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Upper airways volume and craniofacial morphology: a CBCT retrospective study

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“Upper airways volume and craniofacial morphology: a CBCT retrospective study”

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Abstract

Introduction: The upper airways have increasingly been a point of strong interest in orthodontic diagnosis, particularly because of their important role in post-natal facial growth and development. Some studies show that the lowest upper airways volume is associated with Class II mandibular retrusion malocclusion, while the highest volume is associated with Class III mandibular protrusion malocclusion. However, this is a controversial topic and other studies show absence of correlation between these two variables. Due to the limitations of the analysis of the upper airways through two-dimensional diagnostic tools, other approaches are being advocated, namely Cone-Beam Computed Tomography (CBCT).

Objectives: To assess a relationship between the volume of the upper airways and the facial skeletal pattern (Class I, Class II, Class III) in orthodontic patients, through three (3D) dimensional data obtained in CBCT examination.

Material and Methods: Pre-treatment cone-beam computed tomography scans were selected from 49 patients who met the inclusion and exclusion criteria. Measurements were made in order to obtain volumetric data, the minimum cross-section, the axial slice of the nasopharynx, oropharynx and the total structure; the cephalometric tracing was performed for the skeletal type (Class I, II and III). The analysis was repeated in a 22 aleatory sample to determine the intra-operator error. The data were evaluated by a validated method analysis - Kolmogorov-Smirnov, Student's T test and Intraclass Correlation Coefficient.

Results: No statistically significant relationship was found between the ANB angle and the volume of the nasopharynx, oropharynx and total volume, nor with the minimum section and axial section of each of these volume segments. However, there seems to be a relationship between these parameters and the patient's sex, where the male sex has a greater volume than the female sex. Regarding age, there was no statistically significant difference, it appears to be a low to moderate intensity correlation with volume, such that with increasing age there is a decrease in the minimum section of the oropharynx and the total volume.

Conclusions: No relationship was found between craniofacial morphology and upper airway volume. Further well-designed and randomized studies with control groups are needed to scrutinize the potential influence of de skeletal class on the upper airway volume.

Resumo

Introdução: A análise das vias aéreas superiores têm, de forma crescente, passado a integrar diagnóstico ortodôntico por causa da sua influência no crescimento e desenvolvimento craniofacial, nomeadamente a nível da face. Alguns estudos mostram que o menor volume das vias aéreas aparece associado a más-oclusões de classe II com retrusão mandibular, enquanto o maior volume se associa a más-oclusões de classe III com protrusão mandibular. No entanto, é um assunto ainda muito controverso, existindo outros estudos a mostrarem que não existe correlação entre as duas variáveis. Devido às limitações das imagens auxiliares de diagnóstico bidimensionais, têm sido abordadas novas maneiras de avaliar estas estruturas, nomeadamente através da Tomografia Computorizada de Feixe Cónico (TCFC).

Objetivos: Avaliar se há relação entre o volume das vias aéreas superiores e a morfologia craniofacial, especificamente a classe esquelética, através de dados obtidos em exames de TCFC.

Materiais e Métodos: Foram analisados retrospetivamente 49 TCFC de pacientes que cumpriam os critérios de inclusão e de exclusão. De seguida, foram efetuadas as medições para obter os dados relativamente ao volume, à secção mínima e ao corte axial da nasofaringe, orofaringe e a estrutura total. Em paralelo foi executado o traçado cefalométrico e determinado o ângulo ANB para obtenção do tipo esquelético. Os resultados foram comparados e tratados pelos testes estatísticos adequados. Foi selecionada aleatoriamente uma amostra de 22 TCFC para o cálculo do erro intra-operador. Os dados foram avaliados por métodos estatísticos válidos – Kolmogorov-Smirnov, teste T Student e Coeficiente de Correlação Intraclasse.

Resultados: Não foi encontrada nenhuma relação estatisticamente significativa entre o ângulo ANB e o volume da nasofaringe, da orofaringe e o volume total nem com a secção mínima e o corte axial de cada um destes segmentos de volumes. No entanto, parece haver uma relação entre estes parâmetros e o sexo do paciente, onde o sexo masculino apresenta um maior volume do que o sexo feminino. Relativamente à idade, apesar de não se ter encontrado uma diferença estatisticamente significativa, parece haver uma correlação de baixa a moderada intensidade com o volume, em que com o aumento da idade há uma diminuição da secção mínima da orofaringe e do volume total.

Conclusões: Não foi encontrada relação entre a tipologia da classe esquelética e o volume das vias aéreas superiores. Serão necessários mais estudos baseados em amostras aleatórias e com grupos de controlo para aquilatar da influência da classe esquelética no volume das vias aéreas superiores.

Key-words

“orthodontics”, “CBCT”, “upper airways”, “craniofacial morphology”, “pharynx”, “nasopharynx” “orthodontic diagnosis”

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À minha orientadora, por toda a ajuda, pela disponibilidade e pela dedicação.

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List of Abbreviations

CT	Computed Tomography
CBCT	Cone-Beam Computed Tomography
MRI	Magnetic Resonance Imaging
FA	Facial Axis
FDA	Facial Depth Angle
MPA	Mandibular Plane Angle
LFH	Lower Facial Height
MA	Mandibular Arch
2D	Two-Dimensional
3D	Three-Dimensional
HU	Hounsfield Scale
C3	Third Cervical Vertebral
TCFC	Tomografia Computorizada de Feixe Cónico

1. Introduction

Airways consists of the cavity space of all anatomical structures that are traversed by the inspired air until it reaches the lungs.

Airways can also be defined as the path that air takes from outside of the body into inside of it and through the lungs. (1) They are involved in a number of vital and non-vital functions, such as breathing, swallowing and phonation. (2) A normal upper airway allows nasal breathing and has a direct influence in craniofacial development and morphology. (3) When nasal breathing is insufficient or even impossible, it's replaced by mixed or mouth breathing. This adaptation mechanism has repercussions at several levels, namely at the postural and functional of structures that condition the morphology of the dental arches, such as: extended head posture, anterior tongue's position, mandibular posterior rotation, etc, which can lead to malocclusion(1). In most severe cases, inevitably translates into serious respiratory disorders, like snoring and obstructive sleep apnoea(4). There are many reasons that may lead to chronical upper airway obstruction, such as adenoids and tonsils hypertrophy, chronic and allergic rhinitis, irritant environmental factors, infections, congenital nasal deformities, nasal traumas, polyps and tumours. (5) Adaptation to chronic nasal respiratory failure in childhood can determine important sequelae, which is why its early detection is of great relevance.

One of the parameters for classifying and grouping craniofacial morphology is depending on the sagittal maxillary and mandibular relationship: class I, class II and class III. Such spatial organisation between the jaws may be determinant in the size and volume of the upper airways path; and an important part of the craniofacial complex that the orthodontist can interfere with. So, is obligation of the orthodontist to make the early recognition of the problem and manage to plan and perform the treatment, at the most opportune moment. (1, 6)

Although controversial, some studies show a relationship between upper airways volume and malocclusion. The upper airways volume tends to be smaller in class II mandibular retrusion and the highest in class III mandibular protrusion. (1) A lower axial slice is also associated to class II mandibular retrusion individuals which also are likely to obstruction of the upper airways. (6, 7). However, other studies claim that there are no relationship among these conditions.

In the literature, we can find a lot of different ways to evaluate this relationship of these structures and the most common is two-dimensional lateral cephalograms, (which was the gold standard in the past). Nowadays, computed tomography (CT) and Magnetic Resonance Imaging (MRI) for Three-dimensional (3D) images are increasing in relevance. (8, 9) Even though 2D images are easily accessible and low cost, highly reproducible, and the individual is submitted to a low dose of radiation, its limitations are well-known for the two-dimensional projection of a three-dimensional structure. (6)

Nevertheless, CT and MRI also have their limitations due to the fact that they have restricted accessibility, higher cost, longer scanning duration and higher level of radiation. (10) But, three dimensional images may give us not only the dimension but the depth of the airways also. (3) On balance, researchers have concluded that currently the most accurate method is 3D imaging to highlight in further detail the upper airway's anatomical characteristics. (11)

In the last years, Cone-Beam Computed Tomography (CBCT) was introduced in Dentistry as an attempt to overcome the 2D limitations images. Its use is increasing since it's able to perform a three dimensional assessment with lower radiation dose when compared to other radiographic examination, such as TAC. (3, 12) Furthermore, regarding the airways, with this exam we can assess the axial plane, an important plane, once it is perpendicular to the air flow. (13) Advanced technology allows CBCT to provide multiple sections of the airways in different spatial planes (axial, sagittal and coronal) and with different orientations. (14) To sum up, with this tool we can perform not only linear, angular, planar but also volumetric measurements. (15)

The aim of this study is to research the potential relationship between the upper airways volumetric dimension and the facial sagittal skeletal pattern.

2. Material and Methods

2.1. Type of Study

This is a cross-sectional observational retrospective study.

2.2. Time Frame of the Study

This study took place over a period of about seven months. It started with a bibliographical research between November 2019 and March of 2020. The observational study was carried out during March 2020. The analysis of the data and the writing of the final text took place during the months of April and May. The work is expected to be finished by May 2020.

2.3. Literature Review

A bibliography review was performed in order to collect scientifically relevant and current information on the subject, using the database *Medline® (Pubmed)* with the key words: “orthodontics”, “CBCT”, “upper airways”, “craniofacial morphology”, “pharynx”, “nasopharynx” “orthodontic diagnosis” combined through the connector “AND”.

In order to limit the search results, some filters were applied, such as “Publication dates: last 5 years” and “Species: Humans”.

The first step was to select the articles by the title and abstract which seemed to be significant for our study, such as: as controlled longitudinal clinical trials, retrospective and prospective, systematic reviews and review articles, concerning upper airways and orthodontics. The articles that didn’t meet the inclusion criteria or with low scientific relevance were excluded.

Two online text books widely referenced in the area were also used, as well as two dissertations.

2.4. Ethical Considerations

This project was approved by Ethics Committee at Dental Medicine Faculty of University of Porto, Portugal. All data were obtained from a private orthodontics clinic with authorization from the clinical director and the responsible for data protection. All data used for this research were already part of the clinical records, so no patient was subjected to further examination. The collected data were encoded to ensure patient's anonymity and to keep it as a blinded study. All data protection policy was respected.

All patients signed an informed consent for this research and they were given a study explanation.

The authors declare to have no conflicts of interest.

2.5. Sample

2.5.1. Sample calculation

A G* power software was used to calculate the sample size, resulting in an ideal sample of 49 individuals, with a test power of 80%, an alpha value of 0,05 and r of 0,35 to detect moderated correlations. (6)

2.5.2. Inclusion Criteria

The criteria for inclusion were: patients over 18 years of age, with an orthodontic diagnostic file that included a pre-treatment CBCT where at least, upper airway structure depicted until the C3 was visible.

2.5.3. Exclusion Criteria

All participants who have had previous orthodontic treatment, or significant surgery in craniofacial area, or craniofacial syndromes/deformities, or whose CBCT showing upper airway structure depicted less than the third vertebrae (CBCTs which do not show the entire C3 were excluded). (9, 12)

2.5.4. Sample Selection and Characterization

To obtain the final sample, we used the consecutive sampling method, by going through the patient's files and including those that were eligible until the sample size was reached. We acquired a total sample of 17 males and 32 females with age ranging from 18 to 58 that met the inclusion criteria.

During the selection process, we collected the patient's code, birth date and sex, imported it into an *Excel* spreadsheet and finally changed that code to a new one of ours (from 1 to 49).

2.6. 3D imaging method

2.6.1. Image acquisition protocol

All CBCT image acquisitions were performed by the same operator and with the same equipment, following a standardized protocol, in order to get reproducible and comparable results. Patients were in a supine position during the process of scanning, Frankfurt horizontal plane was parallel to the floor and average sagittal plane perpendicular to the ground. Patients were instructed to occlude in the maximum intercuspation and to maintain the tongue touching the palate, not to swallow nor breathe during the all-time of the examination. (3, 12, 16)

2.6.2. Image analysis

The information extracted from the CBCT was exported via DICOM (*Digital imaging and Communications in Medicine)* format and visualized in *Planmeca Romexi*[1] *software.* We created a coded patient's file and imported it into a specific program, where three-dimensional skeletal measurements could be performed - *NemoCeph* (in *NemoStudio*[2]).

This software made the reconstructions of the three planes (sagittal, coronal and axial) and the result was named Volume. (6) In the sagittal plane the Volume was oriented according to the left Frankfurt plane. In the frontal plane Volume was oriented to the plane that intersects the two infraorbital points. Relative to axial plan, the volume was oriented in a way that the patient's middle line was centred. (9) Thus, it was ready to be analysed and measurements performed.

By opening each file, we had access to his/her CBCT examination, teleradiography and photographs. To ensure that each patient's original examinations were not permanently altered, a copy of each CBCT and teleradiography was made. We double clicked on the CBCT's copy to start the measurements and clicked on "upper airways view". We could visualize the upper airways oriented in the three planes of space.

[1] *Planmeca Romexis® Helsinki, Filand*

[2] *Nemotec Dental Studio®*

2.6.3. 3D measurements

For the the airway measurements, we based on the Guijarro Martinez method, which we adapted, creating our own method. (6) The upper airways were segmented in nasopharynx and oropharynx, according to the limits explained below. We settle to calculate the volume of each segmentations, as well as the total volume, and also the respective minimum section area and axial slice. Laryngopharynx volume was excluded from the study.

Upper airways were measured systematically in all the CBCTs. We explore the sagittal sections to choose the one that gave us the best view. The automatically value of 500 of HU was manually adjusted to 450 because it is the most appropriate value in order to get the best upper airway depict. This value was set to all CBCTs to keep it under the same conditions.

First step : to calculate the nasopharynx volume: the software vertical line was adjusted to pass at the most inferior point of sella turca. We scored a point in that line, at the place where it passed in the most inferior part of the sphenoid tangential to line and this became the “roof of the airway”. Then, a horizontal line was drawn through the PNS point until reaches the sphenoid bone. After connecting these points, we double clicked and a triangle figure was created. We selected the option “place point”, (a point that we place in the area where we want to know the volume) and we've marked the dark area of the image, which corresponded to the nasopharynx. At this moment, we changed the option ”tolerance” to 450 HU. Then selected the option to obtain the volume. The software provides three parameters: the volume in cm^3, the min section in mm^2 and the axial slice in mm^2, and a color-coded three-dimensional airway reconstruction is generated.

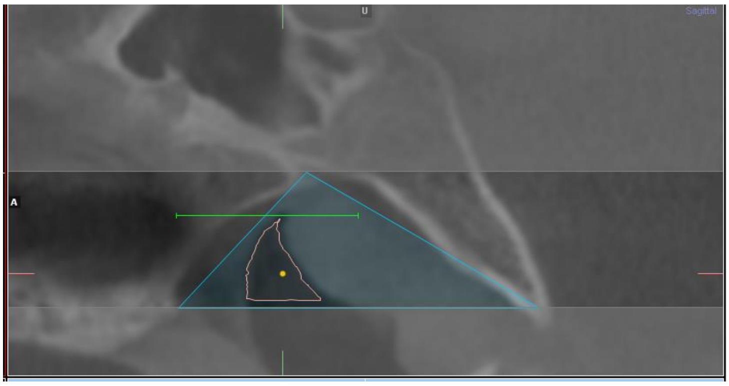


Figure 1 - Nasopharynx Volume

The second step provided the oropharynx volume: measured by the same horizontal line passing through the PNS until the sphenoid bone. A parallel to that line was drawn, passing through the most inferior-anterior point of C3, which we named floor of the airway. After connecting these 4 points, we double clicked and a trapezoid was created. We selected the option “place point”, and marked it in the dark area of the image, which corresponded to the oropharynx. Then, we changed the option ”tolerance” to 450 HU. We selected the option to obtain the volume. The software calculated the parameters and provided: the volume in cm^3, the min section in mm^2 and the axial slice in mm^2 and generated a color-coded three-dimensional airway reconstruction.

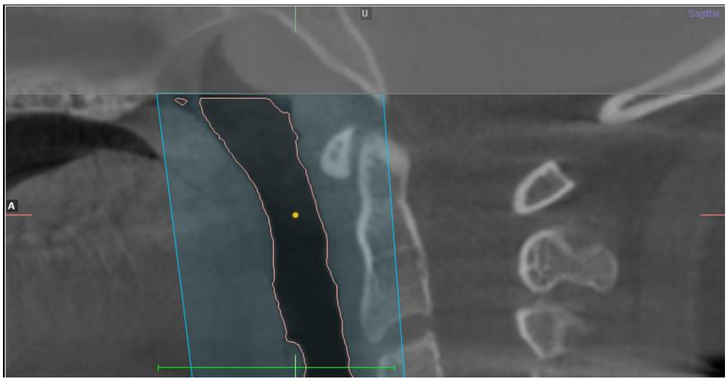


Figure 2 - Oropharynx Volume

The third and last step was the calculation of the total volume: resulted from the combination of the volume of the nasopharynx and the oropharynx, total volume is measured from the roof to the floor of the airway, explained above. The same procedures were performed. After connecting these points, we double clicked and a figure was created. We selected the option “place point”, and marked it in the dark area of the image, which corresponded this time to the total volume. Then, we changed the option ”tolerance” to 450 HU. We selected the option to obtain the volume. The software calculated the parameters and provided: the volume in cm^3, the min section in mm^2 and the axial slice in mm^2 and generated a color-coded three-dimensional airway reconstruction.

Each of these data were transcribed to *Excel* spreadsheet and filled in for each patient, respectively.

2.7. 2D imaging method

Since the aim of the study was to determine a possible relationship between the craniofacial morphology and the upper airways volume, we had to determine the facial skeletal pattern of each individual. In this way, we performed the cephalometric tracing using Ricketts and Steiner analysis. We measured the ANB angle values and divided the patients into Class I, Class II and Class III. It was assumed that angles between -0,5º and 4,5º corresponded to class I malocclusion, higher than 4,5º to class II malocclusion and less than -0,5º to class III malocclusion.

A table with all the cephalometric landmarks used is below.

Table 1 - Cephalometric Landmarks

CEPHALOMETRIC LANDMARK	DEFINITION
A POINT	The innermost point on the contour of the premaxilla between anterior nasal spine and the incisor tooth(17)
B POINT	The innermost point on the contour of the mandible between the incisor tooth and the bony chin(17)
BASION (BA)	The lowest point on the anterior margin of the foramen magnum, at the base of the clivus(17)
SELLA (S)	The midpoint of the cavity of sella turcica(17)
ORBITALE (OR)	The lowest point on the inferior margin of the orbit(17)
ANTERIOR NASAL SPINE (ANS)	The tip of the anterior nasal spine(17)
XI POINT	The point located in the geometric center of the upstream branch of the mandible (6)
MENTON (ME)	The most inferior point on the mandibular symphysis—that is, the bottom of the chin(17)
PORION (PO)	The midpoint of the upper contour of the external auditory canal (anatomic porion), or the midpoint of the upper contour of the metal ear rod of the cephalometer (machine porion)(17)
POGONION (POG)	The most anterior point on the contour of the chin(17)
PTERYGOMAXILLARY FISSURE (PTM)	The point at the base of the fissure where the anterior and posterior walls meet(17)
GONION (GO)	The midpoint of the contour connecting the ramus and body of the mandible(17)
GNATHION (GN)	The most anterior and inferior point on the bony chin(18)
CONDYLION (CD)	The most posterior and superior point on the mandibular condyle(18)
NASION (N)	The most anterior point on the frontonasal suture in the midline(18)
ANTEGONION (AG)	The innermost height of the contour along the curved outline of the inferior mandibular border, low and medial to gonial angle(17)
POSTERIOR NASAL SPINE (PNS)	the tip of the posterior spine of the palatine bone, at the junction of the hard and soft palates(17)

Table 2 - Cephalometric Parameters

CEPHALOMETRIC'S PARAMETERS:		CLINICAL NORMALITY	BIOLOGIC CORRECTION
FACIAL AXIS	Angle formed between cranial base plane (Na-Ba) and facial axis (Ptm-Gn)	90º ± 3º	Increases 0,3º/year after 9 years old
FACIAL DEPTH ANGLE	Angle formed between facial plane (Na – Pog) and Frankfurt Horizontal	87º ± 3º	
MANDIBULAR PLANE	Angle formed between the mandibular plane (Me-Ag) and Frankfurt Horizontal	26 ± 4,5º	Decreases 0,3º/year after 9 years old
LOWER FACIAL HEIGHT	Angle formed between Xi-Ptm and Xi-ANS planes	47º ± 4º	
MANDIBULAR ARCH	Angle formed between mandibular body axis (Xi-Ptm) and condylar axis (Xi-Cd)	26º ± 4º	Increases 0,5º/year
SNA	Angle formed of the combinação S, N and A	82º ± 2º	
SNB	Angle formed of the combination S, N and B	80º ± 2º	
ANB	Angle formed of the combination A, N and B	2º ± 2º	

2.8. Statistical Analysis

Statistical analysis was performed using IBM SPSS, 26 version for Windows (IBM Corp. Released 2018).

The variables under study were characterized by the minimum, maximum, average and standard deviation values, with the results presented in the form of mean ± standard deviation.

The data distribution was assessed using the Kolmogorov-Smirnov, whose results lead to not rejecting the null hypothesis of the test, with a significance level of 5% ($p > 0.05$), indicating that there are no significant deviations from the normality of the data. Thus, it was decided to use parametric tests to meet the research objectives.

To evaluate the measurement error (intra-examiner error), Student's T Test for paired samples and the Intraclass Correlation Coefficient (ICC) were used. 22 measurements were repeated. The Student's T Test allows the assessment of the existence of systematic error, checking if there are significant differences between the initial measurements and the repetitions. The ICC varies between 0 and 1 (the closer to 1, the better the reliability between measurements) and allows to evaluate the random error, checking the consistency between the measurements. A non-significant Student T Test ($p > 0.05$) and a ICC greater than 0.75 (Fleiss, 1999) guarantee the reliability of the measurements.

To meet the objectives of the study, Pearson's Correlation Coefficient was used to study the correlations with volume, with Min Section, with Axial Slice (total volume, nasopharynx volume and oropharynx volume) and with age. Student's t-test for independent samples was also used to assess the significance of differences in relation to sex.

For decision making based on the results of the statistical tests, a significance level of 5% was considered, that is, the correlations/differences were considered statistically significant when the significance value was less than 0.05 ($p < 0.05$). Also highlighted were the cases in which the test results were close to statistical significance ($0.05 \leq p < 0.10$).

3. Results

3.1. Sample

The sample consisted of 49 patients aged between 18 and 58 years, with an average age of 33.7 years (SD = 11.7). Patients between 21 and 40 years old (55.1%) and female (65.3%) predominate (Table 2 and Figure 3 and Figure 4).

Table 3 - Sample Characterization

		n	%
Gender	Female	32	65.3%
	Male	17	34.7%
Age	18-20 years old	7	14.3%
Minimum = 18	21-30 years old	14	28.6%
Maximum = 58	31-40 years old	13	26.5%
Mean = 33.7	41-50 years old	10	20.4%
SD = 11.7	51-60 years old	5	10.2%

Figure 3 - Sample Characterization regarding sex (N=49)

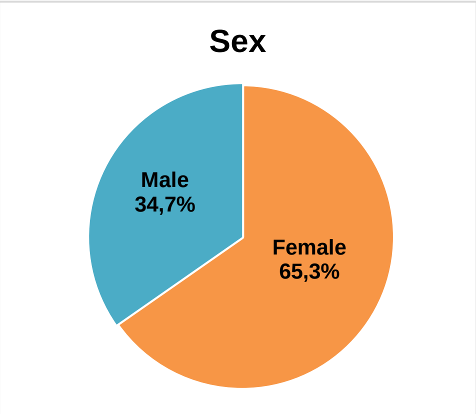
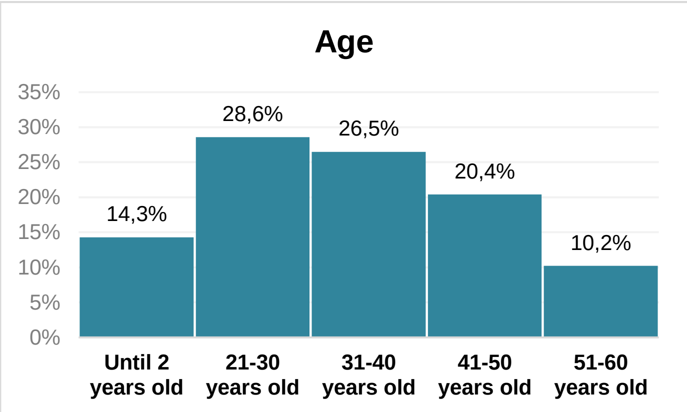


Figure 4 - Sample Characterization regarding age (N=49)



3.2. Error Assessment

To study the error assessment, Student T Test for paired samples (systematic error) and the Intraclass Correlation Coefficient (random error) were used. The results are shown in Table 3.

Table 4 - Results of the analysis of the intra-examiner measurement error (N=22)

	1st Measurement Mean ± SD	Repetition Mean ± SD	$p^{(1)}$	ICC[(2)]
Nasopharynx Volume				
Volume (cm3)	4.35 ± 1.98	4.31 ± 1.97	0.555	0.994
Min Section (mm^2)	304.53 ± 144.17	322.97 ± 117.92	0.263	0.911
Axial Slice (mm^2)	361.79 ± 131.16	372.49 ± 116.65	0.207	0.975
Oropharynx Volume				
Volume (cm3)	19.09 ± 6.31	18.88 ± 6.20	0.287	0.995
Min Section (mm^2)	165.77 ± 65.95	165.78 ± 66.51	0.993	0.999
Axial Slice (mm^2)	244.48 ± 73.42	275.39 ± 102.47	0.099	0.814
Total Volume				
Volume (cm3)	24.05 ± 7.70	23.75 ± 7.80	0.100	0.997
Min Section (mm^2)	165.13 ± 65.60	161.89 ± 63.56	0.297	0.988
Axial Slice (mm^2)	304.36 ± 128.89	301.95 ± 116.21	0.905	0.967

(1) *p* – Significant value of T Student T for paired samples;
(2) ICC – Intraclass Correlation Coefficient

The table shows us that there were no significant statistical differences in the intra-examiners' measurements between the first measurements and the repetitions ($p > 0.05$). The ICC valuables are all greater than 0,90 which indicates excellent levels of consistency in the measurements.

Together, the results of the Student's T-Test and the ICC ensure that there is no systematic or random error in the measurements made, ensuring the consistency and reliability of the measurements

3.3. Measurement Characterization

Table 5 - Characterization of the measures evaluated

	Miinimum	Maximum	Mean	SD
Nasopharynx Volume				
Volume (cm3)	1.44	10.70	4.65	2.20
Min Section (mm^2)	5.12	576.96	312.29	146.80
Axial Slice (mm^2)	159.04	636.32	367.92	130.37
Oropharynx Volume				
Volume (cm3)	8.55	43.48	19.57	8.03
Min Section (mm^2)	56.64	346.72	174.56	84.96
Axial Slice (mm^2)	68.16	480.00	250.41	93.74
Total Volume				
Volume (cm3)	11.80	53.12	24.76	9.51
Min Section (mm^2)	56.32	357.12	173.87	85.11
Axial Slice (mm^2)	80.16	668.64	301.87	141.33
Facial Axis	72.00	101.00	87.80	5.72
Facial Depth Angle	79.00	96.00	88.55	4.20
Mandibular Plane	12.00	39.00	23.27	6.66
Lower Facial Height	38.00	59.00	45.98	4.88
Mandibular Arch	23.00	47.00	34.08	5.66
SNA	72.00	90.00	80.98	4.88
SNB	67.00	85.00	76.80	5.31
ANB	-1.00	11.00	3.98	2.85

The variables under study were characterized by their minimum, maximum, mean and standard-deviation values. The results were presented as mean ± standard-deviation.

3.4. Correlations

3.4.1. Correlation of Cephalometric Parameters with Nasopharynx Volume

Table 6 - Correlations with nasopharyngeal volume

	Nasopharynx Volume		
	Volume (cm3)	**Min Section** (mm^2)	**Axial Slice** (mm^2)
Facial Axis	R = -0.069 (p = 0.640)	R = -0.088 (p = 0.546)	R = -0.001 (p = 0.995)
Facial Depth Angle	R = -0.144 (p = 0.322)	R = -0.096 (p = 0.510)	R = -0.085 (p = 0.562)
Mandibular Plane	R = 0.143 (p = 0.329)	R = 0.108 (p = 0.460)	R = 0.029 (p = 0.843)
Lower Facial Height	R = 0.171 (p = 0.240)	R = 0.226 (p = 0.118)	R = 0.066 (p = 0.653)
Mandibular Arch	R = 0.039 (p = 0.792)	R = -0.015 (p = 0.918)	R = 0.056 (p = 0.703)
SNA	R = -0.032 (p = 0.826)	R = -0.099 (p = 0.499)	R = -0.050 (p = 0.731)
SNB	R = -0.054 (p = 0.711)	R = -0.032 (p = 0.828)	R = -0.049 (p = 0.740)
ANB	R = 0.028 (p = 0.847)	R = -0.021 (p = 0.885)	R = -0.019 (p = 0.896)

R – Pearson's Correlation Coefficient; p – significant value.

3.4.2. Correlation of Cephalometric Parameters with Oropharynx Volume

Table 7 - Correlations with oropharynx volume

	Oropharynx Volume		
	Volume (cm3)	**Min Section** (mm^2)	**Axial Slice** (mm^2)
Facial Axis	R = -0.093 (p = 0.523)	R = -0.076 (p = 0.604)	R = -0.010 (p = 0.946)
Facial Depth Angle	R = -0.120 (p = 0.413)	R = -0.109 (p = 0.457)	R = 0.037 (p = 0.800)
Mandibular Plane	R = -0.022 (p = 0.881)	R = -0.063 (p = 0.666)	R = -0.165 (p = 0.258)
Lower Facial Height	R = 0.036 (p = 0.808)	R = -0.045 (p = 0.761)	R = -0.066 (p = 0.654)

Mandibular Arch	R = 0.107 (p = 0.466)	R = 0.084 (p = 0.568)	R = 0.136 (p = 0.352)
SNA	R = -0.186 (p = 0.201)	R = -0.194 (p = 0.182)	R = 0.029 (p = 0.845)
SNB	R = -0.118 (p = 0.420)	R = -0.122 (p = 0.404)	R = 0.117 (p = 0.423)
ANB	R = -0.197 (p = 0.175)	R = -0.237 (p = 0.100)	R = -0.218 (p = 0.132)

R – Pearson's Correlation Coefficient; p – significant value.

3.4.3. Correlation of Cephalometric Parameters with Total Volume

Table 8 - Correlations with total volume

	Total Volume		
	Volume (cm3)	**Min Section** (mm^2)	**Axial Slice** (mm^2)
Facial Axis	R = -0.103 (p = 0.483)	R = -0.064 (p = 0.664)	R = -0.127 (p = 0.384)
Facial Depth Angle	R = -0.143 (p = 0.329)	R = -0.101 (p = 0.488)	R = -0.141 (p = 0.332)
Mandibular Plane	R = 0.020 (p = 0.889)	R = -0.065 (p = 0.658)	R = 0.075 (p = 0.610)
Lower Facial Height	R = 0.090 (p = 0.538)	R = -0.044 (p = 0.766)	R = 0.066 (p = 0.653)
Mandibular Arch	R = 0.095 (p = 0.515)	R = 0.076 (p = 0.604)	R = 0.088 (p = 0.546)
SNA	R = -0.173 (p = 0.235)	R = -0.176 (p = 0.226)	R = -0.197 (p = 0.176)
SNB	R = -0.119 (p = 0.415)	R = -0.100 (p = 0.493)	R = -0.117 (p = 0.425)
ANB	R = -0.161 (p = 0.269)	R = -0.249 (p = 0.084)	R = -0.145 (p = 0.321)

R – Pearson's Correlation Coefficient; p – significant value.

The comparison between the evaluated parameters with minimum section, axial slice and volume of nasopharynx, oropharynx and total volume are close to zero and there are no significance ($p > 0.05$), meaning absence of correlation.

3.5. Association with Age and Sex

3.5.1. Age

Table 9 - Correlation with Age

	Age
Nasopharynx Volume	
Volume (cm3)	R = 0.182 (p = 0.211)
Min Section (mm^2)	R = 0.215 (p = 0.138)
Axial Slice (mm^2)	R = 0.120 (p = 0.410)
Oropharynx Volume	
Volume (cm3)	R = -0.083 (p = 0.569)
Min Section (mm^2)	**R = -0.280 (p = 0.051)**
Axial Slice (mm^2)	R = -0.111 (p = 0.449)
Total Volume	
Volume (cm3)	R = -0.024 (p = 0.868)
Min Section (mm^2)	**R = -0.273 (p = 0.058)**
Axial Slice (mm^2)	R = -0.100 (p = 0.496)
Facial Axis	R = 0.059 (p = 0.686)
Facial Depth Angle	R = 0.116 (p = 0.429)
Mandibular Plane	R = -0.046 (p = 0.753)
Lower Facial Height	R = 0.110 (p = 0.452)
Mandibular Arch	R = 0.160 (p = 0.271)
SNA	R = 0.177 (p = 0.224)
SNB	R = 0.106 (p = 0.468)
ANB	R = 0.151 (p = 0.301)

R – Pearson's Correlation Coefficient; p – significant value.

Table 8 shows us negative correlations of low to moderate intensity and close to statistical significance with minimum section of oropharynx volume and with minimum section of total volume, indicating that increasing age is associated with decrease in the minimum section of oropharynx volume and total volume.

Also, all correlations of the other variables with age were close to zero, which means absence of correlation.

3.5.2. Sex

Table 10 - Correlation with Sex

	Female (n = 32) Mean ± SD	**Male** (n = 17) Mean ± SD	**T Student Test**
Nasopharynx Volume			
Volume (cm3)	4.20 ± 2.14	5.49 ± 2.11	**p = 0.050**
Min Section (mm^2)	292.60 ± 144.58	349.37 ± 148.04	p = 0.201
Axial Slice (mm^2)	345.86 ± 129.48	409.44 ± 125.32	p = 0.105
Oropharynx Volume			
Volume (cm3)	17.66 ± 6.48	23.17 ± 9.54	**p = 0.020**
Min Section (mm^2)	167.79 ± 84.43	187.32 ±87.06	p = 0.449
Axial Slice (mm^2)	238.40 ± 96.06	273.01 ± 87.47	p = 0.222
Total Volume			
Volume (cm3)	22.45 ± 7.56	29.12 ± 11.38	**p = 0.018**
Min Section (mm^2)	166.81 ± 83.91	187.16 ± 88.34	p = 0.431
Axial Slice (mm^2)	280.92 ± 144.10	341.31 ± 131.01	p = 0.157
Facial Axis	86.63 ± 5.40	90.00 ± 5.82	**p = 0.048**
Facial Depth Angle	87.94 ± 4.11	89.71 ± 4.24	p = 0.163
Mandibular Plane	24.22 ± 7.22	21.47 ± 5.19	p = 0.172
Lower Facial Height	46.66 ± 4.65	44.71 ± 5.19	p = 0.186
Mandibular Arch	32.97 ± 5.28	36.18 ± 5.91	**p = 0.058**

SNA	80.66 ± 5.10	81.59 ± 4.50	p = 0.530
SNB	75.66 ± 5.30	78.94 ± 4.78	**p = 0.038**
ANB	4.66 ± 2.78	2.71 ± 2.59	**p = 0.021**

Generally, average values of volume, minimum section and axial slice were greater in males than in females. The differences were statistically significant in nasopharynx volume (p=0,050), in oropharynx volume (p=0,020) and in total volume (p=0,018).

Regarding other parameters, there were statistically significant differences, or close to statistical significance, in facial axis (p=0,048), in mandibular arch (p=0,058), in SNB (p=0,038) and ANB (p=0,021) – males patients having greater mean values than females in all this parameters.

There were no significant gender differences in the facial angle (p=0,163), in mandibular plane (p=0,172), in lower facial height (p=0,186) nor in SNA (p=0,530).

3.6. Sample Distribution (Normality)

Table 11 - Study of Normal Distribution (Kolmogorov-Smirnov test)

	Kolmogorov-Smirnov Test	
	Measurement (N = 49)	**Repetition** (N = 22)
Nasopharynx Volume		
Volume (cm3)	p ≥ 0.200*	p ≥ 0.200*
Min Section (mm^2)	p ≥ 0.200*	p ≥ 0.200*
Axial Slice (mm^2)	p ≥ 0.200*	p ≥ 0.200*
Oropharynx Volume		
Volume (cm3)	p ≥ 0.200*	p ≥ 0.200*
Min Section (mm^2)	p = 0.176	p = 0.105
Axial Slice (mm^2)	p ≥ 0.200*	p ≥ 0.200*
Total Volume		
Volume (cm3)	p ≥ 0.200*	p ≥ 0.200*
Min Section (mm^2)	p = 0.108	p = 0.078
Axial Slice (mm^2)	p ≥ 0.200*	p ≥ 0.200*

Facial Axis	p = 0.143	-
Facial Depth Angle	p = 0.196	-
Mandibular Plane	p ≥ 0.200*	-
Lower Facial Height	p ≥ 0.200*	-
Mandibular Arch	p ≥ 0.200*	-
SNA	p = 0.126	-
SNB	p ≥ 0.200*	-
ANB	p = 0.167	-

Table 11 shows the significance values (p) of the Kolmogorov-Smirnov tests for the study of the normality of the variables included in the study. The test results lead to not rejecting the null hypothesis of the Kolmogorov-Smirnov test, with a significance level of 5% (p>0,05) indicating that it follows a normal distribution.

4. Discussion

4.1. State-of-art

Upper airways volume can have a direct effect in the quality of life of each patient and the orthodontist have the knowledge and the tools to evaluate this structure. By having the capability of modulate the skeletal structures and change their position, it seems to be relevant to study the influence of the facial skeletal pattern in the upper airways volume and include it in the orthodontic diagnosis.

There are still many controversial results, even though this subject has been discussed for decades, mainly due to the fact that there is no methodologic consensus about the patient position when taking the CBCT (supine or upright), age of the participants and the variety of landmarks used to determine the boundaries of upper airways (some researchers use cervical vertebrae and while others the posterior nasal spine or epiglottis). (1, 10)

4.2. Study and Sample Considerations

This is a transversal retrospective study because only one pre-treatment CBCT was in the data base of each patient.

The literature shows that there are changes during individual growth that influence the upper airway volume, such as changes in pharyngeal soft tissues, mandibular growth and hyoid bone position. (1) It seems that pharyngeal structures grow rapidly until 13 years old and then goes into a period of quiescence between 14 and 18 years old. (19). Though the decision was to select patients above 18 years old.

4.3. Measurements and Imaging Tools

CBCT is a very reliable tool to determine upper airways volume. When compared with other three-dimensional images CBCT delivers three dimensional data at lower costs and radiation. It provides us information that otherwise we couldn't get. (3, 9, 16, 20) Limitations found in two-dimensional examinations were taken into account, and for this reason, three-dimensional imaging was chosen, so it is expected that the measurements accomplished are accurate enough to extract trusty conclusions.

4.4. Results

The p value considered significant was about < 0,05. To overcome intra-examiner errors, the total measurements was to repeat in a randomly chose sample of n=22. Since this error was not statistically significant, it was assured that it cannot be a factor to influence the results.

The results show us that when comparing the cephalometric parameters with the nasopharynx, oropharynx and total volume and their respective minimum section and axial slice, there was no correlation strong enough to be statistically significant. The ANB angle gives us the skeletal class of each individual, so we can conclude that, in this study, there are no variations in the upper airways with craniofacial morphology. These outcomes are in line with Di Carlo and Brasil who didn't find this correlation, also. (16, 21)

It goes against what Zheng found in his study, where a correlation of ANB angle and skeletal classes were statistically significant. (20) The reason for this contradiction may be the fact that they included in the study an evaluation of the vertical pattern of growth and almost all studies that have different results, had that hypothesis in study. (2) According to Claudino, "the greater the ANB angle, the smaller the airway volume" and Abbas Shokri et all added that with an increasing in ANB angle of one unit, it is translated in 0,261 decreasing units in airway volume. (22, 23)

Although we didn't find any correlation between the ANB angle and volume of the upper airways, we found a correlation between patient's sex with volumes, minimum section and axial slice in the nasopharynx, the oropharynx and the total upper airway, wherein male shows greater values than females. Chiang et all. corroborates this positive correlation as well as El and Palomo, who also said that "total upper airway volume of males was larger compared to females". (24, 25) On the opposite side, Zheng et all. didn't find any statistical difference. (20)

Even though in our study there wasn't a statistically significant correlation in upper airways volume and age, a low to moderate negative correlation was perceived, which means that increasing in age is associated with a decreasing minimum section of oropharynx and total volume. It is more likely that the best range of age to analyze upper airways volume might be between 14 and 22 years old, since it appears to be more stable. (19) Once that we have a wide range of ages, and in addition, aging may be an issue in this, these factors may have biased the results.

4.5. Limitations

In this study, we changed manually the HU values to obtain the best view of upper airway as possible (450 HU) and preconized it in all the measurements. However, in some other studies, this value differs because it has not been found a standard value yet. Lenza et all only used one single HU value while other researchers changed it in every measurement, making it difficult to compare. (9) Levels of sensitivities have a great variation among studies, and so it can be a factor to explain the different outcomes, too.

The method of performing the study is not standardized, which can also lead to bias. Measurements were performed until oropharynx because in our CBCTs examinations we can only visualize the third cervical vertebrae, but Shokri measured it until the fourth cervical vertebrae and it can be the reason to explain a different result. (22)

Gender, age and vertical growth pattern variables can somehow change the final conclusions as Ji-Suk Hong could tell in his research that after controlling gender, age and facial size, he could find statistically significant differences regarding cross-sectional areas and volume. (26)

Head position and respiration stage while taking the CBCT may also affect the airway volume and these variables show a lot of variations among researchers. For this study, we collected pre-treatment CBCT, always performed by the same operator and using the same protocol, as explained in the methodology. However, it is difficult to fully control some factors such as head position and breathing during image capture, which may in some way explain the differences in results.

In posterior studies, it is important to control these limitations that couldn't be controlled in this study to decrease the bias error.

5. Conclusion

In the sample used and according to the methodology pursued in this CBCT retrospective study there seems to be no relationship between upper airways volume and the facial sagittal skeletal pattern.

No correlations were found between age and upper airways volume.

It was found a correlation between upper airways volume and gender, with men having higher upper airways volume.

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7. Anexos

DENTEREAL
CLÍNICA DENTÁRIA

Eugénio Joaquim Pereira Martins, Diretor Clínico da Dentereal Clínica Dentária de Vila Real Lda., sita na Rua Cândido Reis nº40, 5000-638 Vila Real, NIF 503214019, venho por este meio autorizar a estudante Ana Carolina Sarrico Madaíl a cedência dos dados clínicos necessários, conforme as considerações éticas que me são exigidas, para a realização do projeto intitulado por "*upper airways volume and and craniofacial morphology: a CBCT retrospective study*" a realizar no âmbito da Unidade Curricular "Monografia de Investigação ou Relatório de Atividade Clínica" no Mestrado Integrado em Medicina Dentária na Faculdade de Medicina Dentária da Universidade do Porto.

Com os melhores cumprimentos,

(Prof. Doutor Eugénio Martins)

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U.PORTO	Unidade de Proteção de Dados	DATA:15/04/2020

PARECER A-10/2020

Nome	Ana Carolina Sarrico Madaíl
Nº Mecanográfico	201602909
Unidade Orgânica	Faculdade de Medicina Dentária da Universidade do Porto (FMDUP)
Título	"Upper airways volume and craniofacial morphology: a CBCT retrospective study"
Ticket Nº	2019121015005516

Sumário do Pedido

No âmbito da unidade curricular de "Monografia de Investigação ou Relatório de Atividade Clínica", integrada no plano de estudos do Mestrado Integrado em Medicina Dentária da FMDUP, pretende a requerente levar a cabo um estudo retrospetivo, destinado a caracterizar tridimensionalmente as dimensões e a morfologia das vias aéreas superiores, por forma a avaliar a sua relação com o crescimento craniofacial e com a classe de padrão esquelético resultante.

O estudo será efetuado com base em imagens de Tomografia Computorizada de Feixe Cónico (CBCT), de pacientes da Clínica Dentária Dentereal, subdivididos em três grupos, de acordo com o padrão esquelético que apresentem: classe I, classe II ou classe III.

Para a realização do estudo, a clínica privada Dentereal – Clínica Dentária de Vila Real, Lda., fornecerá à Investigadora os seguintes dados, já expurgados de identificadores pessoais diretos: data de nascimento dos pacientes, exames de CBCT e datas em que estes foram realizados.

Conclusões

Considerando que,

(1) a clínica Dentereal – Clínica Dentária de Vila Real, Lda. se configura como Responsável pelo Tratamento dos dados acima referidos, nos termos do art.º 4.º/7 do Regulamento Geral sobre a Proteção de Dados;

(2) foi autorizada pelo Diretor Clínico da referida clínica, a cedência desses dados;

(3) as operações de tratamento de dados a desenvolver pela requerente apenas incidirão sobre dados consideráveis anónimos, tendo em conta os meios atualmente colocados à disposição do Homem-médio para direta ou indiretamente identificar uma pessoa singular,

somos do parecer que o tratamento de dados acima referenciado não carece de autorização prévia do Senhor Reitor, pelo que poderá a requerente avançar com a sua realização, sem necessidade de mais formalismos.

Anexos

Anexo 1	Autorização_Diretor_Clínico

a Encarregada da Proteção de Dados da
Universidade do Porto

Susana Rodrigues Pereira

Doutora Susana Rodrigues Pereira

U. PORTO
FACULDADE DE MEDICINA DENTARIA
UNIVERSIDADE DO PORTO

000051 15 MAI 2020

Exmª Senhora
Ana Carolina Sarrico Madaíl
Faculdade de Medicina Dentária da U. Porto

Assunto: Parecer relativamente ao Projeto de Investigação nº 32/2019.
(Upper airways volume and craniofacial morphology: a CBCT retrospective study).

Informo V. Exa. que o projeto supracitado foi analisado na reunião da Comissão de Ética para a Saúde, da FMDUP, no dia 8 de maio de 2020.

A Comissão de Ética é **favorável** à realização do projeto tal como apresentado.

O formulário definitivo de apresentação do trabalho, aprovado pela Comissão de Ética para a Saúde, da FMDUP, acompanha a presente comunicação.

A Comissão de Ética recomenda a existência de um seguro de responsabilidade civil e relembra que a inexistência de seguro responsabiliza diretamente os investigadores.

Subject: Recommendation on the research project nº 32/2019.
(Upper airways volume and craniofacial morphology: a CBCT retrospective study).

I hereby inform that the aforementioned project was analyzed on may 8th 2020, by the Ethics Committee for Health of the Faculty of Dental Medicine,

The Ethics Committee is **favourable** to the project execution.

The final submission form approved by FMDUP's Ethics Committee for Health is attached.

The Ethics Committee recommends the existence of liability insurance and recalls that the absence of insurance directly holds researchers accountable.

Com os melhores cumprimentos,

A Presidente da Comissão de Ética para a Saúde, da FMDUP

Assinado por: Inês Alexandra Costa de Morais Caldas Paiva
Identificação: BI10325794
Data: 2020-05-14 às 19:10:13

rais Caldas

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Explicação do estudo

Título

"Upper airways volume and craniofacial morphology: a CBCT retrospective study" (Volume das vias aéreas e morfologia craniofacial: um estudo retrospetivo em CBCT)

Objetivos

O presente estudo será desenvolvido no âmbito da realização de uma monografia de investigação para conclusão do Mestrado Integrado em Medicina Dentária, ministrado pela Faculdade de Medicina Dentária da Universidade do Porto.

É sabido que a relação entre os maxilares influencia o volume das vias aéreas respiratórias superiores e, uma vez que a respiração tem influência no crescimento e desenvolvimento craniofacial, a ortodontia tem dado cada vez mais relevo a esta vertente em todos os patamares da sua atuação.

A avaliação do espaço das vias aéreas superiores tem sido feita com recurso à análise cefalometria lateral, que se trata de um exame auxiliar de diagnóstico de fácil acesso e baixo custo. No entanto, este exame apresenta algumas limitações, na medida em que apenas nos permite um estudo em duas dimensões. Nos dias de hoje já é possível ter acesso a outros recursos, como é o caso da tomografia computorizada de feixe cónico, um exame em três dimensões, que nos permite uma informação mais completa sobre as estruturas anatómicas envolvidas.

Pretende-se com esta investigação avaliar as dimensões e a morfologia das vias respiratórias superiores, através de um exame tridimensional, e correlacioná-las com o tipo de classe esquelética de cada paciente.

Metodologia

A amostra será constituída por 49 Tomografias computorizadas de feixe cónico que pertencem a pacientes da clínica privada.

A amostra vai ser dividida em 3 grupos conforme o seu padrão esquelético classe I, classe II, classe III. A amostra deverá ser escolhida segundo os critérios de elegibilidade. Através da marcação de pontos no exame tridimensional (tomografia computorizada de feixe cónico), vamos calcular o respetivo volume das vias áreas superiores.

Nenhum paciente foi submetido a qualquer tratamento ou método auxiliar de diagnóstico com o objetivo da realização desta monografia. Todos os recursos obtidos para a sua execução pertencem ao arquivo e foram recolhidos segundo o protocolo utilizado pelas fontes que forneceram os dados.

Está previsto concluir a investigação em Maio de 2020.

Resultados/Benefícios esperados

Pretende-se obter os resultados que permitam responder às perguntas que surgem na base da realização desta dissertação, ou seja, avaliar se existe efetivamente uma correlação do volume das vias aéreas respiratórias superiores nos diferentes tipos de padrão esquelético e, se sim, como se relaciona a sua morfologia com as diferentes classes esqueléticas.

Riscos/Desconforto

A investigação proposta não acresce para o participante qualquer risco ou desconforto, visto que todos os exames e procedimentos clínicos necessários já foram realizados previamente.

Considerações éticas

Durante todo o processo de investigação será mantido o anonimato do participante, sendo atribuído um código numérico. Evita-se assim o acesso, divulgação ou envolvimento de terceiros aos dados pessoais dos participantes.
No decorrer desta investigação, será assegurado de que todos os dados pessoais utilizados irão permanecer na clínica privada “Dentereal- Clinica Dentária de Vila Real, Lda.”, não existindo qualquer possibilidade em realizar transferências de dados.

Data:__ /__ /___

Declaro que recebi, li e compreendi o documento da explicação do estudo.

____

O participante/ O paciente

Declaração de Consentimento Informado

Eu ____(Nome completo), compreendi a explicação que me foi fornecida, por escrito e verbalmente, acerca da investigação com o título *"Upper airways volume and craniofacial morphology: a CBCT retrospective study*" (volume das vias aéreas e a morfologia craniofacial: um estudo retrospetivo em CBCT) conduzida pela investigadora Ana Carolina Sarrico Madaíl na Faculdade de Medicina Dentária da Universidade do Porto, para a qual é pedida a minha participação. Foi-me dada a oportunidade para fazer as perguntas que julguei serem necessárias, e para todas obtive resposta satisfatória.

Tomei conhecimento de que, de acordo com as recomendações da Declaração de Helsínquia, a informação que me foi prestada versus os objetivos, os métodos, os benefícios previstos, os riscos potenciais e o eventual desconforto. Além disso, foi-me afirmado que tenho o direito de decidir livremente, aceitar ou recusar a todo o tempo a sua participação no estudo. Sei que posso abandonar o estudo e que não terei que suportar qualquer penalização, nem quaisquer despesas pela participação neste estudo.

Foi-me dado todo o tempo de que necessitei para refletir sobre esta proposta de participação.
Nestas circunstâncias, consinto participar neste projeto de investigação, tal como me foi apresentado pelo Médico Dentista responsável, sabendo que a confidencialidade dos participantes e dos dados a eles referentes se encontra segura.

Mais autorizo que os dados deste estudo sejam utilizados para este e outros trabalhos científicos, desde que irreversivelmente anonimizados.

Data___/___/_____

Assinatura do responsável pelo participante

____
_

Assinatura da investigadora

____
_

Assinatura do Orientador

____

U.PORTO

FACULDADE DE MEDICINA DENTÁRIA
UNIVERSIDADE DO PORTO

Exmo. Senhor
Diretor do Mestrado Integrado
da Faculdade de Medicina Dentária da Universidade do Porto
Professor Doutor César Fernando Coelho Leal da Silva

Assunto: Parecer da orientadora para entrega do trabalho final de Monografia de Mestrado Integrado em Medicina Dentária

Para os devidos efeitos informo que o Trabalho de Monografia desenvolvido pela Estudante Ana Carolina Sarrico Madail com o título: "Upper airways volume and craniofacial morphology: a CBCT retrospective study" está de acordo com as regras estipuladas na FMDUP, foi por mim conferido e se encontra em condições de ser apresentado em provas públicas.

Porto, 21 de Maio de 2020

Orientadora,
Maria Cristina Figueiredo Pollmann
Professora Associada com agregação

[illegible]

PARECER

(Entrega do trabalho final de Monografia)

Informo que o Trabalho de Monografia desenvolvido pelo(a) Estudante Ana Carolina Sarrico Madail com o título: *Upper airways volume and craniofacial morphology: a CBCT retrospective study*, está de acordo com as regras estipuladas na FMDUP, foi por mim conferido e encontra-se em condições de ser apresentado em provas publicas.

19/5/2020

O(A) Co-Orientador(a)

DECLARAÇÃO

Monografia de Investigação/Relatório de Atividade Clínica

Declaro que o presente trabalho, no âmbito da Monografia de Investigação/Relatório de Atividade Clínica, integrado no MIMD, da FMDUP, é da minha autoria e todas as fontes foram devidamente referenciadas.

18/05/2020

Ana Macedo

O / A investigador(a)

INFORMAÇÃO

(Entrega do trabalho final de Monografia após cumprimento das diretivas emanadas pelo Serviço de Proteção de Dados da U.Porto)

Informo que, relativamente ao Trabalho de Monografia com o título: Upper airways volume and craniofacial morphology: a CBCT retrospective study,

foram cumpridas todas as diretivas emanadas pelo Serviço de Proteção de Dados da U.Porto, encontrando-se em condições de ser apresentado em provas públicas.

18/05/2020

O(A) Estudante

(Nome em maiúsculas): ANA CAROLINA SARRICO MADAIL

(Assinatura): Ana Carolina Sarrico Madail