FACULDADE DE MEDICINA DENTÁRIA
UNIVERSIDADE DO PORTO

"MIDPALATAL SUTURE MATURATION: COMPARATIVE STUDY OF TWO METHODS OF ASSESSMENT USING CBCT"

Research Dissertation

MARIANA DA ROCHA E ALMEIDA

A thesis submitted to the Faculty of Dental Medicine, Porto University with the requirements for the integrated Master's degree in Dental Medicine

Porto, 2019

U.PORTO
FACULDADE DE MEDICINA DENTÁRIA
UNIVERSIDADE DO PORTO

"Midpalatal Suture maturation: Comparative study of two methods of assessment using CBCT"

Author: Mariana da Rocha e Almeida

Student number: 201304629

Phone contact: 915557387

Thesis Supervisor: Dr. Maria João Feio Ponces Ramalhão

Assistant Professor, Faculty of Dental Medicine, Porto University

Thesis Co-supervisor: Dr. Eugénio Joaquim Pereira Martins

Assistant Professor, Faculty of Dental Medicine, Porto University

Acknowledgments

To my counselor, Professor Maria João Ponces, for the motivation, patience and ,above all, for the example as a professional. Thank you for all your support and guidance, essential for this dissertation.

To my co-advisor, Professor Eugénio Martins, for the help and concern in the accomplishment of this work.

To all my family, with special attention to my parents, for the opportunity they gave me to join the Faculty of Dental Medicine, Porto University and for the help to overcome the various obstacles that appeared along the way. Above all, for all the sacrifices they have made over the years, through unconditional love and encouragement. Without them, this unique experience would not be possible.

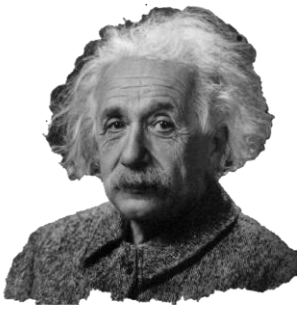
To my sister, my best friend, for all the support and love and for always being there for me in the hardest moments.

To my friends who have always been by my side, for all the love and laughter and for cheering me up in difficult times.

To the friends that I have made during these 5 years, who have never left my side, for the laughter and the unique moments that have made this journey unforgettable.

"The important thing is not to stop questioning. Curiosity has its own reason for existing."

Albert Einstein



Abstract

Introduction: Rapid maxillary expansion is a procedure used by orthodontists to treat maxillary deficiency in the transversal plane. This procedure can only be performed when the midpalatal suture is not fused. For this reason, orthodontists are often challenged with the decision whether the rapid maxillary expansion is the appropriate treatment or, alternatively, the option is the surgically assisted rapid palatal expansion (SARPE) or a micro-implant-assisted rapid palatal expander. Therefore, the maturation of the midpalatal suture should always be evaluated before orthodontic treatment.

Objective: The aim of this research is the validation of the BOKA method, a recently proposed method to be published in the present year of 2019, for the evaluation of the midpalatal suture by means of computed tomography (CT) scans.

Materials and Methods: The state of art was assessed by means of literature review on the Pubmed, Scielo and on the SCOPUS databases. Out of 275 articles found, 33 were selected. The sample consisted of 76 individuals (32 males and 44 females with a mean age of 18,8 ± 11,6 years) who performed concomitant cone bean computed tomography (CBCT). Panoramic-type projections and axial sections from CBCT were collected and analyzed. The data collected and treated was anonymized. Statistical processing was made using SPSS® software.

Results: Weighted Cohen Kappa Coefficient values were higher than 0.85, both in the evaluation of the inter and intra-observer error and for both scales. The Spearman Correlation Coefficient (R = 0.838) and the ICC (0.883) values show the existence of an association between the two scales. The results of the agreement study between the BOKA and Angelieri *et. al* scales recoded show the existence of a moderate agreement, with a weighted Cohen Kappa Coefficient of 0.533 (CI - 95%: 0.289-0.778).

Conclusion: The results of this study demonstrate that the BOKA and Angelieri *et al.* scales have a strong correlation with each other, which leads to the conclusion that the BOKA scale seems to be effective in assessing the maturation of the midpalatal suture. However, since the agreement decreases once the scales are recoded based on the treatment decision, further studies are needed to validate this method concerning its efficacy and clinical applicability as a diagnostic method.

Resumo

Introdução: A expansão rápida da maxila é um procedimento utilizado pelos ortodontistas para o tratamento da deficiência maxilar no plano transversal. Este procedimento só pode ser executado quando a sutura palatina não se encontra fusionada. Assim sendo, a maturação da sutura palatina deve sempre ser avaliada antes de se proceder ao tratamento ortodôntico.

Objetivo: O objetivo desta dissertação de investigação será validar a utilização do método BOKA, um método proposto recentemente, a ser publicado no presente ano de 2019, para a avaliação da maturação da sutura palatina mediana através de tomografias computorizadas.

Material e Métodos: A pesquisa bibliográfica foi baseada em publicações encontradas nas bases de dados da Pubmed, da Scielo e da SCOPUS. De um total de 275 artigos encontrados, foram selecionados 33 para esta dissertação de investigação. A amostra consistiu em 76 indivíduos (32 do sexo masculino e 44 do sexo feminino, com uma média de idade de 18,8 ±11,6 anos) que fizeram CBCT. Foram recolhidas e analisadas as projeções do tipo panorâmica e os cortes axiais provenientes de CBCT. Os dados recolhidos e tratados foram anonimizados. O tratamento estatístico dos dados foi realizado com recurso ao software SPSS®.

Resultados: Os valores do coeficiente de Kappa de Cohen foram maiores que 0,85, tanto na avaliação do erro inter como do erro intra-observador para ambas as escalas. Os valores do Coeficiente de Correlação de Spearman (R = 0,838) e do ICC (0,883) mostram a existência de uma forte correlação entre as duas escalas. Os resultados do estudo de concordância entre as escalas BOKA e Angelieri *et. al.* recodificadas mostram a existência de uma concordância moderada, com um coeficiente de Kappa de Cohen de 0,533 (IC - 95%: 0,289-0,778).

Conclusão: Os resultados deste estudo demonstram que as escalas de BOKA e Angelieri *et al.* têm uma forte correlação entre si, o que leva à conclusão de que a escala BOKA parece ser efetiva na avaliação da maturação da sutura palatina. No entanto, como a concordância diminui quando as escalas são recodificadas com base na decisão do tratamento, conclui-se que mais estudos são necessários para validar esse método no que diz respeito à sua eficácia e aplicabilidade como meio de diagnóstico na prática clinica.

KEYWORDS:

Midpalatal Suture; Maxillary Expansion; Orthodontics; CBCT (Cone-Bean-Computed-Tomography); Computed Tomography; Midpalatal Suture Maturation

Abbreviations:

ANS – Anterior nasal spine

BGS - BOKA grading system

CBCT - Cone bean computed tomography

CVM - Cervical vertebrae method

CI – Confidence Interval

CT – Computed tomography

DICOM - Digital Imaging and Communications in Medicine

HWM – Hand and wrist method

ICC – Intraclass correlation coefficient

M - Medium

MARPE - Micro-implant-assisted rapid palatal expander

MPS – Midpalatal suture

MPSM - Midpalatal suture morphology

MPSD – Midpalatal suture density

OI - Obliteration index

P – Significance value of statistical tests

PNS – Posterior nasal spine

R – Spearman correlation coefficient

RME – Rapid maxillary expansion

SARPE - Surgically assisted rapid palatal expansion

SD - Standard deviation

List of Tables

List of Figures

TABLE OF CONTENTS

Índex:

INTRODUCTION

I. Introduction

Rapid maxillary expansion is a procedure used by orthodontists to treat maxillary deficiency in the transversal plane. The maxillary deficiency is often associated with posterior crossbites, dental crowding and functional and aesthetical problems, such as abnormal tongue posture and narrowing of the pharyngeal airway, resulting in oral breathing problems [(1)]. This procedure can only be performed when the midpalatal suture is not fused or with light interdigitations as these can be an obstacle to the expansion of the maxillary bone [(2)].

The ossification of this suture increases with age. For this reason, orthodontists are often challenged with the decision to choose whether the rapid maxillary expansion (RME) is the appropriate treatment or if, alternatively, the option is the combined surgical treatment [(3)]. Recently, a new treatment has been proposed, called micro-implant-assisted rapid palatal expander (MARPE), in which the forces are applied into palatal micro-implants in order to prevent a surgical disjunction procedure[(4, 5)]. Therefore, the maturation of the midpalatal suture should always be evaluated before orthodontic treatment.

Although the suture ossification seems to increase during or after the pubertal growth spur, the chronological age itself doesn't seem to be the best method to assess whether an individual has reached this development phase or not [(6, 7)]. Based on a study by Melsen *et. al* [(8)], the morphology of the suture changes during the multiple stages of development. These alterations are observed in the biologic behavior and morphology. An increase in the density with aging and skeletal maturation can also be observed [(9, 10)].

Several methods have been proposed over the years for the palatine suture evaluation, such as assessment through occlusal radiographs, which was originally proposed by Relevo and Fishman [(11-15)]. However, they are not the best method for analyzing the midpalatal suture (MPS) morphology since the vomer and the other structures of the external nose usually overlay the radiographic image of the suture, which might cause incorrect interpretations of the actual morphological features [(10, 16, 17)]. Assessment through CBCT was studied by multiple authors and it is still a commonly used method in the present days to evaluate the midpalatal suture fusion and its morphology since it provides a three dimensional analysis without the superimposition of the adjacent structures [(18-24)]. CBCT studies have also been

used to evaluate the maturation of the midpalatal suture through the evaluation of its bone density [25, 26].

In addition, to aid in the weighting of the individual skeletal maturation index, we also evaluate the maturation of the cervical vertebrae [27] and the evaluation of the skeletal maturation index using hand and wrist radiographs [28]. Recently, the assessment through ultrasound examinations [29], using computerized tomography and micro-CT scans were also proposed. [30].

The aim of this research was to validate the BOKA method, a recently proposed method, to be published in the present year of 2019, through its comparison with a method of evaluation of the suture in CBCT proposed by Angelieri *et al.* in 2013. This method is considered a gold standard and is duly studied, described and validated in the literature as effective in determining the maturation of the midpalatal suture of the patient to be subjected to maxillary expansion [18, 31].

The BOKA grading system (BGS) is a recently proposed qualitative method presented in scientific meetings with preliminary results and to be published in the present year of 2019, which grades the maturation of the midpalatal suture, by means of observation of the suture in panoramic X-rays and its posterior classification in four distinct stages, according to the degree of maturation.

The classification method proposed by Angelieri *et al.* is also a qualitative method, which categorizes the maturation of the MPS in 5 stages by observing the suture in the central axis of the CBCT in the anterosuperior dimension, making a cut along the bone plate of the hard palate [18, 31].

Therefore, this study proposes the analysis of the panoramic type projections and the axial sections from CBCT exams. A retrospective study was carried out at the Faculty of Dental Medicine, Porto University with clinical data gathered from an orthodontic private practice. By means of a comparative study of the extracted cuts, it was intended to verify the agreement of the results of the two methods, in order to validate the BOKA classification method.

MATERIAL AND METHODS

II. Material and Methods

Literature Review:

The literature review that was carried out to assess the state of the art related to the subject of this work aimed to acquire up-to-date and relevant scientific information. The research was based on international publications found on the Pubmed, Scielo and Scopus databases and the following key words and combinations of the same were used: "Midpalatal Suture"; "Maxillary Expansion"; "Orthodontics", "CBCT (Cone-Bean-Computed-Tomography)"; "Computed Tomography"; "Midpalatal Suture Maturation" (Table I).

Table I: Search Strategy

Inclusion Criteria	Combinations of Key-Words
Full text availability	Midpalatal Suture AND CBCT
Articles written in English, Portuguese, Spanish and French.	Maxillary Expansion AND CBCT
Studies made in humans	Midpalatal Suture AND Computed Tomography
Systematic Reviews, Meta-Analysis, Clinical Trials, Controlled and Randomized Clinical Trials and Journal Articles	Maxillary Expansion AND Computed Tomography
Articles published in the last 20 years* *With the exception of the articles published by Fishman *et. al* and by Melsen *et. al*, that were considered in the study even though they didn't fit this criteria since they are considered gold standards, regarding the theme of this thesis.[8, 11]	Midpalatal Suture Maturation

Inclusive and exclusive criteria were applied and, out of 275 articles found, 33 were selected for this research dissertation.

Type of study

The present study is a retrospective, cross sectional epidemiological study with an observational and descriptive component.

Sample

The sample consisted of cone bean computed tomography data from 76 individuals who performed the CBCT as a complementary orthodontic diagnostic exam at a private dental practice. The sample was randomly selected from all consecutively orthodontic first appointments that met the criteria mentioned below. This is a retrospective study that was carried out at the Faculty of Dental Medicine, Porto University. The clinical examinations collection took place in a private practice and presupposes the due authorizations by the patients or their guardians. The treated and collected data was anonymized.

From the sample collected, 152 CBCT sections were produced and analyzed in this investigation. (76 panoramic-type projections and 76 axial sections from CBCT). The mean age of the subjects incorporated in this study was 18,8 ± 11,6 years and there were included 32 males and 44 females.

Inclusion and exclusion criteria

As inclusion criteria, the following ones were considered:

- CBCT taken before the beginning of the RME, MARPE or SARPE treatment;
- absence of any craniofacial syndromes, like congenital clefts of the palate or lip;
- absence of previous orthodontic treatment or orthognathic surgery;
- no age limit.

As for the exclusion criteria, the CBCT's that presented the following features were excluded:

- patients who undertook RME, MARPE or SARPE before taking the CBCT;
- low quality CBCT's that didn't allow a clear visualization of the midpalatal suture (for example: grainy or pixelated images);

- missing central incisors or central incisors with a trauma history;
- palatal abnormalities (for example: tori);
- supranumerary teeth (mesiodens);
- mesially impacted maxillary canines.

Radiographic material and method

Radiographic Equipment:

CBCT's were acquired with radiographic equipment with the following technical characteristics:

- Name: Planmeca ProMax ® 3D Mid
- Sensor type: flat screen
- Focal Spot: 0,5mm, fixed anode
- Voxel size: 0,4mm
- Image acquisition: 200/360 degree rotation
- Type of exposure: pulsed
- Volume size: 200x170 mm
- Type of reconstruction: cylindrical

The images were obtained with the individuals in maximum intercuspation, standing and with the head correctly positioned (Frankfurt plane parallel to the ground and the mid sagittal plane perpendicular to the ground).

For the acquisition of the images, some parameters were adjusted:

- Anode voltage: 60-90 kV, 60-120kV
- Anode Current: 1-14 mA
- Exposure time: 9-33 s

After the CBCT acquisition, the information was reconstructed automatically in three-dimensional images in Digital Imaging and Communications in Medicine (DICOM) format so that it could be visualized, oriented and analyzed in Planmeca Romexis software (Planmeca Oy, Helsinky, Finland).

The following steps were executed in order to determine and analyze the maturational stages of the midpalatal suture [18]:

Axial Cuts:

- In order to obtain the axial cut, the cursor was placed at the midsagittal plane in both axial (from the galli crest to the labial sulcus) and coronal (place patient until the 2 infraorbital points are in the same plane) views. As for the sagittal view, the patient's head was oriented until the anteroposterior long axis of the palate was parallel to a line going through the anterior and posterior nasal spines (Figure 1).
- In the case of patients who present a very curved palate, the maturation of the suture was analyzed in 2 distinct cuts, one of the anterior region of the palate and another of the posterior region.
- In the case of patients who present a very thick palate, it was evaluated in the 2 most central axial cuts, and the cut in which the suture shows greater maturation was considered for the study.
- Once the anteroposterior long axis of the palate was positioned horizontally and parallel to the line going through the anterior nasal spine (ANS) to the posterior nasal spine (PNS) points, the axial cuts were saved and used for the classification of the maturation stage of the midpalatal suture according to the 5 stages proposed by Angelieri *et al* [18,31].

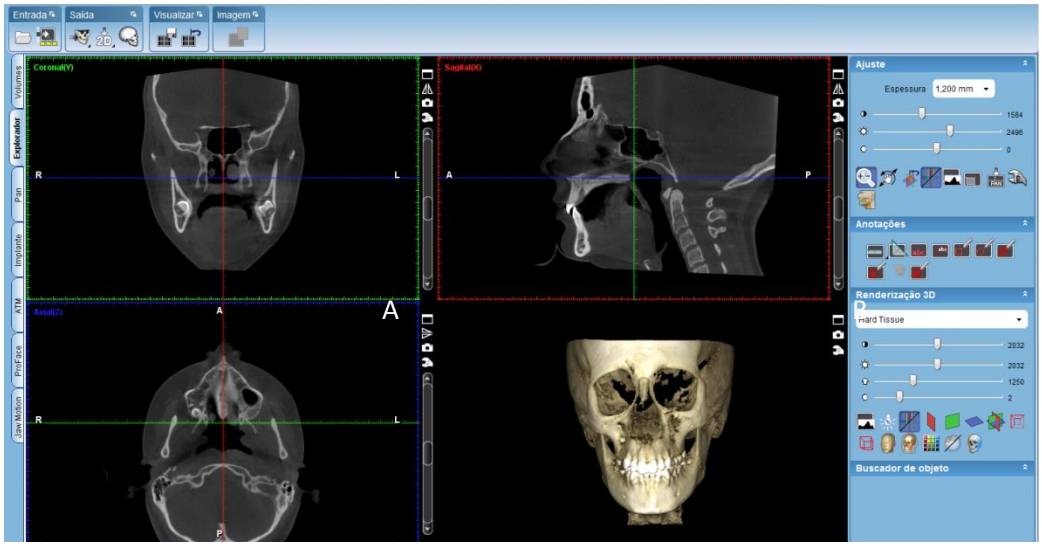
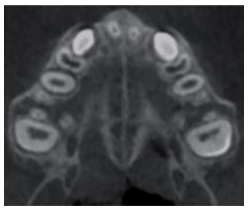
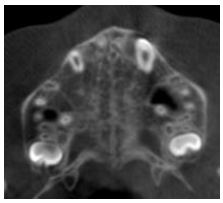
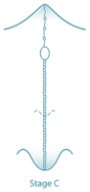
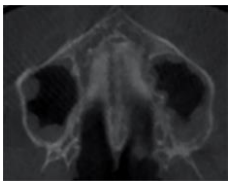
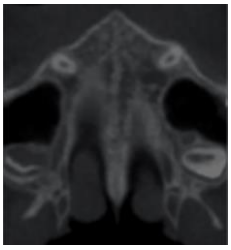
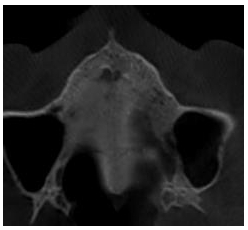


Figure 1: Head orientation in order to obtain the axial cut. A- Coronal View. B – Sagittal view. C - Axial View

Table II: Midpalatal suture classification according to the Angelieri *et. al* method

STAGE A: midpalatal suture presents a straight line of high density (radiopaque-white), slightly sinuous and with little or no interdigitations.		
STAGE B: the midpalatal suture assumes an uneven appearance, presented as a sinuous line of high density. Usually, there are already some small areas where you can see 2 parallel high density lines separated by small, low density spaces.		
STAGE C: it is possible to visualize two sinuous lines of high density parallel and close, separated by small spaces of low density in the maxillary and palatine bones. The suture may have a straight or irregular pattern.		
STAGE D: fusion of the palatine suture can already be verified in the palatine bone (with progressive maturation from posterior to anterior), so it cannot be visualized in this same location. In the maxillary portion, the suture continues to present itself as 2 parallel lines of high density separated by small spaces of low density.		
STAGE E: the fusion of the palatine suture occurs in both the palatine bone and at least a portion of the maxilla. The bone density of the suture is the same as that of the adjacent bone, so it is no longer visible.		

Panoramic Type Projections:

- In order to get the panoramic type projections, the cursor of the image analysis software was positioned on the right side to set a new panoramic cut. Then, the central points of the maxillary teeth were marked, starting at the 2nd right molar and going all the way to the 2nd left molar, in which the latter was double clicked on the cursor (Figure 2).
- After obtaining all the panoramic type projections, they were cropped to only show the region of interest (including the area between the upper central incisors and located between the upper portion of the anterior nasal spine and the lower edge of the maxillary central incisors) and to avoid bias in the research. Then, the images were classified according to the BOKA method:

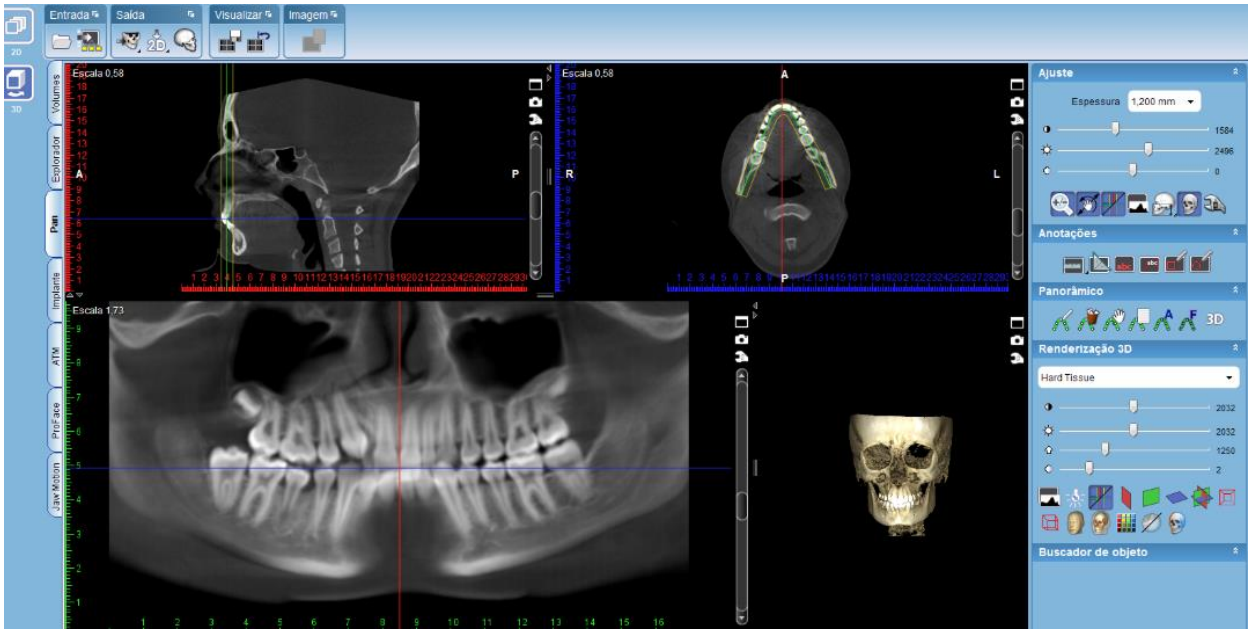
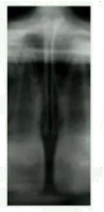
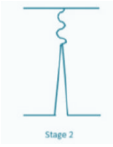
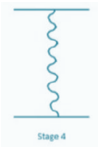


Figure 2: Panoramic curve design in order to obtain the panoramic type projection

Table III: Midpalatal suture classification according to the BOKA method

STAGE 1: the midpalatal suture travels a straight path with parallel lines of high density (radiopaque-white) and little or no interdigitations. It appears as a complete radiolucent (dark) line running from the floor of the nasal cavity to the alveolar crest between the maxillary central incisors.		
STAGE 2: the midpalatal suture presents interdigitations (whitish opaque area) in less than half the distance from the nasal cavity to the alveolar crest between the maxillary central incisors. In the area without interdigitations, we can visualize the open suture, but it is not as radiolucent as in stage 1.		
STAGE 3: the midpalatal suture presents interdigitations in more than half the distance from the nasal cavity to the alveolar crest between the maxillary central incisors. However, the suture does not appear "fully" attached as in stage 4.		
STAGE 4: the midpalatal suture is completely united, with bone interdigitations throughout the distance between the nasal cavity and the alveolar crest between the maxillary central incisors.		

Data collection and analysis protocol

Before importing this information to an external disc, protected by a password, a patient record with a coded identification (ex ID01) was created in order to guarantee anonymity.

Then, the CBCT scans of the patients who met the inclusion criteria were analyzed in the computers of the Orthodontic Department of the Dental Medicine Faculty, Porto University. No changes were made in the contrast, brightness or size of the radiographs.

The examination of the CBCT scans was made by two examiners (the author and another student, both of the last year of the Dental Medicine Integrated Master of the Dental Medicine Faculty, Porto University). Both examiners had never used the *BOKA* or the Angelieri *et al.* method previously. Therefore, they were trained using the teaching material from Angelieri *et al.* and from the BOKA grading system in order to be able to execute such evaluation. A calibration exercise to ensure that the observers had understood the method was also performed.

After the training period, the panoramic type projections and the axial sections from the CBCT scans of the 76 patients were classified by the two observers. A second evaluation was made after two weeks in 30 randomly chosen scans in order to evaluate the intra-examiner error.

These classification values were duly archived in an Excel 16,0® (Microsoft Office, New Mexico, U.S.A) document for further statistical analysis. Later, they were introduced in the SPSS Version 24 for Windows® (IBM corp. New York, U.S.A), where the respective statistical analysis was carried out. Excel® and SPSS® documents were saved in an external disc, encrypted and protected by a password.

Ethical considerations

In this study, the data collected was not accompanied by any identifying information of the patient to which they belong, thus safeguarding individual anonymity. The data was used exclusively in the present study.

The accomplishment of this research project does not add to the participant any type of risk or discomfort neither jeopardizes the well-being of the patients, since it is a cross-sectional descriptive and observational epidemiological study with the use of retrospective data and complementary diagnostic tests already performed and forming an integral part of the clinical processes. For this reason, the exams were not accompanied by informed consent.

This research does not have any financial or economic purposes, having merely academic goals.

Taking these facts into account, the Responsible for Access to Information of FMDUP, the Data Protection Unit of U.PORTO and the Ethics Committee's approvals were requested, and a positive answer was obtained (Annexes 1,2 and 3).

The author has no conflicts of interest to declare.

Statistical Methodology

Sample size calculation

The sample size estimation was done by specifying a test power of 80% (1 - β = 0.80, β being the Type II error) and a significance level of 5% (α = 0.05, α being the Type error I), following the indications of Bujang & Baharum [32]. Under these conditions, taking into account the ordinal scales under study, a minimum sample of 74 patients was required to detect a weighted Cohen Kappa Coefficient of 0.60, corresponding to a good agreement, assuming that the frequencies of each category of answers are not equal. For the evaluation of the intra-rater error, a randomized sub-sample of 30 patients from the total of participants in the study was selected.

Statistical Analysis:

Considering that the main objective of the study is the analysis of agreement between two ordinal categorical scales (BOKA and Angelieri *et. al* grading systems), the Spearman Correlation Coefficient (R) values were presented and the Intraclass Correlation Coefficient (ICC) was used. Considering that this coefficient varies from 0 to 1, the higher the value, the greater the agreement between the pairs of variables.

The inter and intra-observer errors were calculated before the analysis of the agreement between scales was performed, and since the Weighted Cohen Kappa Coefficient values and the percentages of agreement between the pairs were higher than 85% in all cases, proving that both scales are reproducible and applicable, the rest of the investigation was carried out.

The cut-off points proposed by Cicchetti were used to classify the agreement between the evaluations: unacceptable (<0.70), reasonable (0.70 - 0.79), good (0.80 - 0.89) and excellent (≥ 0.90) [33].

Since the purpose of studying a new method of evaluation of the midpalatal suture maturation is its application as a diagnostic method in the choice of appropriate treatment and since the 2 scales studied do not have the same number of categories, both scales have been recoded, according to the treatment decision and the respective data available in literature, in order to have the same number of categories [31]:

Method of Angelieri *et. al*:

- A - stages A and B: It is appropriate to proceed with conventional RME approach
- B - stage C: It is possible to do the expansion with conventional RME, but the success of the treatment is more doubtful and the skeletal effects may be lower
- C - stages D and E: Surgical assisted expansion is advised

BOKA method:

- A - stage 1: It is appropriate to proceed with conventional RME approach
- B - stage 2 and 3: It is possible to do the expansion with conventional RME, but the success of the treatment is more doubtful and the skeletal effects may be lower
- C - stage 4: Surgical assisted expansion is advised

The Weighted Cohen's Kappa Coefficient was used to evaluate the measurement error (inter and intra-examiner) and the correlation between the BOKA and Angelieri *et al.* scales once they were recoded into scales with the same number of categories. This coefficient assumes the maximum value of 1 in the case of perfect agreement between two measurements. The coefficient value is influenced by the magnitude of the discrepancy between the two evaluations, being that the larger the difference between the two evaluations, the greater the penalty on the coefficient value [(34)].

For the classification of the agreement between the pairs of measurements, the cut-off points proposed by Altman were considered: weak (<0, 20), reasonable (0,21 - 0,40) moderate (0.41 - 0.60), good (0.61 - 0.80) and very good (> 0.80) [(35)].

In addition, the percentages of agreement between the pairs of evaluations are also cited.

For the calculation of the weighted Cohen Kappa Coefficient, the package psych, version of 2017, (Revelle, Illinois, U.S.A) available in program R - version 3.3.2 of 2017 (R Core Team, Vienna, Austria) was used[(36)].

A significance level of 5% was considered, which means that the associations were considered statistically significant when the significance level was less than 0.05 ($p < 0.05$).

RESULTS

III. Results

Sample Characterization:

Sample characterization regarding gender and age

The sample consisted of 76 individuals aged between 7 and 58 years, mostly aged between 10 and 20 years (54.0%), with an average age of 18.8 ± 11,6 years. The majority are female (57.9%) (Table IV and Figure 3).

Table IV: Sample characterization regarding gender and age (N = 76)

	Categories	N	%
Gender	Female	44	57.9%
	Male	32	42.1%
Age (years)	< 10 years	13	17.1%
Minimum = 7	10 – 15 years	29	38.2%
Maximum = 58	16 – 20 years	12	15.8%
Medium = 18.8	20 – 30 years	10	13.2%
Standard-Deviation = 11.6	> 30 years	12	15.8%

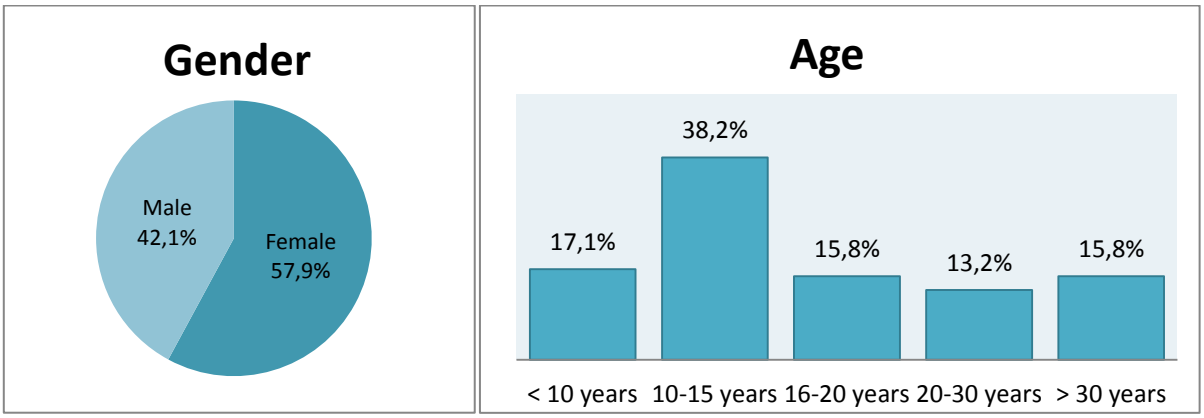


Figure 3: Sample characterization regarding gender and age (N = 76)

Sample Characterization regarding the classification of the BOKA and Angelieri *et. al* scales

Considering the evaluation obtained by the BOKA method, the majority of the patients are in stages 3 and 4 (69.7%). About 1 in 5 (21.2%) are in stage 2 and 9.2% in stage 1.

According to the Angelieri *et. al* method, the majority are in stage C or higher (69.7%), while 1 in 4 (25.0%) is in stage B and 5.3% in stage A.

Table V: Sample characterization regarding the classifications of the BOKA and Angelieri *et. al* scales (N = 76)

	Categories	n	%
BOKA	Stage 1	7	9.2%
	Stage 2	16	21.1%
	Stage 3	33	43.4%
	Stage 4	20	26.3%
Angelieri *et. al*	Stage A	4	5.3%
	Stage B	19	25.0%
	Stage C	14	18.4%
	Stage D	22	28.9%
	Stage E	17	22.4%

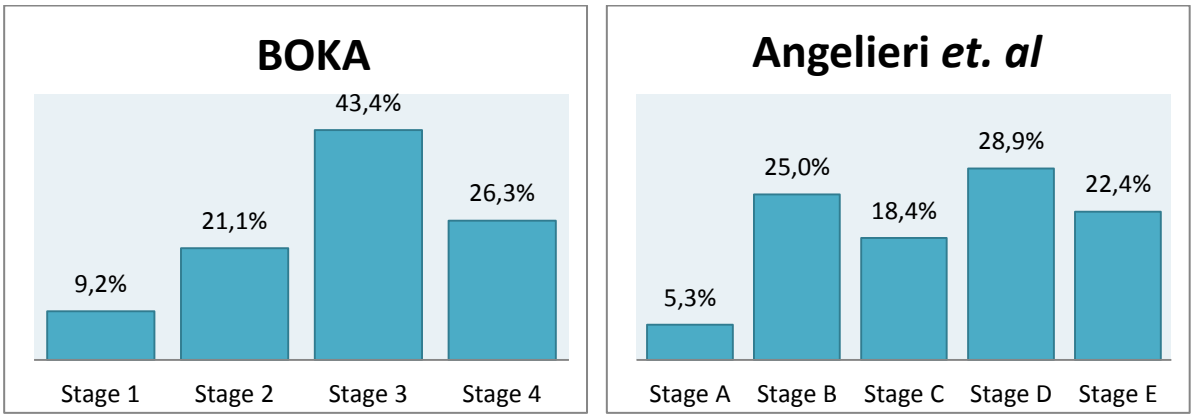


Figure 4: Sample characterization regarding the classifications of the BOKA and Angelieri *et. al* scales (N = 76)

Observational Error

To access observational error, the evaluations of the CBCT's were done by 2 observers, to allow the analysis of the inter-observer error and to avoid the observation bias. In addition, both observers repeated the evaluations of 30 participants after 2 weeks (39.5% of the sample, randomly selected), in order to allow the intra-observer error analysis. The results are presented in Tables VI to XI.

BOKA method:

Weighted Cohen Kappa Coefficient values on the BOKA scale were higher than 0.90, both in the assessment of the inter and intra-observer error (both observers). The percentages of agreement between the pairs were also above 90% in all cases. (Tables VI to VIII).

Table VI: Data from the study of the inter-observer error of the BOKA scale (N = 76)

		Observer 2				Total
		Stage 1	**Stage 2**	**Stage 3**	**Stage 4**	
Observer 1	**Stage 1**	**6**	0	1	0	7
	Stage 2	0	**15**	1	0	16
	Stage 3	0	2	**30**	1	33
	Stage 4	0	0	1	**19**	20
	Total	6	17	33	20	76
Kappa value = 0.927; % of agreement: 92.1% **(70/76)**						

Table VII: Data from the study of the intra-observer error of the BOKA scale – observer 1 (N = 30)

		2nd Analysis				Total
		Stage 1	**Stage 2**	**Stage 3**	**Stage 4**	
1st Analysis	**Stage 1**	**2**	0	0	0	2
	Stage 2	0	**6**	1	0	7
	Stage 3	0	0	**12**	0	12
	Stage 4	0	0	0	**9**	9
	Total	2	6	13	9	30
Kappa value = 0.979; % of agreement: 96.7% **(29/30)**						

Table VIII: Data from the study of the intra-observer error of the BOKA scale – observer 2 (N = 30)

		2nd Analysis				Total
		Stage 1	**Stage 2**	**Stage 3**	**Stage 4**	
1st Analysis	**Stage 1**	**2**	0	0	0	2
	Stage 2	0	**6**	0	0	6
	Stage 3	0	0	**13**	1	14
	Stage 4	0	0	0	**8**	8
	Total	2	6	13	9	30
Kappa value = 0.978; % of agreement: 96.7% **(29/30)**						

Angelieri *el. al* method:

Regarding the Angelieri *et. al* scale (Tables IX to XI), the weighted Cohen Kappa Coefficient is bigger than 0,90 and the percentages of agreement in the inter and intra-observer evaluations are also higher than 85%.

Table IX: Data from the study of the inter-observer error of the Angelieri *et. al* scale (N = 76)

		Observer 2					Total
		Stage A	**Stage B**	**Stage C**	**Stage D**	**Stage E**	
Observer 1	**Stage A**	**3**	0	0	1	0	4
	Stage B	0	**17**	1	1	0	19
	Stage C	0	0	**12**	1	1	14
	Stage D	0	0	1	**20**	1	22
	Stage E	0	0	0	2	**15**	17
	Total	3	17	14	25	17	76
Kappa value = 0.895; % of agreement: 88.2% **(67/76)**							

Table X: Data from the study of the intra-observer error of the Angelieri *et. al* scale – observer 1 (N = 30)

		2nd Analysis					Total
		Stage A	**Stage B**	**Stage C**	**Stage D**	**Stage E**	
1st Analysis	**Stage A**	**0**	0	0	0	0	0
	Stage B	0	**6**	0	0	0	6
	Stage C	0	0	**6**	1	0	7
	Stage D	0	0	2	**6**	1	9
	Stage E	0	0	0	0	**8**	8
	Total	0	6	8	7	9	30
Kappa value = 0.944; % of agreement: 86.7% **(26/30)**							

Table XI: Data from the study of the intra-observer error of the Angelieri *et. al* scale – observer 2 (N = 30)

		2nd Analysis					Total
		Stage A	**Stage B**	**Stage C**	**Stage D**	**Stage E**	
1st Analysis	**Stage A**	**0**	0	0	0	0	0
	Stage B	0	**4**	1	0	0	5
	Stage C	0	0	**7**	0	0	7
	Stage D	0	1	0	**8**	1	10
	Stage E	0	0	0	0	**8**	8
	Total	0	5	8	8	9	30
Kappa value = 0.909; % of agreement: 90.0% **(27/30)**							

Correlation between BOKA and Angelieri *et. al* methods

The results of the correlation study between the BOKA and Angelieri *et. al* scales are presented in Table XII and in Figure 5. The Spearman Correlation Coefficient (R = 0.838) and the ICC (0.883) values show the existence of an association (correlation) between the two scales. This association is graphically visible in Figure 4.

Since the two scales have a different number of categories, it was not possible to display the percentages of agreement.

Table XII: Correlation between BOKA and Angelieri *et. al* methods (N = 76)

		ANGELIERI *ET. AL*					Total
		Stage A	**Stage B**	**Stage C**	**Stage D**	**Stage E**	
BOKA	**Stage 1**	4	1	2	0	0	7
	Stage 2	0	13	3	0	0	16
	Stage 3	0	5	9	17	2	33
	Stage 4	0	0	0	5	15	20
	Total	4	19	14	22	17	76
ICC = 0.883; Correlation Coefficient: 0.838 **(p < 0.001)**							

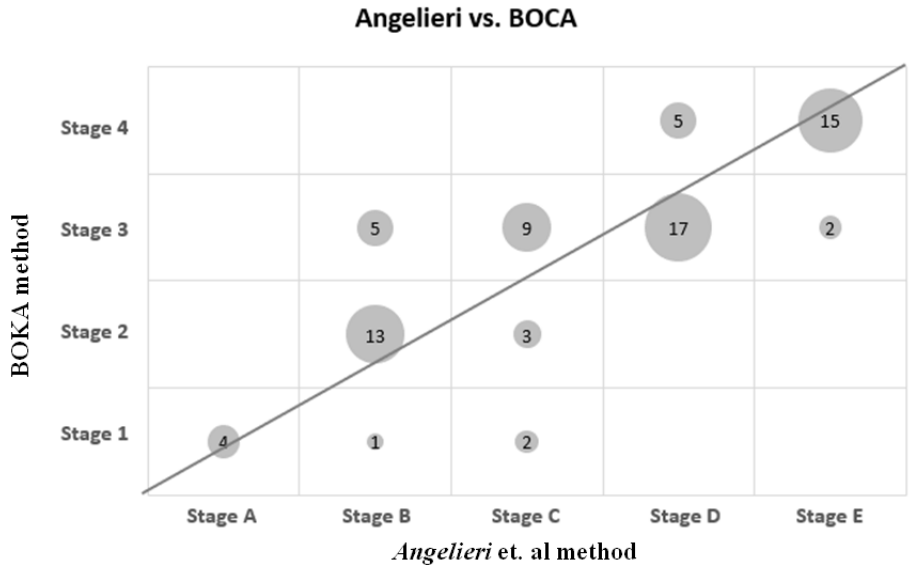


Figure 5: Scatter diagram of the evaluations of the BOKA and Angelieri *et. al* methods - the diameter of the circles is proportional to the number of cases - the values are indicated inside the circles (N = 76)

Agreement between the BOKA and Angelieri *et. al* scales recoded

The results of the agreement study between the BOKA and Angelieri *et. al* scales recoded based on the treatment decision (Table XIII) show the existence of a moderate agreement, with a weighted Cohen Kappa Coefficient of 0.533 (CI - 95%: 0.289-0.778) and a percentage of agreement between classifications of 48.7%.

Compared with the Angelieri *et. al* method, the BOKA method led to a lower percentage of patients in category A (It is appropriate to proceed with conventional RME approach: 9.2% vs. 30.3%) and category C (Surgical assisted expansion is advised: 26.3% vs. 51.3%). On the opposite, the BOKA Method classified more patients into category B (It is possible to do the expansion with conventional RME, but the success of the treatment is more doubtful and the skeletal effects may be lower: 64.5% vs. 18.4%).

Table XIII: Correlation between the BOKA and Angelieri *et. al* scales recoded (N = 76)

		ANGELIERI *ET. AL*			Total
		A (Stages A and B)	**B (Stage C)**	**C (Stages D and E)**	
BOKA	**A (Stage 1)**	**5**	2	0	7 (9.2%)
	B (Stages 2 and 3)	18	**12**	19	49 (64.5%)
	C (Stage 4)	0	0	**20**	20 (26.3%)
	Total	23 (30.3%)	14 (18.4%)	39 (51.3%)	76
Kappa Coefficient = **0.533 (CI - 95%: 0.289-0.778);** Percentage of agreement between classifications: **48.7% (37/76)**					

DISCUSSION

IV. Discussion

The practical usefulness of a diagnostic procedure depends not only on the ease of execution, but also, and above all, on the potential clinical benefit.

The present dissertation aimed, as previously mentioned, on the validation of a recently proposed method of diagnosis of the maturation of the midpalatal suture (BOKA grading system) through the use of 3D generated panoramic x-rays.

Elicitation of the State of Art

The decision on whether a patient is a suitable candidate for RME without assisted surgery is a clinical question that comes across in a lot of adolescents or young adult patients [18].

Since it has been established that the chronological age is unreliable in ascertaining the development status of the MPS during growth, several methods of individual assessment of this suture have been proposed over the years [27, 28].

It has also been proved by histological and microcomputed tomography studies that the presence or absence of fusion / ossification is not the most determining factor in the success or failure of the expansion, while the percentage of fusion in each patient is more decisive [18]. However, these studies have not been able to explain the reason why some adult sutures with small fusion indexes are so difficult to open with conventional techniques. Therefore, factors such as age-related increased rigidity of the maxillary bone and marked interdigitations of the midpalatal and other maxillary structures have been described as the likely causes of the resistance to RME conventional approaches [7, 30].

Understanding individual variability in the development status of the midpalatal suture during growth, such as MPS morphology (MPSM), MPS density (MPSD) and obliteration index (OI), are now considered essential before deciding on the appropriate treatment [2, 7, 25].

Through the revision performed, it is possible to conclude that an accurate diagnostic method is a key element in RME's success. However, it cannot be forgotten that the rigidity

of the maxillary bones sinostosis of the other sutures of the face, such as the frontonasal suture, zygomaticmaxillary suture and zygomatictemporal suture can make orthodontic treatment harder[14, 16].

Considering the information mentioned above, this dissertation was based on the study of two diagnostic methods that evaluate the maturation of the MPS through the assessment of its morphology, being that one of them is based on the examination of axial cuts obtained by CBCT and the other in the analysis of panoramic x-rays.

Sample and methodology

The sample consisted on 76 randomly selected individuals. For this reason, and since the distribution of the sample in terms of age and gender is not uniform, there is an added difficulty when it is intended to correlate the association of the sample with sex and age, not allowing to conclude if there is a statistically significant relationship between them and the maturation of the suture.

Nonetheless, since the purpose of this research study was only to validate the BOKA grading system through its correlation with the Angelieri *et. al* method, the fact that the sample is random does not influence the results [18, 31].

With regard to the methodology, it is important to note that the fact that the two examiners have never used this method before could be a disadvantage, but an intensive training was made to ensure that it would not happen. The CBCT's were cropped to only show the region of interest and to avoid bias in the research. Moreover, it is important to highlight that radiographic diagnosis are always subjective and dependent on the quality of the images and on the clinical experience and knowledge of the professionals, which may lead to inaccuracies in the analysis of results and on the research itself.

However, according to the results, the methods that were studied in this research are both reliable, since the Cohen Kappa Coefficient and percentage of agreement were higher than 85%, both in the inter and intra-observer error analysis and for both of the investigated methods [34].

These results led to the conclusion that there is a great agreement between the measurements, meaning that there is no observational error concerning the BOKA and the Angelieri *et. al* scales, showing that both methods are reproducible and applicable in clinical practice, and in case of the assessment of the MPS via CBCT proposed by Angelieri *et. al*, they are in agreement with the literature[18, 31].

According to Angelieri *et. al*, who proposed a CBCT classification method based on the MPS morphology, when the suture ossification is in A or B stages, conventional RME approach should be effective and have more skeletal effects, since the MPS has lower resistance forces. Concerning stage C, the studies show that the timing for conventional RME is critical, since a lot of areas of initial ossification can be observed throughout the suture and the fusion of the palatine portion of the MPS is about to happen. As for stages D and E, SARME should be the treatment of choice due to the fact that the fusion of the suture has already occurred completely or partially [18] [31].

According to the available literature, conventional RME is considered the treatment of choice and presents a high success rate in individuals who present the suture in stages A, B or C. For individuals aged 15 or older, traditional RME may be considered as the treatment of choice if the suture is in stage C. However, further clinical trials are required to confirm the good prognosis of treatment in these situations [23, 37].

In a study by Haghanifar *et al.* [19], the results showed that the ossification of the midpalatal suture increased with age. On the other hand, a few cases of completely open sutures were also observed in patients older than 20. Therefore, these results are compatible with the hypothesis that the MPS might be the only one that may not be fully closed even in adults [10].

Additionally, some studies have ascribed the possibility of an open suture in elderly patients to a decline in the functional strength of the facial muscles (usually caused by tooth loss or the use of a softer diet), which leads to a decrease in both mechanical and masticatory forces exerted on the maxillary bone and seems to affect the ossification process and the morphology of the MPS [10].

Over the years, articles were published to determine if there was a significant relationship between the classification proposed by Angelieri *et al*. and other developmental age indices.

Jang *et. al* [21] concluded that the hand and wrist method (HWM) and cervical vertebrae method (CVM) indices had a strong correlation with the MPS morphology classification method.

Although the five stages method of classification via CBCT proposed by Angelieri *et. al* has been considered as reliable by several studies and used by many professionals in the last years, a few recent studies defend that the determination of the midpalatal suture density ratio via CBCT is also a valid alternative as a diagnostic method and may even be a more effective predictor of the amount of skeletal response to the RME procedure and to follow up the retention period after the treatment [20, 25, 26].

Even though the classification of MPS morphology proposed by Angelieri *et. al* permits a viable analysis of MPS maturation, it is impossible to obtain routine CBCT exams for all patients in clinical practice. In addition, there are ethical concerns regarding CBCT, due to the high exposure to radiation, particularly in those patients without the need of such a specific diagnosis. For this reason, other diagnostic methods have been proposed, such as those that include Panoramic X-rays [21].

This is why, in this study, 76 panoramic type projections obtained by CBCT images were analyzed in order to find out if the BOKA method, a recently proposed method of evaluation of the midpalatal suture morphology through panoramic radiographies, allows for an effective assessment of the MPS.

However, since the BOKA method is a recently proposed method, there is still no published data supporting it.

The most relatable studies we can find are the ones that assess the MPS maturation through occlusal radiographs. This is also a two-dimensional analysis method, but it is based on an axial view of the suture rather than a panoramic view such as the one proposed by BOKA. Multiple studies have been conducted to determine whether occlusal radiographs are an accurate diagnostic method for MPS maturation [11, 12, 14]. It has been demonstrated that the vomer and other structures from the external nose may overlap the MPS leading to false radiographic interpretations of the midpalatal suture maturation, which might also happen if the suture doesn't run parallel to the X-ray path in its main course [10, 12, 16, 17] .

The existing literature seems to show that occlusal radiographs might be more useful during the treatment and retention period to verify if the suture is open and to aid in the decision whether the palatal expander device can be removed or not[13, 15].

BOKA/Angelieri scales correlation

In fact, the results of this study (Spearman Correlation Coefficient (R = 0.838) and the ICC (0.883)) demonstrate the existence of an association (correlation) between the two scales, disclosing that this method might be a viable alternative to CBCT when it comes to the evaluation of the MPS maturation.

These results allow us to conclude that, in addition to the reproducibility of the methods, our study also has a high reliability and validity, since the correlation values between the two scales evaluated was very good (>0,80), demonstrating that the BGS can be used to access the maturation of the midpalatal suture.

Recoded BOKA/Angelieri scales agreement

Considering that the main objective of studying a new method of assessment of the midpalatal suture maturation is its application in the clinical practice as a diagnostic method, to support the decision of the appropriate treatment, and since the 2 methods studied do not have the same number of categories, both of them have been recoded, according to the data available in literature and based on the treatment decision, in order to have the same number of categories and allowing its clinical use and application [31].

However, unlike in the case of the non-recoded scales, it was observed that, once the scales are recoded into grades with the same number of categories based on the treatment choice, the weighted Cohen Kappa Coefficient decreases to a value of 0.533[34]. This decrease in agreement may be due to a difficulty in recoding the BOKA scale owing to the lack of scientific literature supporting this method, demonstrating that more clinical studies are needed with regard to the BOKA scale in order to enable a greater precision in its interpretation and in the correct choice of treatment based on it.

In addition, by converting a scale with more variables into one with fewer stages, information deficit might occur due to the loss of discriminative capacity at the intermediate stages, causing distortion of the scale [38].

Furthermore, the discriminating capacity of the scales should also be considered, and the fact that the Angelieri *et. al* scale has more variables, turns it into a more discriminatory scale, which means that it allows for a more precise classification and a better distribution by the recoded groups, when compared to the BGS. This aspect may also be related to the decrease of correlation when analyzing the recoded scales [38].

Study limitations and final considerations

Although the results obtained allow for the conclusion that there is a relation between the 2 scales, it is important to mention that an examination through panoramic x-rays should always be made with great care, since the images obtained are a two-dimensional image of a three-dimensional structure. Therefore, it is only possible to visualize a small portion of the whole anteroposterior length of the MPS and some structures might overlap the image of the suture.

Another question that should be considered in this study is that the image obtained in a panoramic type projection through the CBCT may not fully resemble the one obtained in a panoramic x-ray. Recent studies have showed that CBCT images add substantial information when compared to panoramic x-rays and that these variations among the radiographic images were more likely to be detected in the maxillary teeth [39]. However, further studies focused on the evaluation of the bone structures are required.

Moreover, the morphology of the MPS in the radiographic image may present a few differences in relation to the actual structure of the midpalatal suture. For this reason, some studies suggest that a histological or micro-tomography evaluation might be necessary to evaluate the maturation of the MPS with greater precision [18].

Nevertheless, and despite the fact that the results indicate that there is a correlation between the 2 scales, further studies are necessary to confirm the results of the present study. Clinical studies using the BOKA grading system to determine whether the patients

who need maxillary expansion should be treated with conventional RME approach or with MARPE or SARME must be performed, in order to validate its clinical efficacy and applicability.

Future studies in which the BOKA grading system is used to assess the changes in the midpalatal suture following RME (during the retention period), or to decide if the palatal expander can be removed, might also be required to validate the applicability of this method.

CONCLUSION

V. Conclusion

Taking into account the study limitations, the results of this study indicate that:

- The intra and inter-observer agreement were very good both for the BOKA and Angelieri *et. al* methods, which means that both scales are reproducible.
- The BOKA and Angelieri *et. al* scales, when not recoded, have a strong correlation with each other, which leads to the conclusion that the BOKA scale seems to be effective in assessing the maturation of the midpalatal suture.
- When the scales are recoded, on the other hand, the degree of correlation between them decreases, showing that future clinical studies are required in order to prove if the BGS is a valid and reliable method of diagnostic to be used in the clinical practice for the evaluation of the MPS maturation and to support the decision of the appropriate treatment when the need for maxillary expansion is present.

BIBLIOGRAPHIC REFERENCES

VI. Bibliographic references

1. McNamara JA, Jr., Lione R, Franchi L, Angelieri F, Cevidanes LH, Darendeliler MA, et al. The role of rapid maxillary expansion in the promotion of oral and general health. Prog Orthod. 2015;16:33.

2. Isfeld D, Lagravere M, Leon-Salazar V, Flores-Mir C. Novel methodologies and technologies to assess mid-palatal suture maturation: a systematic review. Head Face Med. 2017;13(1):13.

3. Chrcanovic BR, Custodio AL. Orthodontic or surgically assisted rapid maxillary expansion. Oral Maxillofac Surg. 2009;13(3):123-37.

4. Brunetto DP, Sant'Anna EF, Machado AW, Moon W. Non-surgical treatment of transverse deficiency in adults using Microimplant-assisted Rapid Palatal Expansion (MARPE). Dental Press J Orthod. 2017;22(1):110-25.

5. Moon W, Wu KW, MacGinnis M, Sung J, Chu H, Youssef G, et al. The efficacy of maxillary protraction protocols with the micro-implant-assisted rapid palatal expander (MARPE) and the novel N2 mini-implant-a finite element study. Prog Orthod. 2015;16:16.

6. Stuart DA, Wiltshire WA. Rapid palatal expansion in the young adult: time for a paradigm shift? J Can Dent Assoc. 2003;69(6):374-7.

7. Knaup B, Yildizhan F, Wehrbein H. Age-Related Changes in the Midpalatal Suture. J Orofac Ortop Facial. 2004;65(6):467-74.

8. Melsen B. Palatal growth studied on human autopsy material: A histologic microradiographic study. Am J Orthod. 1975;68(1):42-54.

9. Salgueiro DG, Rodrigues VH, Tieghi Neto V, Menezes CC, Goncales ES, Ferreira Junior O. Evaluation of opening pattern and bone neoformation at median palatal suture area in patients submitted to surgically assisted rapid maxillary expansion (SARME) through cone beam computed tomography. J Appl Oral Sci. 2015;23(4):397-404.

10. N'Guyen T, Ayral X, Vacher C. Radiographic and microscopic anatomy of the mid-palatal suture in the elderly. Surg Radiol Anat. 2008;30(1):65-8.

11. Revelo B, Fishman LS. Maturational evaluation of ossification of the midpalatal suture. Am J Orthod Dentofacial Orthop. 1994;105(3):288-92.

12. Thadani M, Shenoy U, Patle B, Kalra A, Goel S, Toshinawal N. Midpalatal Suture Ossification and Skeletal Maturation: A Comparative Computerized Tomographic Scan and Roentgenographic Study. J Indian Acad Oral Med Radiol. 2010. 81-7 p.

13. Gurgel Jde A, Malmstrom MF, Pinzan-Vercelino CR. Ossification of the midpalatal suture after surgically assisted rapid maxillary expansion. Eur J Orthod. 2012;34(1):39-43.

14. David SMN, Castilho JCdM, Ortolani CLF, David AF, Manhães Junior LRC, Matsui RH. Avaliação e mensuração da sutura palatina mediana por meio da radiografia oclusal total digitalizada em pacientes submetidos à expansão rápida maxilar. Rev Dent Press Ortodon Ortop Facial . 2009;14:62-8.

15. Martins M, Costa C, Abrão J, Lúcia Borri M. Rapid maxillary expansion: Radiographic analysis of the midpalatal suture density and its correlation in the osteogenesis stages by digital image. Rev Dent Press Ortodon Ortop Facial. 2009. 38e1-e9 p.

16. Wehrbein H, Yildizhan F. The mid-palatal suture in young adults. A radiological-histological investigation. Eur J Orthod. 2001;23(2):105-14.

17. Ennes J, Consolaro A. Sutura palatina mediana: avaliação do grau de ossificação em crânios humanos. Rev Dent Press Ortodon Ortop Facial. 2004;9:64-73.

18. Angelieri F, Cevidanes LHS, Franchi L, Gonçalves JR, Benavides E, McNamara Jr JA. Midpalatal suture maturation: Classification method for individual assessment before rapid maxillary expansion. Am J Orthod Dentofacial Orthop. 2013;144(5):759-69.

19. Haghanifar S, Mahmoudi S, Foroughi R, Poorsattar Bejeh Mir A, Mesgarani A, Bijani A. Assessment of midpalatal suture ossification using cone-beam computed tomography. Electron Physician. 2017. 4035-41 p.

20. Bigliazzi R, Magalhães AdOS, Magalhães PE, Bertoz APdM, Faltin K, Arita ES, et al. Cone-beam computed tomography evaluation of bone density of midpalatal suture before, after, and during retention of rapid maxillary expansion in growing patients. World Federation of Orthodontists. Journal. 2017;6(1):15-9.

21. Jang H-I, Kim S-C, Chae J-M, Kang K-H, Cho J-W, Chang N-Y, et al. Relationship between maturation indices and morphology of the midpalatal suture obtained using cone-beam computed tomography images. Korean J Orthod. 2016. 345 p.

22. Woller JL, Kim KB, Behrents RG, Buschang PH. An assessment of the maxilla after rapid maxillary expansion using cone beam computed tomography in growing children. Dental Press J Orthod. 2014;19(1):26-35.

23. Tonello DL, Ladewig VM, Guedes FP, Ferreira Conti ACC, Almeida-Pedrin RR, Capelozza-Filho L. Midpalatal suture maturation in 11- to 15-year-olds: A cone-beam computed tomographic study. Am J Orthod Dentofacial Orthop. 2017;152(1):42-8.

24. Ladewig VdM, Capelozza-Filho L, Almeida-Pedrin RR, Guedes FP, de Almeida Cardoso M, de Castro Ferreira Conti AC. Tomographic evaluation of the maturation stage of the midpalatal suture in postadolescents. Am J Orthod Dentofacial Orthop. 2018;153(6):818-24.

25. Abo Samra D, Hadad R. Midpalatal suture: evaluation of the morphological maturation stages via bone density. Prog Orthod. 2018;19(1):29.

26. Grünheid T, Larson CE, Larson BE. Midpalatal suture density ratio: A novel predictor of skeletal response to rapid maxillary expansion. Am J Orthod Dentofacial Orthop. 2017;151(2):267-76.

27. Baccetti T, Franchi L, Cameron CG, Jr. JAM. Treatment Timing for Rapid Maxillary Expansion. Angle Orthod. 2001;71(5):343-50.

28. Fishman LS. Radiographic evaluation of skeletal maturation. A clinically oriented method based on hand-wrist films. Angle Orthod. 1982;52(2):88-112.

29. Sumer AP, Ozer M, Sumer M, Danaci M, Tokalak F, Telcioglu NT. Ultrasonography in the Evaluation of Midpalatal Suture in Surgically Assisted Rapid Maxillary Expansion. Journal of Craniofacial Surgery. 2012;23(5):1375-7.

30. Korbmacher H, Schilling A, Püschel K, Amling M, Kahl-Nieke B. Age-dependent Three-dimensional Microcomputed Tomography Analysis of the Human Midpalatal Suture*. J Orofac Orthop. 2007;68(5):364-76.

31. Angelieri F, Franchi L, Cevidanes LH, Bueno-Silva B, McNamara JA, Jr. Prediction of rapid maxillary expansion by assessing the maturation of the midpalatal suture on cone beam CT. Dental Press J Orthod. 2016;21(6):115-25.

32. Bujang MA. A simplified guide to determination of sample size requirements for estimating the value of intraclass correlation coefficient: A review2017. 1-11 p.

33. Cicchetti DV. Guidelines, criteria, and rules of thumb for evaluating normed and standardized assessment instruments in psychology. Psychological Assessment. 1994;6(4):284-90.

34. Cohen J. Weighted kappa: Nominal scale agreement provision for scaled disagreement or partial credit. Psychological Bulletin. 1968;70(4):213-20.

35. Altman DG. Practical Statistics for Medical Research: Taylor & Francis; 1990.

36. Revelle W. psych: Procedures for Psychological, Psychometric, and Personality Research. R Package Version 1.0–952013.

37. Ladewig VM, Capelozza-Filho L, Almeida-Pedrin RR, Guedes FP, de Almeida Cardoso M, de Castro Ferreira Conti AC. Tomographic evaluation of the maturation stage of the midpalatal suture in postadolescents. American journal of orthodontics and dentofacial orthopedics : official publication of the American Association of Orthodontists, its constituent societies, and the American Board of Orthodontics. 2018;153(6):818-24.

38. Rogers L. Discrimination Testing in Sensory Science: A Practical Handbook: Elsevier Science; 2017.

39. Schmidt JC, Gutekunst CJ, Dagassan-Berndt D, Schmidlin PR, Walter C. Comparison of Two-Dimensional and Three-Dimensional Radiographs Using Clinically Relevant Parameters. Dent J. 2019;7(2).

ANNEXES

VII. Annexes:

Annex 1: Ethics Committee Approval

U.PORTO
FACULDADE DE MEDICINA DENTÁRIA
UNIVERSIDADE DO PORTO

Exmª Senhora
Mariana da Rocha Almeida
Faculdade de Medicina Dentária da U. Porto

000125 04 FEV 2019

(CC à Orientadora Srª. Prof. Doutora Maria João Ponces)

Assunto: Parecer relativamente ao Projeto de Investigação nº 25/2018.
(Midpalatal suture maturation. Comparative study of two methods of assessement using CBCT).

Informo V. Exa. que o projeto supracitado foi analisado na reunião da Comissão de Ética para a Saúde, da FMDUP, no dia 1 de fevereiro de 2019.

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

Subject: Recommendation on the research project nº 25/2018.
(Midpalatal suture maturation. Comparative study of two methods of assessement using CBCT).

I hereby inform that the aforementioned project was analyzed on 1st february, 2019 by the Ethics Committee for Health of the Faculty of Dental Medicine,

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

Com os melhores cumprimentos,
A Presidente da Comissão de Ética para a Saúde, da FMDUP

Inês Morais Caldas

Prof. Doutora Inês Alexandra Costa Morais Caldas

Rua Dr. Manuel Pereira da Silva, 4200-393 Porto - Portugal
Telefone: +351 22 090 11 80; Fax: +351 898 11 01
www.fmd.up.pt

Annex 2: RAI-FMDUP Approval

U.PORTO

AUTORIZAÇÃO RAI-FMDUP 07000019

Pedido para a reutilização de registos clínicos para fins de Investigação

Investigador: ***Mariana da Rocha e Almeida***

E-mail: marianaralmeida17@gmail.com Tlm: 915 557 387

O seu pedido para reutilizar registos clínicos para fins de investigação foi registado com o número em epígrafe, e foi por mim **autorizado**, no uso dos poderes legais em que estou investido como Responsável pelo Acesso à Informação (RAI) da Faculdade de Medicina Dentária da Universidade do Porto.

A presente autorização, que tem um âmbito estritamente jurídico e natureza imperativa, no domínio do acesso e reutilização da informação de saúde, dos registos clínicos, à guarda legal e institucional da FMDUP, **não dispensa o necessário e pertinente parecer da Comissão de Ética e autorização do Director da FMDUP**. Por isso mesmo, da comunicação da presente deliberação, será dado conhecimento ao Exmo. Senhor Director e à Exma. Senhora Presidente da Comissão de Ética, já que a **investigação deve ser abordada numa perspectiva integrada, onde a requerente deve ser a primeira a assumir, que o Estatuto de Investigador significa um conjunto de direitos e obrigações, quer de natureza jurídica, quer de natureza ética, quer, ainda, com o necessário enquadramento na estratégia institucional.**

O presente pedido de reutilização de registos clínicos para fins de investigação, intitulado: ***"Midpalatal Suture maturation: Comparative study of two methods of assessment using CBCT"*** subsume-se no fenómeno da reutilização para fins de I&D, consagrado quer na Lei 26/2016, de 22 de Agosto, quer na Directiva 2013/37/EU, de 26 de Junho, do Parlamento Europeu e do Conselho.

Aproveito esta oportunidade para a felicitar por ter feito este pedido de reutilização de registos clínicos para fins de Investigação & Desenvolvimento, o que significa estar a exercer um direito que tem enquanto investigadora, e ainda, para a informar, que a reutilização de documentos do sector público, neste caso registos clínicos, sem autorização da entidade competente, o RAI, é uma contra-ordenação prevista e punida nos termos do artigo 39º, da Lei 26/2016, de 22 de Agosto.

Não hesite em me contactar, para o endereço rai@fmd.up.pt ou para o Tlm: 967 020 912, para esclarecer qualquer dúvida.

Com os melhores cumprimentos, votos de sucesso na investigação, e na expectativa que a mesma venha a contribuir para a sociedade do conhecimento que todos, legitimamente, almejamos.

Considere-me, sinceramente, ao seu dispor

Porto, 27/02/2019

Américo dos Santos Afonso
RAI – Art.º 9, Lei 26/2016, de 22 de Agosto

Faculdade de Medicina Dentária da Universidade do Porto
Rua Dr. Manuel Pereira da Silva, 4200-393 Porto PORTUGAL

Annex 3: Data Protection Unit of U.PORTO Approval

U.PORTO	Unidade de Proteção de Dados	DATA: 24.01.2019

PARECER A-1/2019

Nome	Mariana Rocha e Almeida
Nº Mecanográfico	201304629
Unidade Orgânica	Faculdade de Medicina Dentária (FMDUP)
Título do Tratamento/Estudo	Midpalatal suture maturation: Comparative study of two methods of assessment using CBCT
Nº de Ticket	2018123115000224

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 clínico sem intervenção com o objetivo de validar o método BOKA, através da sua comparação com um método de avaliação da sutura em CBCT de 2013. Assim sendo, este estudo propõe-se a analisar as projeções do tipo panorâmica e os cortes axiais provenientes de exames de CBCT. Trata-se de um estudo retrospetivo a realizar na Faculdade de Medicina Dentária da Faculdade do Porto com resultados de exames clínicos realizados numa clínica privada de ortodontia. Com o estudo comparativo dos cortes efetuados pretende verificar-se a concordância dos resultados dos dois métodos, de modo a validar o método BOKA.
Os dados a serem utilizados serão de saúde (projeções do tipo panorâmica e os cortes axiais provenientes de exames de CBCT), sendo os mesmos fornecidos pela clínica privada em formato digital, purgados de quaisquer outros dados para além da Idade e Sexo do paciente.

Conclusões

Nos termos do art.º 5.º/5 da Lei n.º 12/2005, de 26 de Janeiro, o processo clínico só pode ser consultado por médico incumbido da realização de prestações de saúde a favor da pessoa a que respeita ou, sob a supervisão daquele, por outro profissional de saúde obrigado a sigilo e na medida do estritamente necessário à realização das mesmas, sem prejuízo da investigação epidemiológica, clínica ou genética que possa ser feita sobre os mesmos, ressalvando-se o que fica definido no tocante à investigação sobre o genoma humano.
Donde, encontrando-se as projeções do tipo panorâmica e os cortes axiais provenientes da tomografia computadorizada de feixe cónico que a requerente pretende analisar, com vista à realização da respetiva dissertação de investigação, inscritas no processo clínico dos pacientes da clínica médico-dentária supra referida, impenda sobre esta última o dever de garantir que a informação a facultar à aqui requerente resulta expurgada de quaisquer dados suscetíveis de identificar, direta ou indiretamente, os titulares daqueles exames.

Quanto ao mais:

(1) estabelecendo o art.º 4.º/4 da referida Lei n.º 12/2005 que "o acesso a informação de saúde pode, desde que anonimizada, ser facultado para fins de investigação";

Qualquer incidente que se possa configurar como uma violação de Dados Pessoais, deve ser reportado, sem demora injustificada, para o endereço **incidente.seguranca@uporto.pt**.

(2) configurando-se as projeções do tipo panorâmica e os cortes axiais provenientes da tomografia computadorizada de feixe cónico que a requerente pretende analisar, quando não associados a quaisquer outros identificadores que não o género e a idade, como dados anonimizados, tendo em conta os meios colocados à disposição do ser-humano médio para a identificação de uma pessoa singular;

somos do parecer que o tratamento de dados que a requerente pretende levar a cabo não carece de autorização prévia do Senhor Reitor, podendo a mesma avançar com a sua realização.

a Encarregada de Proteção de Dados
da Universidade do Porto

Susana Rodrigues Pereira
Doutora Susana Rodrigues Pereira

U.PORTO
FACULDADE DE MEDICINA DENTÁRIA
UNIVERSIDADE DO PORTO

Annex 4: Thesis Supervisor Approval

PARECER

Monografia de Investigação/Relatório de Atividade Clínica

Informo que o Trabalho de Monografia desenvolvido pela estudante Mariana da Rocha e Almeida com o título "Midpalatal Suture maturation: Comparative study of two methods of assessment using CBCT" está de acordo com as regras estipuladas na FMDUP, foi por mim conferido e encontra-se em condições de ser apresentado em provas públicas.

Porto, 24 de maio de 2019

O orientador

U.PORTO
FACULDADE DE MEDICINA DENTÁRIA
UNIVERSIDADE DO PORTO

Annex 5: Thesis Co- Supervisor Approval

PARECER

Monografia de Investigação/Relatório de Atividade Clínica

Informo que o Trabalho de Monografia desenvolvido pela Mariana da Rocha Almeida com o título "Midpalatal Suture maturation: Comparative study of two methods of assessment using CBCT" está de acordo com as regras estipuladas na FMDUP, foi por mim conferido e encontra-se em condições de ser apresentado em provas públicas.

Porto, 24 de maio de 2019

O co-orientador

U.PORTO
FACULDADE DE MEDICINA DENTÁRIA
UNIVERSIDADE DO PORTO

Annex 6: Researcher's Statement

DECLARAÇÃO

Monografia de Investigação/Relatório de Atividade Clínica

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

Porto, 24 de maio de 2019

A investigadora

Mariana da Rocha e Almeida