (3.14)	13.9-17.4	3 (3.28)	0.0378
Number of malformations	Soft palate (AP)	10.78 (3.6)	8.7-12.9	15.71 (2.58)	14.2-17.1	4.92 (2.84)	0.0011
	2 a 4	11.87 (3.60)	9.79-13.94	16.12 (3.04)	14.3-17.9	4.25 (3.37)	0.0046
	≥ 5	9.33 (3.44)	7.3-11.3	15.16 (1.94)	14.0-16.2	5.83 (1.83)	0.0003
Number of malformations	Midpoint between soft palate and base of epiglottis (AP)	11.85 (3.20)	10.0-13.7	16.28 (3.95)	14.0-18.5	4.42 (3.13)	0.0011
	2 a 4	12.75 (2.60)	11.2-14.2	17 (4)	14.7-19.3	4.25 (3.69)	0.0070
	≥ 5	10.66 (3.77)	8.4-12.9	15.33 (4.03)	13.0-17.7	4.66 (2.50)	0.0030
Number of malformations	Midpoint between soft palate and base of epiglottis (Transverse)	24.07 (5.34)	20.9-27.1	29.5 (5.95)	26.0-33.0	5.42 (4.83)	0.0011
	2 a 4	25.87 (5.64)	22.7-29.1	30.37 (4.71)	27.6-33.0	4.5 (3.54)	0.0044
	≥ 5	21.66 (4.17)	19.2-24.0	28.33 (7.63)	24.0-32.8	6.66 (6.31)	0.0245
Number of malformations	Diameter for tongue position	2 (2.60)	0.5-3.5	4.35 (3.79)	2.2-6.5	2.35 (4.92)	0.1085
	2 a 4	1.25 (2.81)	- 0.37 a 2.87	4.37 (4.53)	1.8-7.0	3.12 (5.38)	0.0723
	≥ 5	3 (2.09)	1.8-4.2	4.33 (2.94)	2.6-6.0	1.33 (4.50)	0.2503

*Diameter in mm.

In patients with 2 to 4 malformations and in the group with 5 or more craniofacial malformations, it was observed that the mean post-surgical distance in the upper pharyngeal space was greater than the pre-surgical distance (27 mm versus 22.62 mm; MD 4.37 mm [p <0.05]) and (23 mm versus 17.66 mm; MD 5.33 mm [p 0.0020]), respectively. The same was observed in the inferior pharyngeal space (18.5 mm versus 14.62 mm; MD 3.87 mm [p 0.0073]) and (18 mm versus 12.66 mm; MD 5.33 mm [p 0.0044]), respectively. This was also observed at the base of the epiglottis (17.75 mm versus 14.37 mm; MD 3.37 mm [p 0.0041]) and (15.66 mm versus 12.66 mm; MD 3mm [p 0.0378]), and in the soft palate (16.12 mm versus 11.87 mm; MD 4.25 mm [p 0.0046]) and (15.16 mm versus 9.33 mm; MD 5.83 mm [p 0.0003]). This finding was similarly observed at the midpoint between the soft palate and the base of the epiglottis (AP) (17 mm versus 12.75 mm; MD 4.25 mm [p 0.0070]) and (15.33 mm versus 10.66 mm; MD 4.66 mm [p 0.0030]), as well as at the midpoint between the soft palate and the base of the epiglottis (transverse) (30.37 mm versus 25.87 mm; MD 4.5 mm [p 0.0044] and (28.33 mm versus 21.66 mm; MD 6.66 mm [p 0.0245]).

The other distances showed no significant differences in their pre- and post-surgical means when assessed according to the number of craniofacial malformations of the patient; details are in Table 3.

In the group of patients with a severe degree of OSAHS, it was observed that the mean post-surgical distance in the superior pharyngeal space and inferior pharyngeal space was greater than the pre-surgical distance (26.18 mm versus 21.45 mm; MD 4.72 mm [p 0.0000]) and (18.72 mm versus 13.54 mm; MD 5.18 mm [p 0.0002]). The same was observed in the soft palate (16.45 mm versus 11.36 mm; MD 5.09 mm [p 0.0001]), and at the midpoint between the soft palate and the base of the epiglottis in its transverse diameter (30.27 mm versus 24 mm; MD 6.27 mm [p 0.0011]). The rest of the distances did not show significant differences in their pre and post-surgical means. Details can be seen in Table 4).

Table 4. Airway measurements (repair points) pre and post-surgical by severity of OSAHS*

	Anatomical repairs	Pre-qx. measurement [mean (sd)]	CI 95%	Measure postqx. [mean (sd)]	CI 95%	Difference [mean (sd)]	p-value
Degree of OSAHS	Upper pharyngeal space (AP)	20.5(6.3)	16.9-24.13	25.28(5.6)	22.0-28.5	4.78 (1.92)	0.0009
	Mild**	15		21		6	,,
	Moderate	18 (4.24)	15.5-20.3	22.5 (2.12)	21.1-23.8	1.5 (2.12)	0.1024
	Severe	21.45 (6.68)	17.5-25.3	26.18 (6.03)	22.7-29.7	4.72 (2.05)	0.0000
Degree of OSAHS	Lower pharyngeal space (AP)	13.78 (3.5)	11.8-15.9	18.28 (2.97)	16.5-19.9	4.5 (3.25)	0.0011
	Mild**	11		13		2	,,
	Moderate	16.5 (0.70)	16.0-16.9	18.5 (0.70)	18.1-18.9	2 (0)	,,
	Severe	13.54 (3.69)	11.4-15.7	18.72 (2.90)	17.0-20.4	5.18 (3.37)	0.0002
Degree of OSAHS	Distance from hyoid bone to base of mandible	16.28 (5.8)	12.9-19.7	12.35 (4.9)	9.5-15.1	- 3.9 (4.42)	0.0074
	Mild**	14		13		-1	,,
	Moderate	15 (8.48)	10.1-19.9	10 (0)	10.0-10.0	- 5 (8.48)	0.7211
	Severe	16.72 (5.96)	13.1-20.1	12.72 (5.49)	9.5-15.9	- 4 (4.14)	0.9952
Degree of OSAHS	Base of epiglottis (AP)	13.64 (3.7)	11.5-15.8	16.85 (3.5)	14.9-18.9	3.21 (2.80)	0.0018
	Mild**	10		12		2	,,
	Moderate	13 (4.24)	10.5-15.4	14.5 (3.53)	12.5-16.5	1.5 (0.70)	0.1024
	Severe	14.09 (3.88)	11.9-16.2	17.72 (3.25)	15.9-19.5	3.63 (3.04)	0.0013
Degree of OSAHS	Soft palate (AP)	10.78 (3.6)	8.7-12.9	15.71 (2.58)	14.2-17.1	4.92 (2.84)	0.0011
	Mild**	10		11		1	,,
	Moderate	8 (4.24)	5.5-10.3	14 (1.14)	13.3-14.7	6 (2.82)	0.1024
	Severe	11.36 (3.66)	9.2-13.4	16.45 (2.25)	15.1-17.8	5.09 (2.80)	0.0001
Degree of OSAHS	Midpoint between soft palate and base of epiglottis (AP)	11.85 (3.20)	10.0-13.7	16.28 (3.95)	14.0-18.5	4.42 (3.13)	0.0011
	Mild**	9		10		1	,,
	Moderate	11 (0)	11.0-11.0	13 (0)	13.0-13.0	2 (0)	,,
	Severe	12.27 (3.49)	10.2-14.3	17.45 (3.55)	15.4-19.5	5.18 (3.12)	0.0001
Degree of OSAHS	Midpoint between soft palate and base of the epiglottis (Transverse)	24.07 (5.34)	20.9-27.1	29.5 (5.95)	26.0-33.0	5.42 (4.83)	0.0011
	Mild**	23		25		2	,,
	Moderate	25 (11.31)	18.5-31.5	27.5 (9.19)	22.2-32.9	2.5 (2.12)	0.1720
	Severe	24 (4.89)	21.1-26.9	30.27 (5.84)	26.9-33.7	6.27 (5.12)	0.0011
Degree of OSAHS	Diameter for tongue position	2 (2.60)	0.5-3.5	4.35 (3.79)	2.2-6.5	2.35 (4.92)	0.1085
	Mild**	0		1		1	,,
	Moderate	2 (0)	2.0-2.0	4 (1.41)	3.2-4.9	2 (1.41)	0.1476
	Severe	2.18 (2.89)	0.5-3.9	4.72 (4.14)	2.3-7.1	2.54 (5.57)	0.0804

*Diameter in mm; **Single value (no standard deviation and no confidence interval); '' Few measures

The aim of this study is to describe the pre-surgical characteristics and post-surgical changes in the airway, assessed by CT, in patients who underwent MMA surgery for obstructive sleep apnea-hypopnea syndrome secondary to craniofacial architectural malformations.

In the sample analyzed it was found that the anatomical repairs that presented post-surgical changes were the upper and lower pharyngeal space, base of the epiglottis, soft palate, the midpoint between the soft palate and the base of the epiglottis in its AP and transverse diameter in the group of patients who presented between 2 to 4 and 5 or more craniofacial malformations, with significant differences. Additionally, in all patients with a severe degree of OSAHS, post-surgical changes were obtained in the upper and lower pharyngeal space, in the soft palate and in the midpoint between the soft palate and the base of the epiglottis in its transverse diameter, with statistically significant differences (Figures 9 and 10).

These results are similar to those described by Fairburn et al.(8), Faria et al. (9), Abramson et al. (10), Li (4) and Sittita vorn wong et al.(7) who demonstrated significant increases in the upper pharyngeal space, epiglottis base, hard palate and soft palate, midpoint between the soft palate and epiglottis base in their AP and transverse diameter, after MMA surgery. The analysis of the study in relation to the number of malformations provides new information, since, although it is known that airway parameters correlate with the presence and severity of OSAHS, changes based on this characteristic have not been previously evaluated (10).

In the results we found no significant differences in the distance from the hyoid bone to the base of the mandible and in the diameter for tongue position in patients with 2 or more craniofacial malformations, and the degree of OSAHS did not seem to have differences in terms of increased measurements in these anatomical repairs; the above may be due to the low sample size, which translates into a low statistical power that may not show true differences. However, what is appreciated in the clinic is that, in spite of not finding differences in the images, airway collapse does decrease in the patients; this is due to the fact that surgery reduces airway resistance, thus decreasing the possibility of collapse. These findings were verified in the post-surgical analysis with fiber optics. These advances translate into an improvement in the respiratory disturbance index in polysomnography, as demonstrated in other series (11).

The main malformations found in this work were collapsed pyriform openings and maxillary retrognathism followed by uvula elongation or excessive flexibility, tongue retropositioning and mandibular retrognathism, findings that, although they were not the main ones in this investigation, are similar to those reported by Conley et al. (12).

The proposal of the points of concern presented in this work can be a starting point to define the measures that should be considered in the tomographic report of patients with these characteristics, since the adequate report of these measures can even determine the success of the intervention, that is, the decrease in the number of apnea events during sleep. The proposed repairs in this study can be an alternative in the search for the standardization of these measures in radiologists, especially because they are informative measures for the clinician; however, it has not been objectively established that an increase in the measures by means of a surgical intervention conditions a functional improvement, established as a reduction in the number of apnea events as well as relief in the side effects caused by OSAHS, since the assessment must be accompanied by a functional study of the airway.

In Colombia (13) the pre and post-surgical assessment -as well as the surgical planning of these patients- is performed with cephalometry through lateral radiography, and an approximate volume of the airway is inferred only with the anteroposterior measurement of the airway at the repair points. This is not the best diagnostic method to evaluate the real diameter of the airway -there are reports of patients with severe OSAHS who have a normal cephalometric analysis and adequate spaces in the posterior airways-, since radiography does not allow the assessment of soft tissues or muscular structures; in addition, it provides only a two-dimensional image that does not allow estimating the volume accurately, as CT does (10).

Therefore, in spite of the fact that in clinical practice it is usual to use radiography, the referred advantages of tomography should be taken into account, since it provides a better detail of the repair points, allows a better evaluation of the results and a better pre-surgical planning.

In the authors' opinion, this is the first series -in Colombia- of patients submitted to an MMA surgical procedure in which the airway was studied by means of CT. And, additionally, it presents information on the outcomes in airway diameters according to the severity of OSAHS, as has been described in other series (10).

Conclusions

We were able to characterize the change in pre- and postsurgical measurements of airway repair points in patients with OSAHS. These findings, together with the detailed description of the repair points proposed in this work, can be a guide for the general radiologist when reporting a study for this purpose.

Additionally, it was found that it was possible to describe with greater accuracy the different diameters of the airway, which will help the clinician in surgical planning and also in the objective and quantifiable assessment of the changes occurred in the airway after the intervention.

The contribution to the research achieved with the present work was to solve a question regarding what happens with the airway measurements when performing MMA surgery in patients with OSAHS, using CT as diagnostic image.

This work opens the possibility of performing a follow-up in time of the changes in the airway, which is interesting to see which are the evolutionary changes of the airway diameters in these patients and if the MMA surgery can guarantee its success, at least in the anatomical measures, in the long term.

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Correspondence

Luis Manuel Alejandro Acosta Rosas
Clínica Universitaria Colombia
Carrera 66 # 23-46
Bogotá, Colombia
acostarosas@gmail.com

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