UNESP - Universidade Estadual Paulista
“Júlio de Mesquita Filho”
Faculdade de Odontologia de Araraquara

Adriana Souza de Jesus

Avaliação tomográfica da expansão rápida da maxila assistida cirurgicamente (ERMAC) e por mini-implantes (ERMAMI) em indivíduos com maturação óssea avançada

Araraquara

2020

UNESP - Universidade Estadual Paulista
“Júlio de Mesquita Filho”
Faculdade de Odontologia de Araraquara

Adriana Souza de Jesus

Avaliação tomográfica da expansão rápida da maxila assistida cirurgicamente (ERMAC) e por mini-implantes (ERMAMI) em indivíduos com maturação óssea avançada

Dissertação apresentada à Universidade Estadual Paulista (Unesp), Faculdade de Odontologia, Araraquara para obtenção do título de Mestre em Ciências Odontológicas, na Área de Ortodontia.

Orientador: Ary dos Santos-Pinto

Araraquara

2020

Jesus, Adriana Souza de
Avaliação tomográfica da expansão rápida da maxila assistida cirurgicamente (ERMAC) e por mini-implantes (ERMAMI) em indivíduos com maturação óssea avançada / Adriana Souza de Jesus.-- Araraquara: [s.n.], 2020
54 f.; 30 cm.

Dissertação (Mestrado em Ciências Odontológicas) – Universidade Estadual Paulista, Faculdade de Odontologia
Orientador: Prof. Dr. Ary dos Santos-Pinto

1. Técnica da expansão palatina 2. Procedimentos de ancoragem ortodôntica 3. Tomografia computadorizada de feixe cônico I.Título

Ficha catalográfica elaborada pela Bibliotecária Marley C. Chiusoli Montagnoli, CRB/5646
Universidade Estadual Paulista (Unesp), Faculdade de Odontologia, Araraquara
Serviço Técnico de Biblioteca e Documentação

Adriana Souza de Jesus

Avaliação tomográfica da expansão rápida da maxila assistida cirurgicamente (ERMAC) e por mini-implantes (ERMAMI) em indivíduos com maturação óssea avançada

Comissão julgadora

Dissertação para obtenção do grau de Mestre em Ciências Odontológicas, área de Ortodontia

Presidente e Orientador: Prof. Dr. Ary dos Santos Pinto

2º Examinador: Prof. Dr. João Roberto Gonçalves

3º Examinador: Profª. Dra. Daniela Gamba Garib Carreira

Araraquara, 18 de fevereiro de 2020.

DADOS CURRICULARES

Adriana Souza de Jesus

Nascimento:	25/08/1992 – Belém/PA
Filiação:	Vera Lucia Souza de Jesus Evandro José de Jesus
2010-2015:	Curso de Graduação em Odontologia pela Universidade Federal do Pará – UFPA.
2015-2017:	Curso de Especialização em Ortodontia pela Universidade Estadual Vale do Acaraú, UVA, Brasil
2016-2018:	Curso de Especialização na modalidade Residência Multiprofissional com área de concentração em Atenção à Clínica Integrada pelo Hospital Universitário João de Barros Barreto, HUJBB, Brasil.
2018-2020:	Curso de Pós-graduação em Ciências Odontológicas, área de concentração em Ortodontia, nível Mestrado pela Faculdade de Odontologia de Araraquara – FOAr – UNESP

AGRADECIMENTOS

A finalização deste trabalho é o resultado de um longo caminho que começou com os conhecimentos adquiridos na base da minha iniciação científica na graduação da UFPA no Pará e está evoluindo na UNESP de Araraquara. Por isso, há uma longa lista de pessoas que fizeram parte do meu crescimento e, por então, agradeço a todos que de alguma forma passaram pela minha vida e contribuíram para a construção de quem eu sou hoje.

A Deus, que permitiu que tudo isso acontecesse ao longo de minha vida e que em todos os momentos é o maior mestre que alguém pode conhecer.

A meus pais, Evandro e Vera de Jesus, pela determinação e luta pela minha formação e por abrirem mão e postergarem muitos de seus sonhos para que eu pudesse realizar os meus.

À toda minha família que, com muito carinho me apoiou para que eu chegasse até esta etapa de minha vida, em especial, minha avó materna Benedita Ferreira de Souza pelo incentivo e por sempre demonstrar seu amor e orgulho.

Ao meu orientador, Prof. Dr. Ary dos Santos-Pinto, por dar-me a oportunidade de ser sua orientada, pela confiança depositada em mim, pelos conhecimentos e experiências transmitidos para realização deste trabalho e em outras situações, aprendo muito a seu lado.

Aos amigos de turma do mestrado, Julianna Parizotto, Karina Borsato e Éder Cavichioli pelo compartilhamento não só dos conhecimentos ortodônticos mas pelo convívio, solidariedade e amizade. Julianna, nossa amizade foi muito especial pra mim durante o mestrado, espero que ela dure para sempre, do mesmo jeito que nasceu: cheia de risos, muito respeito e carinho. À Cibele Braga, doutoranda quando eu comecei esse projeto, obrigada por confiar, ensinar sua linha de pesquisa e ceder suas amostras, esse trabalho não seria possível sem seu apoio e orientação. Estar tão longe de casa nos distancia do convívio com nosso núcleo familiar, portanto, não posso deixar de citar os nomes dos amigos que me acolheram em seu núcleo e em diversos momentos cuidaram e me fizeram sentir parte de sua família: Raimundo Pinto, Celi Oliveira, Anderson Pinto e Rayane Pinto (família querida de Bauru).

À Universidade Estadual Paulista “Júlio de Mesquita Filho”, nas pessoas de seu Magnífico Reitor Dr. Sandro Roberto Valentini e do Excelentíssimo Senhor Vice-Reitor Dr. Sergio Roberto Nobre.

À Faculdade de Odontologia de Araraquara, da Universidade Estadual Paulista “Júlio Mesquita Filho” (FOAr-UNESP), em nome da sua Diretora Profa. Dra. Elaine Maria Sgavioli Massucato e do Vice-Diretor Prof. Dr. Edson Alves de Campos.

Ao Programa de Pós Graduação em Ciências Odontológicas, representado pela Coordenadora Profa. Dra. Fernanda Lourenção Brighenti.

Ao Departamento de Clínica Infantil, em nome do seu Chefe de Departamento Profa. Dra. Josimeri Hebling Costa e do Vice chefe Prof. Dr. Luiz Gonzaga Gandini Júnior.

Aos docentes da Disciplina de Ortodontia da Faculdade de Odontologia de Araraquara - UNESP, Prof. Dr. Ary dos Santos Pinto, Prof. Dr. Dirceu Barnabé Raveli, Prof. Dr. João Roberto Gonçalves, Profa. Dra. Lídia Parsekian Martins, e Prof. Dr. Luiz Gonzaga Gandini Júnior.

Aos demais colegas de pós-graduação, sejam do mestrado ou doutorado, pelo auxílio na forma de conselhos e ensinamentos valiosos que ajudaram a compor meus conhecimentos ortodônticos.

Aos funcionários do Departamento de Clínica Infantil da Faculdade de Odontologia de Araraquara - UNESP, Totó, Diego, Pedrinho, Flávia, Dulce e Soninha e aos funcionários da Seção de Pós-Graduação Cristiano e José Alexandre, pela disposição em ajudar nas questões relacionadas ao curso de mestrado.

À CAPES:

O presente trabalho foi realizado com apoio da Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) - Código de Financiamento 001.

Jesus AS. Avaliação tomográfica da expansão rápida da maxila assistida cirurgicamente (ERMAC) e por mini-implantes (ERMAMI) em indivíduos com maturação óssea avançada [dissertação de mestrado]. Araraquara: Faculdade de Odontologia da UNESP; 2020.

RESUMO

Este estudo clinico retrospectivo avaliou as alterações esqueléticas, dentárias e de tecido mole nasal produzidas com a expansão rápida da maxila assistida por mini-implantes (ERMAMI) e comparou aos efeitos encontrados com a expansão rápida da maxila assistida cirurgicamente (ERMAC) realizadas em pacientes com maturação óssea avançada, bem como foi analisada a associação entre idade, posição do parafuso expansor, densidade e espessura óssea na região de sutura palatina mediana com os resultados (sucesso ou insucesso) gerados com a ERMAMI. Foram selecionadas tomografias de 30 indivíduos tratados por ERMAMI e 24 tratados com ERMAC, adolescentes e adultos, com atresia maxilar, mordida cruzada posterior bilateral ou unilateral. Para as avaliações, foram utilizadas tomografias computadorizadas de feixe cônico antes (T0) e após o término da expansão (T1). Foi avaliado o desempenho dos sistemas ERMAC e ERMAMI (alterações dentárias, esqueléticas e tecido mole nasal) comparando as médias de cada variável antes e depois do tratamento, empregando *o test t-Student* para comparar as médias de dois grupos com amostras dependentes. Já o teste t-Student para amostras independentes foi realizado para comparar as alterações dentárias, esqueléticas e de tecido mole nasal da expansão maxilar entre os grupos. A correlação entre o efeito ortopédico de abertura ou não da sutura palatina mediana (sucesso e insucesso) e idade do paciente, posição do parafuso expansor, bem como sua taxa de densidade e espessura foram avaliados utilizando o teste de correlação de Pearson.

Palavras chave: Técnica da expansão palatina. Procedimentos de ancoragem ortodôntica. Tomografia Computadorizada de Feixe Cônico.

Jesus AS. Tomographic evaluation of rapid maxillary expansion assisted surgically (SARPE) and through mini-screw (MARPE) in individuals with advanced bone maturation [dissertação de mestrado]. Araraquara: Faculdade de Odontologia da UNESP; 2019.

ABSTRACT

This retrospective clinical study evaluated the skeletal, dental, and nasal soft tissue changes produced by mini-screw assisted rapid maxillary expansion (MARPE) and compared the effects found with surgically assisted rapid maxillary expansion (SARPE) in patients with advanced bone maturation, as well as the association between age, density and bone thickness in the midpalatal suture region with the results (success or failure) generated with MARPE. CT scans of 30 individuals treated by MARPE and 24 treated with SARPE, adolescents and adults, with maxillary atresia, bilateral or unilateral posterior crossbite, were selected. For the evaluations, cone-beam computed tomography was used before (T0) and after (T1) the completion of expansion. The performance of the MARPE and SARPE systems (dental, skeletal and nasal soft tissue alterations) was evaluated by comparing the means of each variable before and after treatment, using the Student t-test to compare the means of two groups with dependent samples. The Student t-test for independent samples was performed to compare dental, skeletal and nasal soft tissue changes of maxillary expansion between groups. The correlation between the orthopedic effect of opening or not the midpalatal suture (success and failure) and the age of the patient, as well as its density rate and thickness were evaluated using Pearson's correlation test**.**

Keywords: Palatal expansion technique. Orthodontic anchorage procedures. Cone-Beam Computed Tomography.

SUMÁRIO

1 INTRODUÇÃO 10

2 OBJETIVO 12

2.1 Objetivos Específicos 12

3 PUBLICAÇÕES 13

3.1 Artigo 1 14

3.2 Artigo 2 32

4 CONSIDERAÇÕES FINAIS 49

REFERÊNCIAS 50

ANEXO A - CERTIFICADO DE COMITÊ DE ÉTICA 52

1 INTRODUÇÃO

O correto relacionamento transversal entre os arcos dentários é essencial para a obtenção de uma oclusão estável e funcional. As discrepâncias transversais envolvem alterações dentárias, esqueléticas ou a combinação de ambas[1,2]. A expansão rápida da maxila (ERM) foi introduzida pela primeira vez em 1860 por Angell[3] e, é um método estabelecido de tratamento das discrepâncias transversais que aumenta o perímetro do arco pelo rompimento da sutura palatina mediana, e esta se reorganiza rapidamente por meio do reparo do tecido conjuntivo e formação óssea. Geralmente é utilizada para tratar a constrição da maxila, mordida cruzada posterior, discrepâncias no comprimento do arco em pacientes em crescimento[4].

A idade é um fator muito importante na ERM. Em adultos, devido à maturação das suturas palatina mediana e resistência do pilar zigomático, a resposta à expansão palatal com ERM é menos bem sucedida. O alargamento resultante da largura maxilar ocorre mais devido à flexão óssea alveolar e inclinação dentária em adultos[5].

Além de sua incapacidade de produzir expansão esquelética completa em adultos, a ERM pode trazer efeitos colaterais indesejáveis, como falha na expansão do arco, inclinação vestibular da coroa, deiscência do osso alveolar, reabsorção radicular, redução da espessura óssea vestibular e perda óssea marginal[6,7].

A ERM assistida cirurgicamente (ERMAC) tem sido frequentemente utilizada para superar as limitações acima mencionadas por meio da liberação cirúrgica das suturas fechadas que resistem às forças de expansão em adultos e vem sendo utilizada como principal método cirúrgico para esse tratamento[8]. No entanto, os pacientes tendem a relutar em submeter-se a múltiplos procedimentos cirúrgicos e a demanda para o tratamento não cirúrgico tem aumentado[9].

Com a finalidade de prevenir os efeitos dentoalveolares indesejáveis e otimizar o potencial de expansão esquelética em indivíduos com estágios avançados de maturação óssea, a técnica de expansão rápida da maxila assistida por mini-implantes (ERMAMI) foi proposta por Lee e colaboradores[10] em 2010 e já tem sido utilizada como abordagem clinicamente eficaz e estável para a correção não cirúrgica da discrepância transversal em pacientes adultos[9,11] .

Um estudo clínico retrospectivo[9] foi publicado com o objetivo de determinar a taxa de sucesso e a estabilidade em adultos jovens (média de 20.9 ± 2.9 anos de idade) da expansão com ERMAMI. Os resultados mostraram que dos 69 pacientes tratados, 9 apresentaram falhas na separação da sutura palatina mediana (taxa de sucesso de 86,96%). Esta estatística mostra uma boa taxa de sucesso desta terapia podendo ser utilizada como uma alternativa ao tratamento da expansão cirúrgica. O efeito ortopédico de aumento na largura maxilar representou 43,34% da expansão total em relação ao aumento da largura inter-molar. As quantidades de recidiva pós-tratamento da largura maxilar e inter-molar foram -0,07 mm e -0,42 mm, respectivamente, durante o período de retenção. Concluíram que a expansão maxilar com ERMAMI pode ser uma modalidade de tratamento clinicamente aceitável e estável para adultos jovens com deficiência transversal de maxila. Os autores também observaram que com o aumento da idade, a quantidade de expansão dentoalveolar era maior em relação aos efeitos ortopédicos de expansão da maxila. Dessa forma, afirmaram que, em pacientes mais velhos, a rigidez do esqueleto craniofacial poderia limitar os efeitos esqueléticos do ERMAMI. Por isso, a previsibilidade de sucesso deve ser bem explicada ao paciente, pois o ERMAMI ainda é susceptível à falha.

Este estudo tem como objetivo utilizar tomografias computadorizadas de feixe cônico (TCFC) para comparar as alterações dentárias, esqueléticas maxilares e de tecido mole nasal em pacientes que foram tratados com ERMAMI e com ERMAC por meio de duas abordagens cirúrgicas diferentes.

2 OBJETIVO

Avaliar, por meio de tomografias computadorizadas, as alterações dentárias, esqueléticas e de tecido mole nasal produzidas pela expansão rápida da maxila assistida por mini-implantes ortodônticos (ERMAMI) realizada em pacientes que já atingiram a maturidade óssea e compará-los aos efeitos encontrados com a expansão rápida da maxila assistida cirurgicamente (ERMAC).

2.1 Objetivos Específicos

- Avaliar o efeito nasomaxilar ósseo e dentário transversal resultante da ERMAMI por meio de tomografia computadorizada e compará-lo com o efeito encontrado no grupo ERMAC;
- Avaliar as mudanças de tecido mole nasal após a ERMAMI comparando com as mudanças encontradas no grupo ERMAC.
- Observar a correlação entre os resultados do ERMAMI (sucesso e insucesso da expansão ortopédica) com a taxa de densidade e espessura da sutura palatina, posição do parafuso expansor e idade do paciente.

3 PUBLICAÇÕES

Esta dissertação de mestrado foi escrita em dois artigos correspondentes a versão em português dos artigos científicos elaborados para publicação em periódicos internacionais:

Artigo 1. Would midpalatal suture density and thickness, expander screw position and patient's age affect the success of miniscrew-assisted rapid palatal expansion?

Artigo 2. Nasomaxillary and dental effects of MARPE and two SARPE approaches

3.1 ARTIGO 1*

Would midpalatal suture density and thickness, expander screw position and patient's age affect the success of miniscrew-assisted rapid palatal expansion?

ABSTRACT

Introduction: The objective of this study was to evaluate whether the success or failure of miniscrew-assisted rapid palatal expansion (MARPE) in patients with advanced bone maturation (ABM) could be related to factors such as: midpalatal suture density (MSD), bone thickness (MBTh), expander screw position (ESP) and patient's age. Methods: CBCT of 25 individuals, both sexes, 15 to 37 years old, presenting transverse maxillary deficiency and complete skeletal maturation (CVMS stage V) treated using MARPE were evaluated. The success of MARPE was confirmed by the midpalatal suture (MPS) opening and failure when no opening or limited separation of MPS occurred. Data were analyzed using t-test for independent samples for differences in the variables of success and failure cases and the Pearson correlation test to evaluate the relation of the success and age, ESP, MPSD, and MBTh. MPSD ratio was based on Grünheid's study. MBTh was measured at intervals of 4mm from the incisive foramen in sagittal section. ESP was measured in the axial view, from the incisor foramen to the center of the expander screw. Results: Both age and MBTh at 12mm and 16mm were correlated with MARPE successful opening ($p<0.05$). Cases of MARPE failure occurred in older mean age compared to success cases. The ESP had similar averages in cases of success (15.34mm) and failure (13.51mm). Conclusion: There was no correlation between ESP and MARPE success and the older the patient with ABM, the lower the success rates of MARPE (94.1% decreasing to 90% and 76% up to 25, 30 and 37 years respectively). MARPE success was not related to MPSD but to a greater MBTh at 12mm and 16mm.

---

* Artigo escrito conforme as normas bibliográficas da revista American Journal of Orthodontics and Dentofacial Orthopedics.

INTRODUCTION

Rapid maxillary expansion is the standard treatment method for patients presenting transverse deficiency of the maxillary bone. In this treatment modality, expanders are used in order to apply lateral forces to the teeth which increases the perimeter of the arch and by disarticulating the midpalatal suture (MPS). The suture reorganizes rapidly through the repair of connective tissue and bone formation[1,2].

Previous studies have shown that about 10% of the total population and 30% of adult orthodontic patients have some transverse maxillary deficiency related to posterior crossbite[3–5]. MPS disarticulation is easily obtained in children but, in adult patients, this suture presents increasingly complex interdigitations, which makes it more difficult to open[6]. The midpalatal and circummaxillary sutures initiate the ossification process approximately in late adolescence and become more rigid with advancing age[7,8.] When the expansion is performed in patients with more advanced bone maturation (ABM), the widening of the maxillary width occurs more due to alveolar bone flexion and dental inclination[9]. In addition, it may be associated with undesirable effects like radicular buccal alveolar fenestrations, failure to open the MPS, alveolar bending, extrusion of posterior teeth, pain, instability, and root resorption[10].

The Miniscrew Assisted Rapid Maxillary Expander (MARPE) technique reported by Lee et al.[11] emerged as a clinically effective and stable approach for non-surgical correction of transverse discrepancy in adult patients[12,13.] Clinical studies have been demonstrating successful results using MARPE in adults[14,15]. However, even using MARPE, orthopedic maxillary expansion may not occur in some cases. It remains unclear why few MARPE cases fail, but differences in calcification patterns of the MPS and craniofacial architecture (higher resistance) may be contributing factors[13,16].

A retrospective clinical study by Choi et al.[13] showed that increasing age, the amount of dentoalveolar expansion was greater in relation to the orthopedic effects of maxillary expansion. Thus, they stated that, in older patients, the rigidity of the craniofacial skeleton could limit the skeletal effects of MARPE. Therefore, the predictability of success should be well explained to the patient, since MARPE is still susceptible to failure.

In clinical practice, orthodontists still cannot define precisely whether rapid expansion of the maxilla anchored in mini-implants will or will not succeed in adult patients. A method to maximize the effects of the MARPE technique in clinical situations has not been thoroughly studied[14]. In this sense, it is interesting to study the factors that may be associated with the success or failure of the MPS opening in these patients to better predict the outcome of the expansion procedure.

This research aimed to evaluate whether the success or failure of MARPE in patients with ABM is related to factors such as midpalatal bone density and thickness, expander screw position and patient’s age.

MATERIAL AND METHODS

The sample of this retrospective study included cone-beam computed tomography (CBCT) of 25 individuals (men and women), between 15 and 37 years old, treated with MARPE. Table I shows the sample distribution.

The inclusion criteria were CBCT’s before (T0) and after maxillary expansion (T1), of subjects presenting transverse maxillary deficiency with unilateral or bilateral posterior crossbite (a difference greater than 5 mm between the transverse distance of the palatal cusps of the first maxillary molars and the transverse distance of the first lower molars central sulcus) with complete skeletal maturation confirmed by examination of the cervical vertebrae. All subjects were in CVMS stage V of Hassel and Farman's analysis modified by Baccetti, Franchi and McNamara[17]. Cases with previous orthodontic treatment, cleft lip and palate, and syndromic conditions were excluded. Four cases that meet the inclusion criteria (success cases) were excluded since MARPE appliance was in place on the initial tomographic evaluation, restricting the visualization of bone structures for measurements.

MARPE Treatment

Patients were treated by RME using a hybrid expander device supported by four orthodontic mini-implants inserted paramedian to the midpalatal suture and attached to the molars (Peclab, Belo Horizonte - Minas Gerais, Brazil) (Fig 1). MARPE positioning and miniscrew sizes were planned using initial CBCT images (T0) considering bone thickness and the available palate space to accommodate the expander device.

All mini-implants were installed manually with a manual contra-angle driver (Peclab Kit, Belo Horizonte, Brazil). To measure the insertion torque, a torque wrench was used. All steps were performed by the same clinician.

The activation protocol was 2/4 turn immediately after mini-implants placement and 2/4 turn daily on the following days (1/4 in the morning and 1/4 at night), varying from 14 to 18 days until full correction was achieved. After expansion, the expander screw was locked and kept in place, without activation, for the following four months.

CBCT scans before (T0) and after (T1) expansion were taken using the i-CAT Next Generation scanner (Imaging Sciences International, Hatfield, PA, USA) configurated for exposure time of 7 seconds with 120 kV. The tomographic images were acquired with a field of view of 23 X 17 cm and a voxel size of 0.3 mm. Data were exported in the digital image and communication in medicine (DICOM) format. All CBCTs were taken before bonding brackets or any other apparatus.

The success of the orthopedic expansion of the maxilla with MARPE was confirmed by the opening of the medial palatine suture observed by the separation of the two halves of the palatine process confirmed in the tomographic examination after the activation period. Treatment failure was defined when the separation of the MPS was not observed in the tomographic examination. In cases on which moderate MPS separation was observed anteriorly but the posterior portion of the palate did not show significant changes (≤ 1.0 mm), it was considered a limited result and it was included as a failure of the technique. Maxillary changes were obtained by the difference of the linear measurements achieved (T1-T0). The images were oriented as Fig 2 (A, B and C) and the measure was made in axial slice (MIF = measurement between infraorbital foramens, PP = lateral walls between the greater palatine foramina and AP = lateral walls of the incisive foramen). The measurements, described in Table II, were used to separate the sample in success and failure cases, since the expansion values of the success cases were statistically higher than the failure cases.

MPS Density

To evaluate the density of the medial palatine suture (MPSD ratio) initial tomographic exams (T0) of each patient were used. CBCT images were oriented using Dolphin 3D software (Dolphin Imaging, Chatsworth, CA, USA) to adjust the palatal plane in the sagittal and frontal views to yield an axial slice through the center and parallel to the hard palate.

After orientation, the scans were exported and saved in DICOM format. Thereafter, gray density measurements were performed using Mimic's software from Materialize version 21.0 (Leuven, Belgium), with a cut thickness of 0.5 mm. Average gray density values were determined following the protocol previously described in the study of Grünheid et al.[18]. Regions of the suture (GDs), soft palate (GDsp), and palatal process of the maxilla (GDppm) were defined (Fig 2) and average gray density values were used to calculate the midpalatal suture density (MPSD) ratio by the following equation.

$$\text{MPSD ratio} = \frac{GD_s - GD_{sp}}{GD_{ppm} - GD_{sp}}$$

Midpalatal bone thickness (MBTh) and Expander screw position (ESP)

Dolphin 3D software was used to measure midpalatal bone thickness and the MARPE screw position. To determine the MBTh, T0 images were used, oriented as Fig 3. In the sagittal view, the posterior wall of the incisive foramen and the posterior nasal spine were positioned to pass throughout the same horizontal plane. The MBTh was measured perpendicular to the horizontal plane at intervals every 4 mm from the incisive foramen to posterior limit of 32 mm (Fig 3C). The position of the expander screw was measured in the axial view, from the distal aspect of the incisor foramen to the center of the expander screw (measure D Forame-Screw) using the T2 image (Fig 4).

Statistical Analysis

Estimation of the sample size was performed with G*power software (G*power version 3.0.10, University of Kiel, Germany) for two-tailed t-test and effect size of 0.8 and for correlation test and effect size of 0.5, both with an alpha of 0.05 for a group of 25 individuals resulted in a power of 97% and 80% respectively.

To determine the intra-examiner error calculation, all scans were re-analyzed, randomly by the same examiner, with a two-week interval between the first and second evaluation. The reproducibility of the method was evaluated using the Intraclass Correlation Coefficient (ICC) and t-test for repeated measures (systematic error evaluation) for all measures used in this study.

In order to verify the normality of the data, they were submitted to the Shapiro-Wilk test. Mean and standard deviation were calculated for the variables with normal distribution. Median and confidence intervals at 95% probability were calculated for the variables that did not exhibit a normal distribution. Data were analyzed using the t-test for independent samples to evaluate differences in the variables between cases of success and failure of the maxillary expansion.

The correlation of the success of the maxillary expansion according to the age, expander screw position, density and bone thickness of the MPS were observed using the Pearson correlation test.

The level of significance adopted for the rejection of the hypotheses examined was 0,05. The calculations for the statistical analysis were performed by the SPSS program - version 16.0 for Windows (release 16.01 - nov. 2007). SPSS Inc. 1989-2007.

RESULTS

ICC values were greater than 0.945 for all measurements, indicating excellent intraexaminer reliability (Table III). The mean difference among the first and second measurements was lesser than 0.18 and none of the variables showed significant differences indicating that the replicate measurements showed no systematic error (Table IV).

Mean values, standard deviations, and ranges of the continuous dependent variables measured are shown in Table V. Statistically significant associations were found for the variables age ($p=0.001$), and bone thickness at the interval from 12 and 16 mm behind the incisor foramen ($p= 0.016$ and 0.014 respectively). MARPE failure cases occurred in individuals with an older mean age compared to the younger mean of the success cases.

The MBTh pattern is illustrated on Graph 1. A pattern of decrease in thickness in the region from 4 to 16 mm posterior to the incisive foramen followed by an increase from 16 to 24 mm was observed in both groups. The success cases showed a slightly less decrease in thickness than the failure cases. A significantly greater MBTh (5.31 to 5.17 mm) in the region 12 to 16 mm posterior to the incisive foramen was found in the success group compared to the failure cases (1.76 to 2.01 mm).

The position of the expander screw had similar averages in the cases of failure (13.51 mm) and success cases (15.34mm). There is no correlation between the position of the expander screw and the successful opening of the MPS (tables V and VI).

According to the results of Pearson's correlation test, age correlated negatively with the success of MARPE, ie, success decreases with increasing age (Table VI). The number of success and failure cases according to the age of the patients is illustrated in Graph II. For the variable MPS bone density, no correlation to success or failure was observed. Regarding bone thickness in the 12 and 16mm regions behind the incisor foramen, positive correlations were observed with the success of MARPE.

No correlations were found when the age of patients in cases of the success and failure of the MARPE therapy was associated with the other variables (Table VII).

DISCUSSION

Given the limitation of orthopedic results and the uncertain prognosis of conventional RME in late adolescence[9], a personalized assessment of a patient's bone characteristics in the area of interest would be an important success predictor of RME. The present study used miniscrew-assisted rapid maxillary expansion (MARPE) as an alternative treatment for maxillary atresia in patients with ABM and correlated the success of MARPE technique with palatine bone density and thickness, expander screw position and patient’s age.

The overall success rate of midpalatal opening (MARPE success) in this sample was 76%, of which 19 out of 25 patients achieved significant skeletal expansion. Choi et al. observed in their study a success rate of 87% in a sample of 69 patients aged 18 to 28 years treated by RME assisted by a Hyrax device supported by 4 miniscrews[13]. The success rate was lower in our study, however, the age range was higher (up to 37 years of age). In addition, the present study considered as successful those cases with transverse skeletal enlargement greater than 1 mm, because in cases of limited suture opening (less than 1 mm), transverse correction was not clinically possible. The results of the current study (Table V, VI and VII) also showed that the higher the age, the lower the expansion success rate ($p = 0.001$).

Graph 2 highlights that, almost all the patients up to 25 years of age had success in opening the MPS with MARPE (94.1%), only one case of 17 years old had failure. In older patients, the cases of failure begin to manifest more frequently, reducing the success rate. Up to 30 years the success rate was 90% and up to 37 years was 76%. This study corroborates the research of Oliveira et al.[19] whose results showed that age was negatively correlated with the success of MARPE, in contrast to tomographic analysis of the maturation stages of MPS that showed no correlation. These authors divided the success rate of MARPE according to age groups 15-19, 20-29 and 30-37, showing a decreasing rate of 83.3%; 81.9% and 20% respectively.

Although the mean age of MARPE failure cases was statistically higher when compared to successes cases, the possibility of failure even in young individuals cannot be excluded since we had a case of limited MPS opening in a 17-year-old patient and non-opening in a 24-year-old. Furthermore, one 34 year-old patient was successfully treated with MARPE. So, it’s clear that there is individual variability in the result of this therapy and the age alone may not be considered as the only factor to safely determine MARPE prognosis. It is important to investigate other related factors that may influence the failure of MARPE in these patients.

Studies on palatine bone thickness are mostly focused on the determination of the best place to anchor miniscrews and not whether bone thickness is related to the resistance of sutural opening[20–22]. The following mentioned studies are related to the stability of the miniscrews inserted into the palatine region surrounding the MPS. Gracco et al.[20] searching the most suitable region of the palate for miniscrew placement analyzed the tomographs of 162 patients aged from 10 to 44 years and measured the thickness of the palatal bone at 20 sites. They found a continuous decrease in the MBTh with no difference among different age groups and concluded that the thickest part of the palate is the anterior region (mean 8.66), but bone thickness in the posterior region (mean 4.02) is also suitable for screws of appropriate diameter and length. Yadav et al.[21] compared the MBTh in the anterior, middle, and posterior part of the palate in growing and non-growing males and females. They also found that MBTh decreased from the anterior palate (canine–first premolar) region (mean of 8.29 males and 6.79 females) towards the posterior palate (first molar–second molar) region (mean of 4.15 males and 4.31 females). They concluded that the palatal bone thickness was higher in the anterior part of the palate (between the canine and first premolar), so there are chances that bone to mini-implant contact area will be better; thus, primary stability of the mini-implant will be better. Conversely, Ryu et al.[22] compared the bone thickness of the palatal area in early and late mixed and early permanent dentitions according to dental age and observed an increase in thickness at the MPS area in all 3 groups.

The present study found a different pattern of MBTh in the success cases, starting with a thicker anterior cortical bone in the region 4 to 8 mm behind the incisor foramen (6.27 mm and 6.30 mm) and decreasing progressively in the region from 8mm to 16mm (6.30 mm; 5.31 mm and 5.17 mm) posterior to the incisor foramen. Then, a progressive increase in the MBTh through the region 16mm to 24 mm (5.17mm; 5.75mm and 6.15mm) and another progressive decrease up to the region 32mm behind the incisor foramen (6.15mm; 5.24mm and 4.41mm). Regarding the failure cases, we found a similar pattern but decreasing in thickness just after region 4 mm behind the foramen and an overall reduced thickness in relation to success cases with a significant difference in the 12 and 16mm regions (Table V).

The position of the expander screw had similar mean distances in the cases of failure and success, 13.51mm and 15.34mm respectively, which means that it was positioned in equivalent regions in all cases. Although there is no correlation between the position of the expander screw and the successful opening of the MPS, we can observe that it remained positioned within the range of 12 to 16 mm posterior to the incisive foramen, where the bone thickness showed positive correlations with the cases of success (Tables V and VI). The results suggest that greater bone thickness in the MPS region may not lead to greater resistance to suture separation in the MARPE technique. In addition, it can be argued that the higher palatal thickness should favor the primary stability of mini-implants and the consequent improvement in MARPE expander anchorage, which may contribute to the success of this therapy. However, this study cannot confirm this, as the measured region was the MPS and not the parasutural region where the mini-implants are precisely positioned.

Concerning bone density, literature has shown that palatal bone densities are higher in non-growing than in growing patients[21] or significantly higher in adults than in adolescents[23]. The current study did not observe a correlation between age and bone density in the suture (Table VII).

The study of Grünheid et al.[18] intending to find a predictor factor of the skeletal response to conventional RME showed that the MPSD ratio has the potential to become a useful clinical predictor of the skeletal response to RME. The results of the present study did not confirm this assumption for MARPE since there was no correlation between the success of the MPS opening and its density (Tables VI and VII). Their paper correlated success and failure cases of conventional expansion using a dentosupported appliance[18]. In cases treated with MARPE density does not interfere, probably because the forces transmitted by MARPE act differently from dentosupported appliances as shown previously in finite element studies[24]. Furthermore, there were no differences in the density ratio in the success and failure cases (Table V).

We consider that the limitation of the current study was its retrospective design, where a convenience sample is used and in which generalizations considering the total population should be made with caution. The amount of expansion was adapted and not standardized for each patient. Ideally, each patient should need the same amount of expansion. Nevertheless, the activation protocol was standardized for all subjects overcoming these limitations.

CONCLUSIONS

- The findings over the success of MARPE therapy in patients with advanced bone maturation have shown that the older the patient, the lower the success rates in opening the midpalatal suture with MARPE.
- Until 25 years old, the success rate expected with MARPE treatment is 94.1%. Up to 30 years the success rate decreases to 90% and to 76% up to 37 years.
- Greater bone thickness in the MPS region does not cause greater resistance to its separation in the MARPE technique.
- Greater midpalatal bone thickness in the regions 12mm to 16mm behind the incisor foramen represents a relevant factor in the success of opening the midpalatal suture with MARPE.
- MPS density was not related to the sutural opening resistance since there was no correlation between this variable and the success of the MARPE technique.

REFERENCES

1. McNamaraa JA. Maxillary transverse deficiency. Am. J. Orthod. Dentofac. Orthop. 2000;117(5):567–70.

2. Bishara SE, Staley RN. Maxillary expansion: Clinical implications. Am. J. Orthod. Dentofac. Orthop. 1987;91(1):3–14.

3. Egermark-Eriksson I, Carlsson GE, Magnusson T, Thilander B. A longitudinal study on malocclusion in relation to signs and symptoms of cranio-mandibular disorders in children and adolescents. Eur. J. Orthod. 1990.

4. Brunelle JA, Bhat M, Lipton JA. Prevalence and Distribution of Selected Occlusal Characteristics in the US Population, 1988–1991. J. Dent. Res. 2017.

5. da Silva Filho OG, Santamaria Jr. M, Filho LC. Epidemiology of Posterior Crossbite in the Primary Dentition. J. Clin. Pediatr. Dent. 2007.

6. Angelieri F, Cevidanes LHS, Franchi L, Gonçalves JR, Benavides E, McNamara JA. Midpalatal suture maturation: Classification method for individual assessment before rapid maxillary expansion. Am. J. Orthod. Dentofac. Orthop. 2013.

7. Handelman CS. Nonsurgical rapid maxillary alveolar expansion in adults: A clinical evaluation. Angle Orthod. 1997.

8. Handelman CS, Wang L, BeGole EA, Haas AJ. Nonsurgical Rapid Maxillary Expansion in Adults: Report on 47 Cases Using the Haas Expander. Angle Orthod. 2000.

9. Handelman C. Palatal expansion in adults: The nonsurgical approach. Am. J. Orthod. Dentofac. Orthop. 2011;140(4):462–8.

10. Suri L, Taneja P. Surgically assisted rapid palatal expansion: A literature review. Am. J. Orthod. Dentofac. Orthop. 2008.

11. Lee K-J, Park Y-C, Park J-Y, Hwang W-S. Miniscrew-assisted nonsurgical palatal expansion before orthognathic surgery for a patient with severe mandibular prognathism. Am. J. Orthod. Dentofac. Orthop. 2010;137(6):830–9.

12. Lim H-M, Park Y-C, Lee K-J, Kim K-H, Choi YJ. Stability of dental, alveolar, and skeletal changes after miniscrew-assisted rapid palatal expansion. Korean J. Orthod. 2017;47(5):313–22.

13. Choi S-H, Shi K-K, Cha J-Y, Park Y-C, Lee K-J. Nonsurgical miniscrew-assisted rapid maxillary expansion results in acceptable stability in young adults. Angle Orthod. 2016;86(5):713–20.

14. Carlson C, Sung J, McComb RW, Machado AW, Moon W. Microimplant-assisted rapid palatal expansion appliance to orthopedically correct transverse maxillary deficiency in an adult. Am. J. Orthod. Dentofac. Orthop. 2016;149(5):716–28.

15. Suzuki H, Moon W, Previdente LH, Suzuki SS, Garcez AS, Consolaro A. Miniscrew-assisted rapid palatal expander (MARPE): the quest for pure orthopedic movement. Dental Press J. Orthod. 2016.

16. Lee KJ, Park YC, Park JY, Hwang WS. Miniscrew-assisted nonsurgical palatal expansion before orthognathic surgery for a patient with severe mandibular prognathism. Am. J. Orthod. Dentofac. Orthop. 2010.

17. Baccetti T, Franchi L, McNamara JA. An Improved Version of the Cervical Vertebral Maturation (CVM) Method for the Assessment of Mandibular Growth. Angle Orthod. 2002.

18. Grünheid T, Larson CE, Larson BE. Midpalatal suture density ratio: A novel predictor of skeletal response to rapid maxillary expansion. Am. J. Orthod. Dentofac. Orthop. 2017.

19. Oliveira C. Tomographic evaluation of rapid maxillary expansion assisted by orthodontic mini-implants in individuals with advanced bone maturation. 2019.

20. Gracco A, Lombardo L, Cozzani M, Siciliani G. Quantitative cone-beam computed tomography evaluation of palatal bone thickness for orthodontic miniscrew placement. Am. J. Orthod. Dentofac. Orthop. 2008.

21. Yadav S, Sachs E, Vishwanath M, et al. Gender and growth variation in palatal bone thickness and density for mini-implant placement. Prog. Orthod. 2018.

22. Ryu JH, Park JH, Vu Thi Thu T, Bayome M, Kim Y, Kook YA. Palatal bone thickness compared with cone-beam computed tomography in adolescents and adults for mini-implant placement. Am. J. Orthod. Dentofac. Orthop. 2012.

23. Han S, Bayome M, Lee J, Lee YJ, Song HH, Kook YA. Evaluation of palatal bone density in adults and adolescents for application of skeletal anchorage devices. Angle Orthod. 2012.

24. MacGinnis M, Chu H, Youssef G, Wu KW, Machado AW ilso., Moon W. The effects of micro-implant assisted rapid palatal expansion (MARPE) on the nasomaxillary complex--a finite element method (FEM) analysis. Prog. Orthod. 2014.

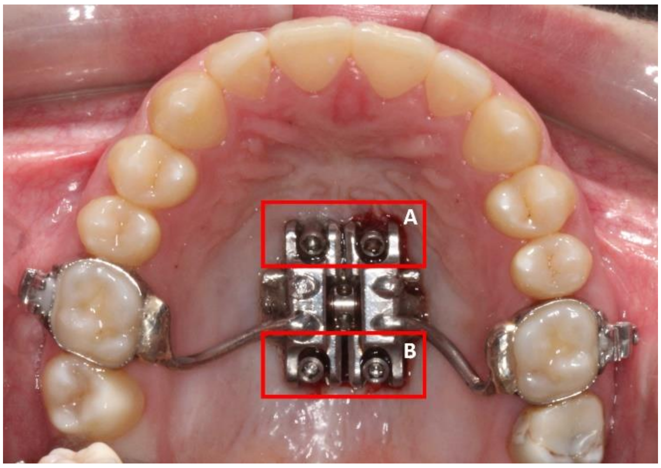


Fig 1. The miniscrew assisted rapid palatal expander (MARPE): **A,** 2 anterior mini-implants, size 1.8 mm size in diameter with transmucosal of 4 mm and 7 mm of length and **B,** the 2 posterior mini-implants were of 1.8 mm size in diameter with 4 mm of transmucosal and 5 mm of length.

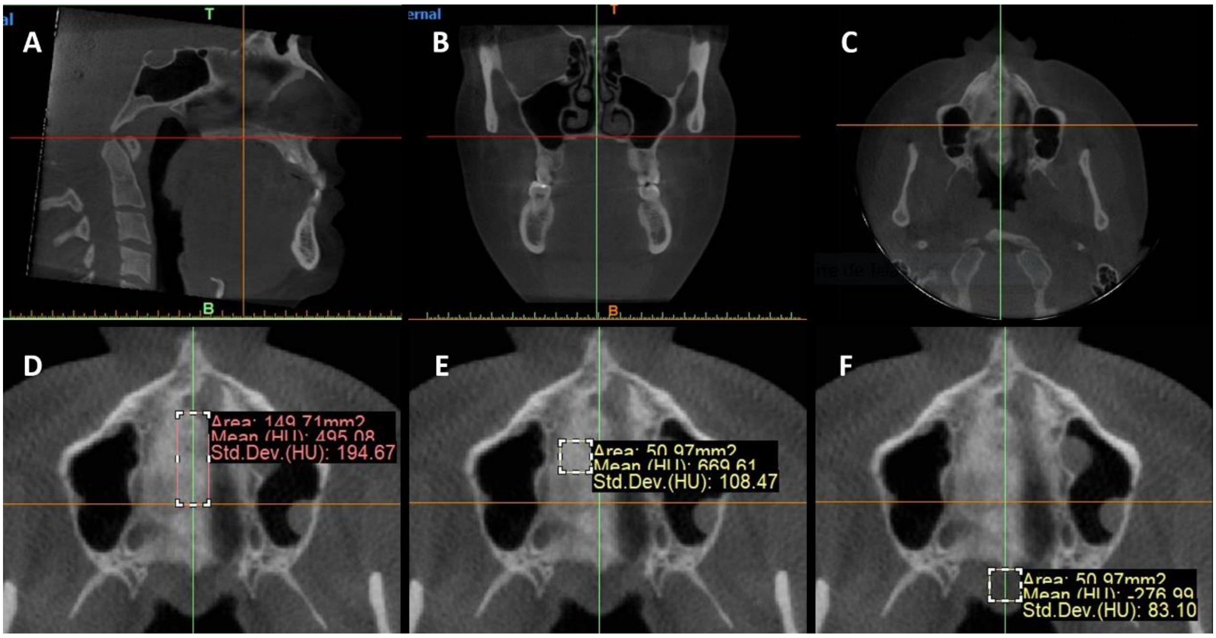


Fig 2. Views of the 3-dimensional reconstructions in Mimic's software after pre-orientation in Dolphin Software: **A**, sagittal and **B**, frontal views used to orient the hard palate parallel to the true horizontal; **C**, central slice used for measurements; Regions used to determine average gray density values: **D**, the gray density of the suture was determined in a rectangle centered on the midpalatal suture from the distal aspect of the incisive foramen to the distal aspect of the first molar crown; **E**, the gray density of the palatal process of the maxilla was determined in a square predetermined by the software at the cortical portion of the palatal process of the maxilla; **F**, the gray density of the soft palate was determined in the same square in a posterior area representing the soft palate.

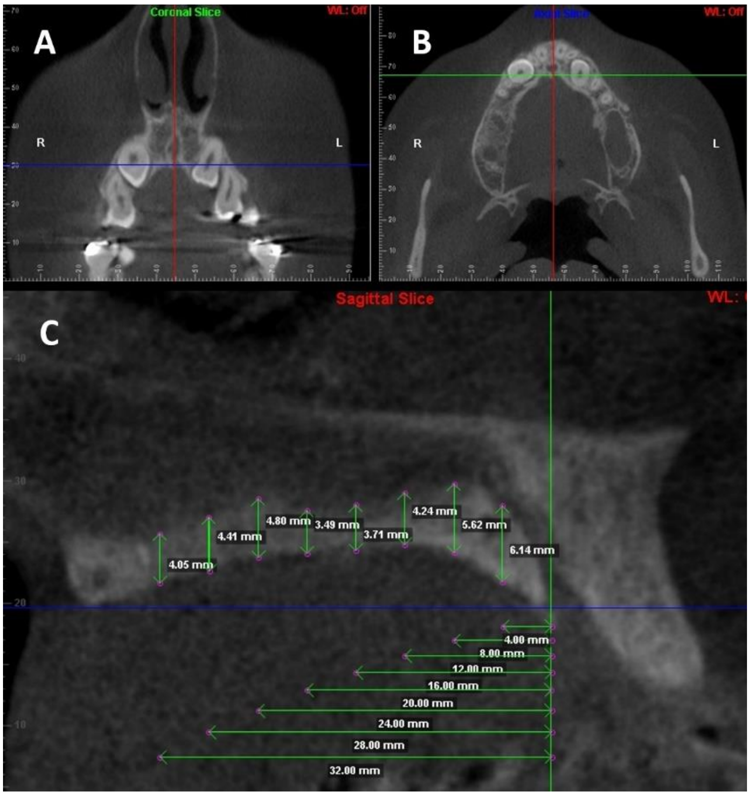


Fig 3. Orientation of the 3-dimensional reconstructions in Dolphin Imaging software: **A**, coronal view used to orient the hard palate perpendicular to the true vertical; **B**, axial view; **C**, sagittal section through the center of the palate, with midpalatal bone thickness measurements every 4 mm behind the incisive foramen.

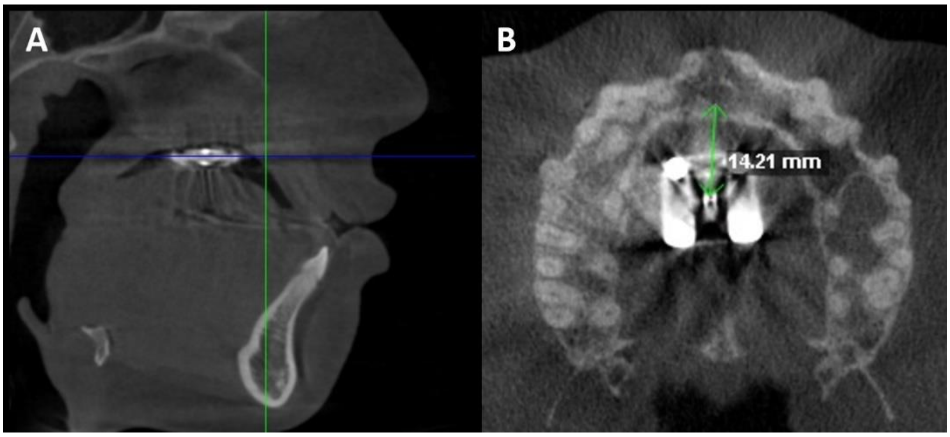
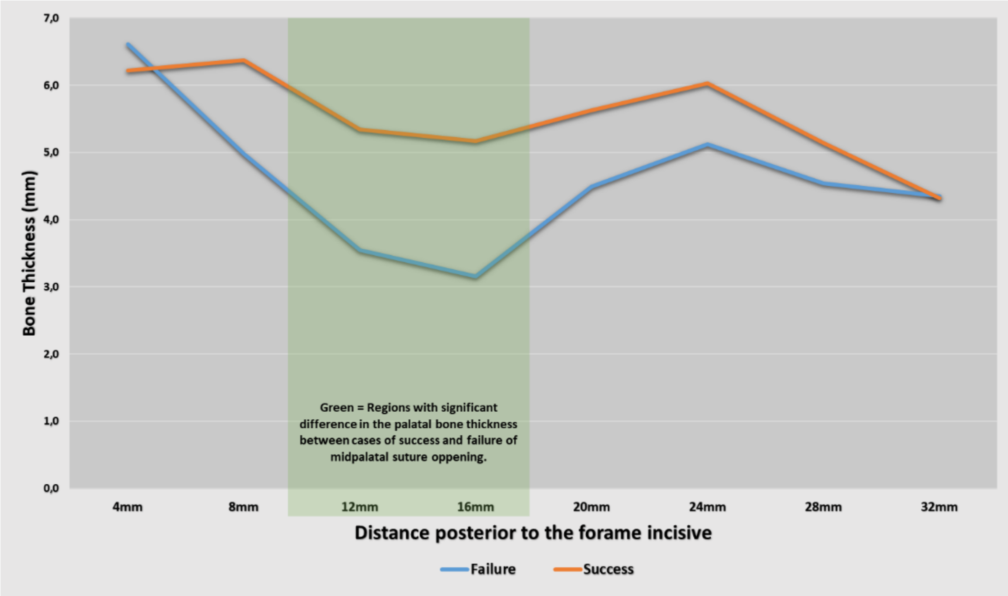
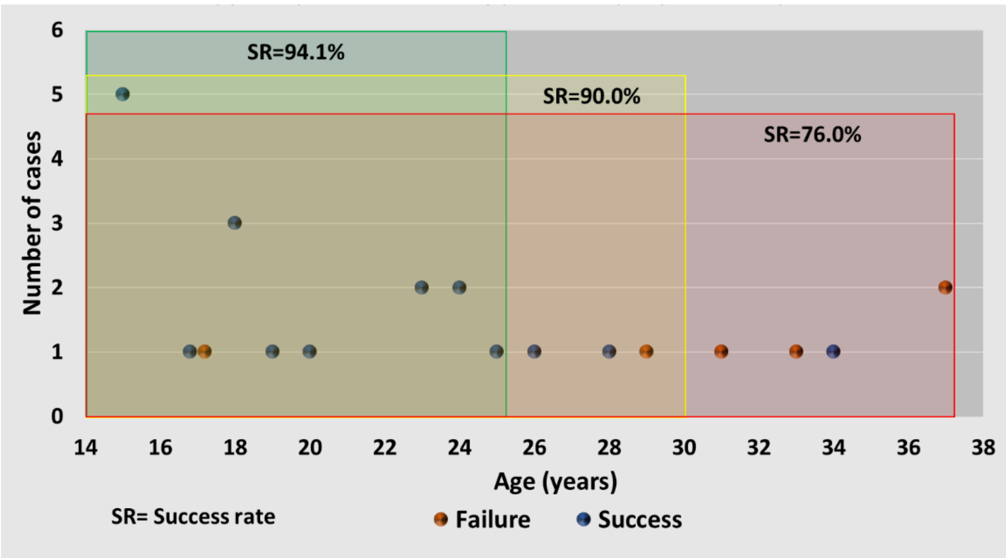


Fig 4. Orientation of the 3-dimensional reconstructions in Dolphin Imaging software: **A,** In the sagittal view the horizontal slice in the center of the expander parallel to the palatal plane; **B,** Axial view showing the measurement of the expander screw position.



Graph 1. Midpalatal Bone Thickness (sagittal view) according to MARPE therapy effect.



Graph 2. Number of success and failure cases of midpalatal suture opening in MARPE therapy according to patients' age.

Table I. Sample description according to treatment effect, sex and age

			Age	
Treatment effect	Sex	n	Min	Max
Success	Male	6	15	25
	Female	12	15	34
	Total	18	15	34
Failure	Male	2	26	31
	Female	5	17	37
	Total	7	15	34

Table II. Tomographic indicators to assess the success of orthopedic expansion of MARPE technique (difference between pre- and post-activation).

Measurements		MIF	PP	AP
Success(A) N=19	Mean	2,83	2,70	3,47
	S.E.	0,27	0,20	0,33
	Min	1,14	1,48	1,93
	Max	5,32	4,39	6,17
Failure (B) N=6	Mean	0,47	0,61	0,71
	S.E.	0,16	0,20	0,24
	Min	-0,16	0,03	-0,06
	Max	0,90	1,08	1,40
T test bi-caudal*	Comparations	A>B	A>B	A>B

*p<0,05

Table III. Intraclass correlation coefficient (ICC) test of the measurements.

	Cronbach's Alpha	**95% Confidence Interval**			
	ICC	Lower	Upper	F	P
MPSD ratio	0.974	0.941	0.989	39.1	0.000
D Forame-Screw	0.972	0.936	0.988	36.1	0.000
BoneThickness 4	0.995	0.990	0.998	221.4	0.000
BoneThickness 8	0.997	0.993	0.999	325.4	0.000
BoneThickness 12	0.993	0.984	0.997	145.3	0.000
BoneThickness 16	0.945	0.874	0.976	18.3	0.000
BoneThickness 20	0.953	0.891	0.980	21.1	0.000
BoneThickness 24	0.959	0.906	0.982	24.5	0.000
BoneThickness 28	0.998	0.996	0.999	563.4	0.000
BoneThickness 32	0.998	0.995	0.999	466.8	0.000

Table IV. Test t to evaluate systematic errors of replicate measurements.

	Mean diff	**S.E.**	**t**	**P**
MPSD ratio	-0.02	0.01	-1.389	0.178
D Forame-Screw	0.06	0.14	0.401	0.692
BoneThickness 4	0.01	0.05	0.210	0.835
BoneThickness 8	0.05	0.04	1.303	0.206
BoneThickness 12	0.08	0.06	1.365	0.185
BoneThickness 16	0.18	0.17	1.074	0.294
BoneThickness 20	0.17	0.17	0.960	0.347
BoneThickness 24	0.12	0.14	0.848	0.405
BoneThickness 28	0.02	0.03	0.684	0.501
BoneThickness 32	-0.04	0.03	-1.355	0.189

Table V. Intervening factors for the success or failure of the medial palatine suture opening.

	Failure			Success			Diference		Confidence Interval		Levene		t teste		
Variable	N	Mean	S. D.	N	Mean	S. D.	Mean	S. E.	Lower	Upper	F	Sig.	T	df	p
Age (years old)	6	30.67	7.42	19	20.63	7.42	10.03	2.73	4.37	15.70	0.196	0.662	3.666	23	**0.001**
MPSD ratio	6	0.78	0.18	19	0.73	0.18	0.05	0.08	-0.12	0.22	0.526	0.475	0.616	23	0.544
D Forame-Screw (mm)	6	13.51	2.39	19	15.34	2.09	-1.83	1.01	-3.92	0.26	0.077	0.783	-1.812	23	0.083
BoneThickness 4 (mm)	6	6.61	2.00	19	6.27	1.52	0.34	0.77	-1.25	1.93	0.685	0.416	0.438	23	0.665
BoneThickness 8 (mm)	6	4.98	1.22	19	6.30	1.55	-1.32	0.70	-2.76	-0.12	1.579	0.221	-1.897	23	0.070
BoneThickness 12 (mm)	6	3.55	1.35	19	5.31	1.47	-1.76	0.68	-3.16	-0.36	0.034	0.854	-2.601	23	**0.016**
BoneThickness 16 (mm)	6	3.16	1.30	19	5.17	1.69	-2.01	0.75	-3.78	-0.45	0.918	0.348	-2.660	23	**0.014**
BoneThickness 20 (mm)	6	4.49	1.85	19	5.75	2.01	-1.26	0.92	-3.18	0.65	0.082	0.778	-1.363	23	0.186
BoneThickness 24 (mm)	6	5.12	2.16	19	6.15	1.65	-1.04	0.83	-2.75	0.68	0.190	0.667	-1.247	23	0.225
BoneThickness 28 (mm)	6	4.54	2.19	19	5.24	1.80	-0.70	0.88	-2.54	1.13	1.454	0.226	-0.794	23	0.435
BoneThickness 32 (mm)	6	4.35	2.30	19	4.41	1.62	-0.06	0.94	-1.79	1.67	2.348	0.139	-0.070	23	0.945

Table VI. Correlation between the success of MARPE, age, density and thickness of the median palatine suture.

	Success		Age		MPSD ratio	
	r	p	R	P	r	p
Success			**-0.61**	**0.001**	-0.13	0.544
Age	**-0.61**	**0.001**			0.12	0.584
MPSD ratio	-0.13	0.544	0.11	0.584		
D Forame-Screw	0.35	0.085	-0.33	0.111	-0.02	0.949
BoneThickness 4	-0.90	0.665	0.31	0.132	-0.03	0.877
BoneThickness 8	0.37	0.070	**-0.41**	**0.044**	-0.07	0.724
BoneThickness 12	**0.48**	**0.016**	**-0.50**	**0.010**	-0.10	0.635
BoneThickness 16	**0.48**	**0.014**	-0.31	0.138	-0.04	0.866
BoneThickness 20	0.23	0.186	-0.13	0.544	0.13	0.527
BoneThickness 24	0.25	0.225	-0.09	0.687	0.11	0.615
BoneThickness 28	0.16	0.435	0.07	0.726	-0.06	0.780
BoneThickness 32	0.02	0.945	0.15	0.466	-0.03	0.881

Table VII. Correlation between age and density & thickness of the median palatine suture in the success and failure of MARPE.

	Age (Sucess)		Age (Failure)	
	R	P	r	p
MPSD ratio	0.19	0.433	0.32	0.534
BoneThickness 4	0.17	0.491	0.63	0.185
BoneThickness 8	-0.37	0.125	0.11	0.838
BoneThickness 12	-0.32	0.178	-0.28	0.584
BoneThickness 16	-0.70	0.777	0.17	0.752
BoneThickness 20	0.17	0.480	-0.29	0.579
BoneThickness 24	0.30	0.214	-0.33	0.527
BoneThickness 28	0.30	0.207	0.05	0.928
BoneThickness 32	0.28	0.252	0.07	0.893

3.2 ARTIGO 2*

Nasomaxillary and dental effects of MARPE and two SARPE approaches.

ABSTRACT

Introduction: This controlled retrospective study evaluated dental and nasomaxillary changes in patients with advanced bone maturation who underwent rapid palatal expansion (RPE) with miniscrew (MARPE) and surgically assisted (SARPE) techniques. Methods: Thirty-six patients were divided into 3 groups of 12: MARPE, SARPE without alar base cinch, and SARPE with alar base cinch. Measurements were taken from CBCT images obtained before (T0) and after (T1) expansion. Changes in dental (D66S, D66I) maxillary (MxMol), nasal floor in molar and canine regions (NaFMol, NaFCan), nasal cavity in molar and canine regions (NaCMol, NaCCan), choanal aperture (CA) and nasal soft tissue (NW) widths were compared using paired t-tests. Results: The MARPE technique had smaller dental changes [D66s ($p=0.025$)] and greater nasomaxilar expansion [MxMol, NaCMol, NaCCan, NaFMol and CA ($p<0.05$)] compared to both SARPE techniques. Changes in NW were not statistically significant between groups ($p=0.200$). The percentage of opening according to D66S expansion is 48% for NaCMol and 40% for NaCCan in MARPE against 22% and 15% for the cases of SARPE no cinch and for the SARPE with cinch 14% and 8%. Conclusions: MARPE promotes a greater increase in the nasal cavity and choanal widths in RPE than SARPE techniques. MARPE, SARPE with cinch and SARPE no cinch can promote enlargement of nasal soft tissue width.

---

[*] Artigo escrito conforme as normas bibliográficas da revista American Journal of Orthodontics and Dentofacial Orthopedics.

INTRODUCTION

The correct transverse relationship between the dental arches is essential to obtain a stable and functional occlusion. The transverse discrepancies involve dental and skeletal changes or the combination of both[1,2]. Rapid maxillary expansion (RME) was first introduced by Angell[3] in 1860 and is an established method of treatment of transverse discrepancies that increases the perimeter of the arch by disruption of the medial palatine suture, which reorganizes rapidly through repair of connective tissue and bone formation. This technique is generally used to treat maxillary constriction, posterior crossbite, and arch length discrepancies in growing patients[4].

Age is a very important factor in RME. In adults, due to the maturation of the median palatine suture and resistance of the zygomatic pillar, the response to palatal expansion with RME is less successful. The resulting widening of the maxillary width occurs more due to alveolar bone flexion and dental inclination in adults[5].

In addition, due to its inability to produce complete maxillary expansion in adults, RME can have undesirable side effects, such as failure of arch expansion, buccal inclination of the crown, alveolar bone dehiscence, root resorption, reduction of the buccal bone thickness and marginal bone loss[6,7].

Surgically Assisted Rapid Palatal Expansion (SARPE) has been frequently used to overcome the above-mentioned limitations by the surgical release of closed sutures that resist expansion forces in adults and has been used as the main surgical method for this treatment[8]. However, patients tend to be reluctant to undergo multiple surgical procedures and the demand for non-surgical treatment has increased[9].

In order to prevent undesirable dentoalveolar effects and to optimize the potential for maxillary expansion in individuals with advanced stages of bone maturation, the Mini-Screw Assisted Rapid Maxillary Expander (MARPE) technique was proposed by Lee et al.[10] and has been used as a clinically effective and stable approach for non-surgical correction of transverse discrepancy in adult patients[9,11]. A retrospective clinical study showed a good success rate of this therapy as an alternative to the treatment of surgical expansion[9].

To the best of our knowledge, no study in the literature compared the differences in the effect of these techniques for correction of transverse maxillary deficiency.

This study aims to use cone beam computed tomography (CBCT) scans to compare nasomaxillary and dental alterations in patients who were treated with MARPE and SARPE using two different surgical approaches (with and without alar base cinch).

MATERIAL AND METHODS

Approval was obtained from the Ethics Committee of the Araraquara Dental School, Unesp (Protocol 12643419.1.0000.5416).

This is a retrospective, non-randomized, controlled clinical study composed of three groups.

The inclusion criteria for CT scans were: initial images (before any treatment) of subjects with complete skeletal maturation (confirmed by examination of the cervical vertebrae - CVMS stage V from the Hassel and Farman analysis modified by Baccetti, Franchi and Mc-Namara[12]) , aged between 15 and 39 years, both genders and the availability of CBCT images of the maxilla. Exclusion criteria were: imaging after any previous orthodontic treatment, cleft lip and palate, and syndromic conditions.

CBCT's were selected before and after the expansion of 36 individuals between 15 and 39 years old from Dental and Research Dentistry Center COESP, in João Pessoa (Paraíba) and the São Paulo State University (UNESP), in Araraquara (São Paulo) archives. The selected exams were obtained with the i-CAT scanner (Imaging Sciences International, Hatfield, Pa), voxel size of 0.2 to 0.3 mm and with variable Fov depending on the structure of interest requested in the examination.

Treatment of the MARPE group

The patients were treated by RME using a hybrid expander device supported by four orthodontic mini-implants inserted paramedian to the midpalatal suture and attached to the molars (Peclab, Belo Horizonte - Minas Gerais, Brazil). MARPE positioning was planned using initial CBCT images (T0) so that miniscrews were inserted in a region of adequate bone thickness and in the portion of the palate that fits the expander device.

The mini-implants were installed manually with a manual contra-angle driver (Peclab Kit, Belo Horizonte, Brazil). To measure the insertion torque, it was used the torque wrench. All steps were performed by the same researcher.

The activation protocol was 2/4 turn immediately after mini-implants placement and 2/4 turn daily on the following days (1/4 in the morning and 1/4 at night), varying from 14 to 18 days until full correction was achieved. After expansion, the expander screw was locked and kept in place, without activation, for four months.

Treatment of the SARPE group

Patients in this group underwent surgically assisted rapid maxillary expansion and were divided according to the kind of surgical approach that was employed: The patients of the group SARPE with cinch, passed through the standard Le Fort I circumvestibular approach followed by alar base cinch and patients of the group SARPE no cinch passed through a subtotal vestibular approach associated to a V-shaped incision at the maxillary midline in the labial frenulum region, without alar base cinch. All the procedures were performed under general anesthesia in a hospital environment between the years 2010 and 2012. The hyrax expander device was used with ¼ turn (0.2mm) activation protocol three times daily until the crossbite correction. The beginning of the activation occurred seven days after the surgical procedure. When the expansion was completed, the device was locked and held for four months, then removed and replaced for a palatal bar in the first molars.

Tomographic evaluation

CBCT scans before (T0) and after (T1) MARPE expansion and stabilization of the expander screw were obtained using the i-CAT Next Generation tomography (Imaging Sciences International, Hatfield, PA, USA). The image acquisition protocol was the face examination with a field of view of 16 cm in diameter,10 cm in height and voxel size of 0.3 mm.

In the SARPE group, the CBCTs were obtained for each patient before surgery (T0) and 6 months after expansion (T1), using the same i-CAT (Imaging Sciences International, Hatfield, PA, USA) tomography with 0.25mm voxel.

The data were exported in the digital image and communication in medicine (DICOM) format and analyzed in the Dolphin 3D software (Dolphin Imaging, Chatsworth, CA, USA), randomly, by a single previously calibrated examiner.

The tomographic reconstructions were positioned according to the intracranial reference planes as described by Cevidanes et al.[13]

Skeletal, Dental and Nasal soft tissue Measures

The definitions of the measures are listed in Table I. To measure the skeletal effects of maxillary orthopedic expansion, linear measurements were performed to quantify the nasomaxillary opening in coronal sections (Fig 1 A, B, C and F). In order to quantify the dental expansion and inclination effects, cross-sectional linear measurements were performed (Fig 1 C and D). The Nasal soft tissue measurement can be observed in Fig 1 E.

Statistical analysis

To determine the intra-examiner error calculation, all scans were re-analyzed, randomly by the same examiner, with a two-week interval between the first and second evaluation. The reproducibility of the method was evaluated using the Intraclass Correlation Coefficient (ICC) and t-test for repeated measures (systematic error evaluation) for all measures used in this study. Student's t-test for dependent sample was used to evaluate systematic error in the replicate measurements.

In order to verify the normality of the data, they were submitted to the Shapiro-Wilk test. Mean and standard deviation were calculated for the variables with normal distribution. Median and confidence intervals at 95% probability were calculated for the variables that did not exhibit normal distribution. The Levene test was applied to verify the homogeneity of variances between the groups (MARPE and SARPE).

Student's t-test for dependent sample was used to compare the means before and after the expansion. Anova test and Tukey post hoc test for differences among groups were used to compare the expansion changes achieved between the 3 groups (MARPE and SARPE with cinch and SARPE without cinch).

The level of significance adopted for the rejection of the hypotheses was 0.05. The calculations for the statistical analysis were performed by the SPSS program - version 16.0 for Windows (release 16.01 - Nov. 2007). SPSS Inc. 1989-2007.

RESULTS

The ICC values for all linear measurements were greater than 0.95 (Table IIa) indicating good intra-examiner reliability and the paired t-test (Table IIb) is showing the evaluation of systematic error.

All baseline characteristics (before the expansion -T0) presented no significant differences between groups except NaCCan whose mean was higher in the SARPE no cinch group (24.57mm ± 1.83) as presented in Table III.

The parameters showed significant increases after treatment ($p<0.001$) for the MARPE group, except for the D66I (Table IV). The SARPE groups also showed significant increases with treatment except for D66I and NaFMol.

The difference between groups after treatment are showed in Table V. The MARPE technique had smaller dental changes [D66s ($p=0.025$)] and greater skeletal expansion [MxMol ($p=0.010$)] compared to both SARPE techniques. Graph 1 shows the percentage of change relative to the amount of dental arch expansion for the variables MxMol, NaCMol, NaCCan, NW and CA.

The expansion of the nasal cavity [NaCMol ($p=0.016$)] and floor of the nasal cavity [NaFMol ($p=0.001$)] at the posterior region (molar) was also higher for MARPE technique. In the anterior region (canine) the expansion of the nasal cavity was grater in MARPE ($p=0.017$) but the floor of the nasal cavity in this region didn't show significant changes between groups.

Expansion by MARPE technique increases both anterior and posterior regions of the nasal cavity (NaCCan and NaCMol), but SARPE opening is more evident in the anterior region (Fig 2). SARPE with alar base cinch presented smaller nasal cavity expansion.

The CA region after treatment was also greater in MARPE ($p=0.002$).

Changes in NW were not statistically significant between groups ($p=0.200$).

DISCUSSION

SARPE and MARPE are frequently used to correct transverse deficits in adult patients[8,9,11]. The main goal of the treatments is to correct occlusion. However, changes in the proportion of nasal cavity and soft tissue may result from the underlying skeletal movements that occurs[14]. This study aims to use CBCT scans to compare these changes in both techniques.

Regarding dental changes, the sample evaluated had similar upper and lower aches widths before treatment which represents a transverse discrepancy (D66I – D66S) of 6,8mm and 7,1mm for the cases in the group of SARPE with cinch and no cinch respectively and 7,3 mm for the cases in the MARPE group. Dental arch expansion achieved in the MARPE group (5,8 mm) was smaller than in the SARPE group (7,7mm).

In contrast, the present study demonstrated that expansion with the MARPE technique contributed greater than SARPE in nasomaxillary improvements. An increase in the width of the nasal cavity at the anterior (canine) and posterior (molar) regions was observed. Graph 1 illustrates that in MARPE cases, after dental arch expansion, the nasal cavity increases 48% in molar region and 40% in canine region against 22% and 15% for the cases of SARPE no cinch and for the SARPE with cinch 14% and 8% in the same measures. Significant expansion of the nasal cavity width has been reported using conventional RPE[15], SARPE[16,17], and MARPE[18,19].

Regarding MARPE effects, the study of Lim et al.[19] corroborates with our results. They analyzed some skeletal changes after miniscrew-assisted rapid palatal expansion in 24 adult patients and find in the molar region an average increase of 1.61 in the nasal cavity and 2.20 in the floor. They also analyze the cases 1 year after treatment and showed that these averages tend to decrease a little (1.25 cavity and 1.56 floor). The average increase of width of the same measures in our study was greater despite the smaller sample (2.20 cavity and 3.46 floor), however we only analyzed the tomographic images immediately after the end of expansion.

The results of the current study also show that expansion by MARPE increases both anterior and posterior regions of the nasal cavity but SARPE techniques opening is more evident in the anterior region with small amount of increase at the posterior region (Fig 2). This pattern of “v shape” opening at the axial view of the midpalatal suture after SARPE has already been reported in the literature[20] and can be explained because tooth-supported appliances usually used after SARPE, are not able to promote disarticulation of the posterior sutures, especially pterygopalatine [21]. The use of four mini-implants in the device, allows the separation force to be distributed along the entire suture length and this promotes the more parallel split of the midpalatal suture in an anteroposterior direction[22].

Posteriorly located between the nasal cavity and the nasopharynx, the CA is an important space of air passage. Individuals with atresia or obstruction of that space can present clinical manifestations of breathing problems[23,24]. This is the first study to analyze changes in this anatomic region after treatment with SARPE and MARPE. Interestingly, it was observed that in some cases of our sample the CA decreased, especially in cases of SARPE with cinch (-15% after dental arch expansion). The mean differences of CA were statistically significant ($p=0.002$) with an opening of 0.78mm (MARPE), 0.32mm (SARPE no cinch) and reduction of -0.10mm (SARPE with cinch).

According to the study of Warren et al., an increase in the cross-sectional area of the nasal cavity can facilitate easy breathing [25]. This statement has been confirmed by some studies in airway flow after SARPE [26,27] and, more recently, MARPE [28,29]. In this sense, the increase of width in nasal cavity that occurs together with increase of choanal aperture in the cases of the current study may have similar effects on airway improvement. Furthermore, because MARPE presented largest increase of this measure, the effects of MARPE technique in airway flow would probably be better than SARPE as well. However, it is important to highlight that clinical significance of the findings over airway flow of these studies has to be interpreted with caution because of measurement errors that can be associated with the volumetric data of CBCTs[30]. Therefore, additional studies are necessary for the accurate evaluation of differences in airway changes after MARPE and SARPE in adults.

Some of the effects proportionated by these expansion techniques may be clinically desirable, while others because of the increasing attention paid by patients and professionals to the aesthetic aspects of treatment [31], may represent unfavorable side effects of the treatment, such as changes in nasal soft tissue. Studies on facial soft tissue changes after conventional RPE have shown a significantly increased in nasal width[32,33].

The results of the present study showed significant differences for the NW from T0-T1 in all the groups, and according to Graph 1 an increase of 35% (MARPE) and 16% (for both SARPE techniques) in NW occurred after dental arch expansion but the comparison between groups showed no statistically significant differences for this measure. This means that no matter what technique is used to perform palatal expansion in adults, an enlargement of nasal soft tissue will occur even if the alar base sutures were performed in the SARPE technique to maintain the alar width as it was before surgery. Previous studies have reported that the type of surgical approach or performing alar base cinch sutures in SARPE were not sufficient to prevent widening of the nose and suggested that overcorrection is necessary in cases where widening of the alar base is not desirable [34]. As for MARPE, no tools to prevent this soft tissue effect to happen was ever studied.

CONCLUSIONS

- MARPE technique increased the nasal cavity width at anterior and posterior regions at the same amount. SARPE technique expanded this region in a “V shape” patter, with a greater increase in the anterior than posterior region. However, the expansion of the anterior region in both techniques was the same.

- The percentage of changes in nasal cavity and choanal aperture relative to the amount of dental arch expansion for MARPE is greater them SARPE techniques. Thus, MARPE may bring more benefits to individuals with respiratory problems related to the atresia of these regions.

- MARPE, SARPE with cinch and SARPE no cinch can promote enlargement of nasal soft tissue width. There are no significant differences in nasal soft tissue width after expansion with both MARPE and SARPE.

REFERENCES

1. Haas AJ. The treatment of maxillary deficiency by opening the midpalatal suture. *Angle Orthod.* 1965.

2. Bishara SE, Staley RN. Maxillary expansion: Clinical implications. *Am. J. Orthod. Dentofac. Orthop.* 1987;91(1):3–14.

3. Cosmos DA-D, 1860 undefined. Treatment of irregularity of the permanent or adult teeth. *ci.nii.ac.jp*.

4. McNamaraa JA. Maxillary transverse deficiency. *Am. J. Orthod. Dentofac. Orthop.* 2000;117(5):567–70.

5. Handelman C. Palatal expansion in adults: The nonsurgical approach. *Am. J. Orthod. Dentofac. Orthop.* 2011;140(4):462–8.

6. Garib DG, Henriques JFC, Janson G, de Freitas MR, Fernandes AY. Periodontal effects of rapid maxillary expansion with tooth-tissue-borne and tooth-borne expanders: A computed tomography evaluation. *Am. J. Orthod. Dentofac. Orthop.* 2006;129(6):749–58.

7. Garrett BJ, Caruso JM, Rungcharassaeng K, Farrage JR, Kim JS, Taylor GD. Skeletal effects to the maxilla after rapid maxillary expansion assessed with cone-beam computed tomography. *Am. J. Orthod. Dentofac. Orthop.* 2008;134(1):8.e1-8.e11.

8. Cureton SL, Cuenin M. Surgically assisted rapid palatal expansion: orthodontic preparation for clinical success. *Am. J. Orthod. Dentofacial Orthop.* 1999;116(1):46–59.

9. Choi S-H, Shi K-K, Cha J-Y, Park Y-C, Lee K-J. Nonsurgical miniscrew-assisted rapid maxillary expansion results in acceptable stability in young adults. *Angle Orthod.* 2016;86(5):713–20.

10. Lee K-J, Park Y-C, Park J-Y, Hwang W-S. Miniscrew-assisted nonsurgical palatal

expansion before orthognathic surgery for a patient with severe mandibular prognathism. *Am. J. Orthod. Dentofac. Orthop.* 2010;137(6):830–9.

11. Lim H-M, Park Y-C, Lee K-J, Kim K-H, Choi YJ. Stability of dental, alveolar, and skeletal changes after miniscrew-assisted rapid palatal expansion. *Korean J. Orthod.* 2017;47(5):313–22.

12. Baccetti T, Franchi L, McNamara JA. An Improved Version of the Cervical Vertebral Maturation (CVM) Method for the Assessment of Mandibular Growth. *Angle Orthod.* 2002.

13. Cevidanes L, Oliveira AEF, Motta A, Phillips C, Burke B, Tyndall D. Head Orientation in CBCT-generated Cephalograms. *Angle Orthod.* 2009;79(5):971–7.

14. Ramieri GA, Nasi A, Dell'Acqua A, Verzé L. Facial soft tissue changes after transverse palatal distraction in adult patients. *Int. J. Oral Maxillofac. Surg.* 2008;37(9):810–8.

15. Görgülü S, Gokce SM, Olmez H, Sagdic D, Ors F. Nasal cavity volume changes after rapid maxillary expansion in adolescents evaluated with 3-dimensional simulation and modeling programs. *Am. J. Orthod. Dentofac. Orthop.* 2011.

16. Tausche E, Hansen L, Hietschold V, Lagravère MO, Harzer W. Three-dimensional evaluation of surgically assisted implant bone-borne rapid maxillary expansion: A pilot study. *Am. J. Orthod. Dentofac. Orthop.* 2007.

17. Asscherickx K, Govaerts E, Aerts J, Vande Vannet B. Maxillary changes with bone-borne surgically assisted rapid palatal expansion: A prospective study. *Am. J. Orthod. Dentofac. Orthop.* 2016;149(3):374–83.

18. Clement E, Krishnaswamy N. Skeletal and dentoalveolar changes after skeletal anchorage-assisted rapid palatal expansion in young adults: A cone beam computed tomography study. *APOS Trends Orthod.* 2017;7(3):113.

19. Lim HM, Park YC, Lee KJ, Kim KH, Choi YJ. Stability of dental, alveolar, and skeletal changes after miniscrew-assisted rapid palatal expansion. *Korean J. Orthod.* 2017.

20. Deeb W, Hansen L, Hotan T, Hietschold V, Harzer W, Tausche E. Changes in nasal volume after surgically assisted bone-borne rapid maxillary expansion. *Am. J. Orthod. Dentofac. Orthop.* 2010;137(6):782–9.

21. Chung CH, Goldman AM. Dental tipping and rotation immediately after surgically assisted rapid palatal expansion. *Eur. J. Orthod.* 2003.

22. Cantarella D, Dominguez-Mompell R, Mallya SM, et al. Changes in the midpalatal and pterygopalatine sutures induced by micro-implant-supported skeletal expander, analyzed with a novel 3D method based on CBCT imaging. *Prog. Orthod.* 2017;18(1):34.

23. Aslan S, Yilmazer C, Yildirim T, Akkuzu B, Yilmaz I. Comparison of nasal region dimensions in bilateral choanal atresia patients and normal controls: A computed tomographic analysis with clinical implications. *Int. J. Pediatr. Otorhinolaryngol.* 2009;73(2):329–35.

24. Likus W, Bajor G, Gruszczyńska K, Baron J, Markowski J. Nasal region dimensions

in children: A CT study and clinical implications. *Biomed Res. Int.* 2014;2014:13–6.

25. Warren DW, Hairfield WM, Seaton DL, Hinton VA. The relationship between nasal airway cross-sectional area and nasal resistance. *Am. J. Orthod. Dentofac. Orthop.* 1987;92(5):390–5.

26. Nada RM, van Loon B, Schols JGJH, et al. Volumetric changes of the nose and nasal airway 2 years after tooth-borne and bone-borne surgically assisted rapid maxillary expansion. *Eur. J. Oral Sci.* 2013;121(5):450–6.

27. Wriedt S, Kunkel M, Zentner A, Wahlmann UW. Surgically assisted rapid palatal expansion. An acoustic rhinometric, morphometric and sonographic investigation. *J. Orofac. Orthop.* 2001;62(2):107–15.

28. Storto CJ, Garcez AS, Suzuki H, et al. Assessment of respiratory muscle strength and airflow before and after microimplant-assisted rapid palatal expansion. *Angle Orthod.* 2019.

29. Hur JS, Kim HH, Choi JY, Suh SH, Baek SH. Investigation of the effects of miniscrew-assisted rapid palatal expansion on airflow in the upper airway of an adult patient with obstructive sleep apnea syndrome using computational fluidstructure interaction analysis. *Korean J. Orthod.* 2017.

30. Obelenis Ryan DP, Bianchi J, Ignácio J, Wolford LM, Gonçalves JR. Cone-beam computed tomography airway measurements: Can we trust them? *Am. J. Orthod. Dentofacial Orthop.* 2019;156(1):53–60.

31. William Arnett G, Bergman RT. Facial keys to orthodontic diagnosis and treatment planning-part II. *Am. J. Orthod. Dentofac. Orthop.* 1993.

32. Huang J, Li C-Y, Jiang J-H. Facial soft tissue changes after nonsurgical rapid maxillary expansion: a systematic review and meta-analysis. *Head Face Med.* 2018;14(1):6.

33. Kim KB, Adams D, Araújo EA, Behrents RG. Evaluation of immediate soft tissue changes after rapid maxillary expansion. *Dental Press J. Orthod.* 2012;17(5):157–64.

34. Alves N, Oliveira TFM, Pereira-Filho VA, Gonçales ES, Gabrielli MAC, Passeri LA. Nasolabial changes after two different approaches for surgically assisted rapid maxillary expansion. *Int. J. Oral Maxillofac. Surg.* 2017.

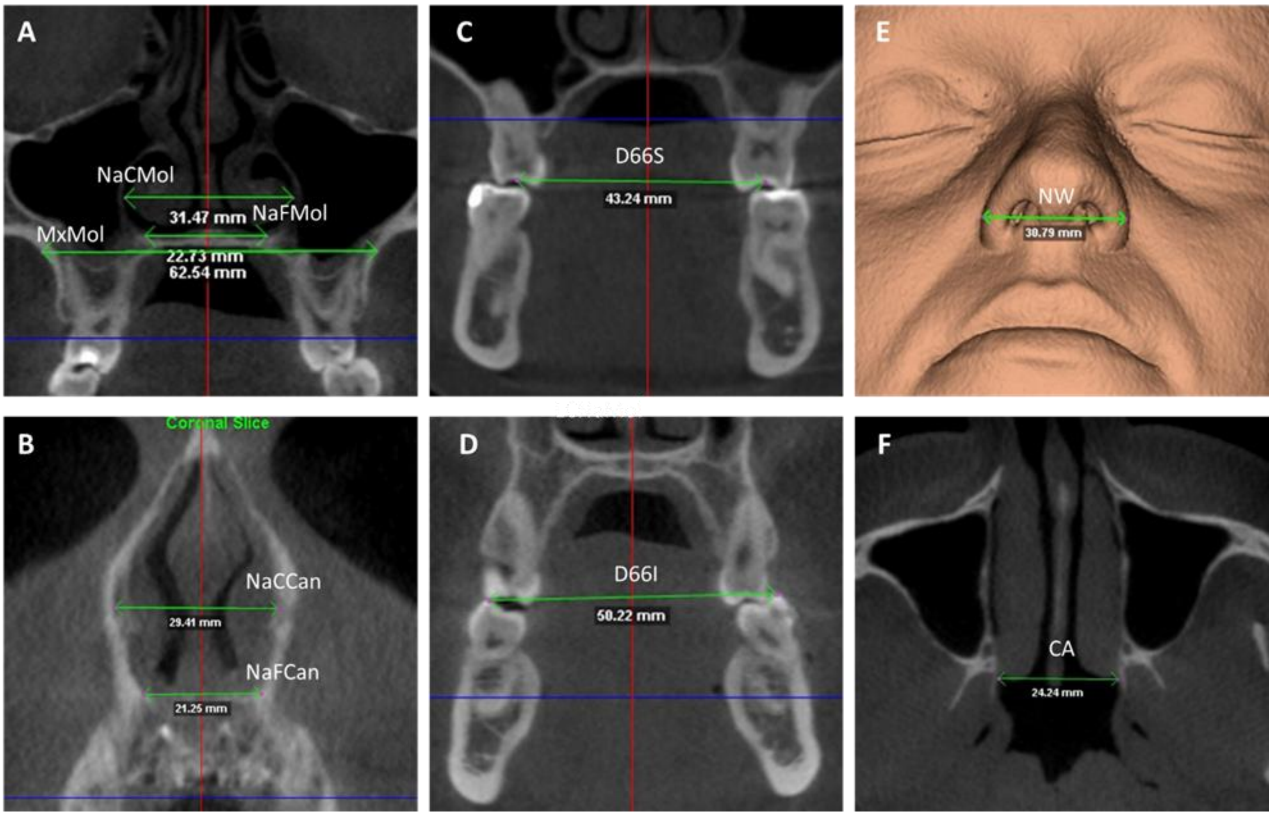


Fig 1. Views of the 3-dimensional reconstructions in Dolphin Imaging Software with skeletal and soft tissue linear measurements: **A,** coronal view showing the measures Nasal cavity width in the molar region (NaCMol), Floor of the nasal cavity width in the molar region (NaFMol) and Maxillary width in the molar region (MxMol); **B,** Measures Nasal cavity width in the canine region (NaCCan) and Floor of the nasal cavity width in the canine region (NaFCan); **C**, Measure Inter-sulcus width (D66S); **D**, Measure Inter-cusp width (D66I); **E**, facial reconstruction showing Nasal width (NW) measure; **F**, coronal view showing the choanal aperture measure (CA).

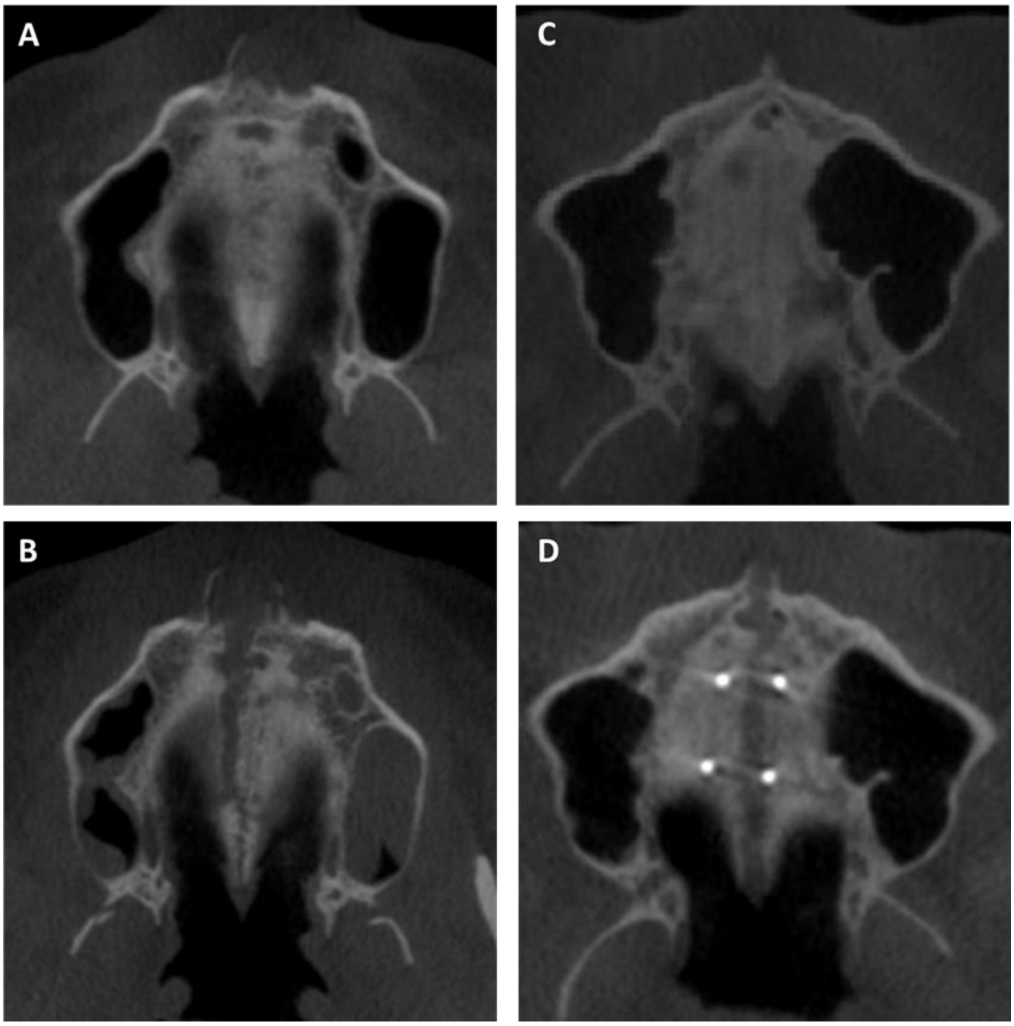


Fig 2. Axial views of CBCTs comparing the opening patter of SARPE and MARPE techniques: **A**, SARPE case before expansion (T0); **B**, SARPE case after expansion (T1) showing the “v shape” patter of opening; **C**, MARPE case before expansion (T0); **D**, MARPE case after expansion (T1) showing a parallel pattern of opening.

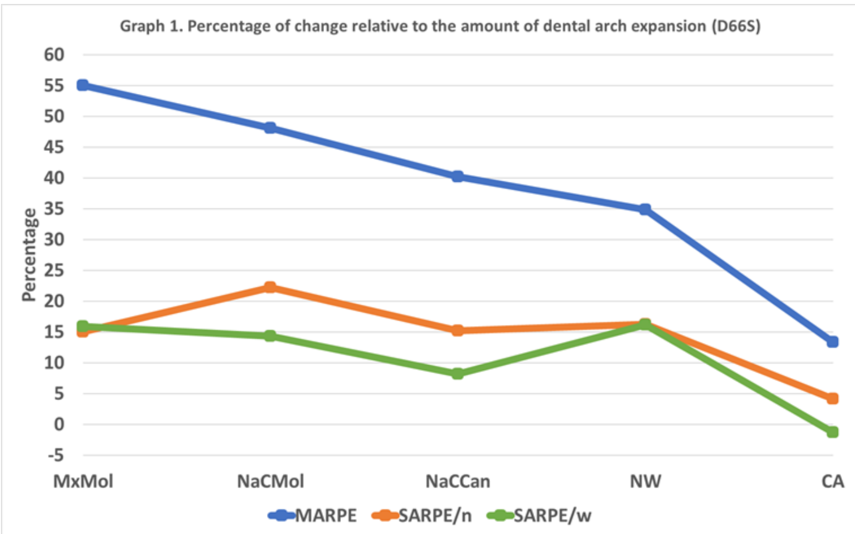


Table I. Definitions of the parameters used in this study

Parameter	***Code***	***Section for measurements***	***Definition***
		Skeletal Nasomaxillary Measures	
Maxillary width in the molar region	MxMol	Coronal section passing through the upper first molar furcation bilaterally	Distance between the points located at the intersection of the zygomatic process and maxillary tuberosity
Nasal cavity width in the molar region	NaCMol	Coronal section passing through the upper first molar furcation bilaterally	Distance between the widest portions of the nasal cavity
Floor of the nasal cavity width in the molar region	NaFMol	Coronal section passing through the upper first molar furcation bilaterally	Floor of the nasal cavity, parallel to the palatal plane
Nasal cavity width in the canine region	NaCCan	Coronal section passing through the distal of the upper canine bilaterally	Distance between the widest portions of the nasal cavity
Floor of the nasal cavity width in the canine region	NaFCan	Coronal section passing through the distal of the upper canine bilaterally	Floor of the nasal cavity, parallel to the palatal plane
Choanal aperture	CA	Axial section parallel to the palatine bone	Bony choanal aperture width between both pterygoid processes
		Dental Measures	
Inter-sulcus width	D66S	Coronal section passing through the first molar furcation bilaterally	Distance between the upper first molar sulcus bilaterally
Inter-cusp width	D66I	Coronal section passing through the first molar furcation bilaterally	Distance between the mesiobuccal cusp of the lower first molar bilaterally
		Nasal Soft Tissue Measure	
Nasal width	NW	-	Measured by the widest width between the nose wings (ala)

Table IIa. Intraexaminer reliability assessment.	
Variable	*ICC (Confidence Interval)*
D66S	0.998(0.998-0.999)
D66I	0.998(0.997-0.999)
MxMol	0.997(0.995-0.998)
NaCMol	0.997(0.995-0.998)
NaCCan	0.991(0.986-0.994)
NaFMol	0.997(0.996-0.998)
NaFCan	0.995(0.992-0.996)
CA	0.985(0.976-0.991)
NW	0.998(0.997-0.999)

Table IIb. Test t to evaleate systematic erros of replicate measurements

Variable	Mean diff.	S.E.	t	p
D66S	0,01	0,03	0,1650	0,8690
D66I	0,07	0,03	2,2110	**0,0300**
MxMol	0,00	0,05	-0,0980	0,9220
NaCMol	-0,05	0,05	-1,0080	0,3170
NaCCan	-0,04	0,04	-0,9320	0,3540
NaFMol	0,04	0,04	0,9630	0,3390
NaFCan	-0,04	0,04	-1,0880	0,2800
CA	-0,11	0,08	-1,3410	0,1840
NW	-0,07	0,04	-1,6620	0,1010

Table III. Baseline characteristics. Comparison between groups

	Group	*N*	*Mean*	*S.D.*	*Anova*		*Min*	*Max*
D66S	Marpe	12	43.81	2.67	0.955		36.85	47.36
	Sarpe no cinch	12	43.40	4.87			33.06	49.83
	Sarpe with cinch	12	43.38	4.08			38.78	52.91
D66I	Marpe	12	50.13	3.73	0.978		43.49	56.43
	Sarpe no cinch	12	50.53	6.50			37.61	61.50
	Sarpe with cinch	12	50.19	4.43			40.38	56.50
MxMol	Marpe	12	59.62	4.52	0.847		49.69	65.34
	Sarpe no cinch	12	60.30	3.91			54.12	67.78
	Sarpe with cinch	12	59.31	4.41			52.91	67.80
NaCMol	Marpe	12	30.64	2.37	0.120		26.77	34.51
	Sarpe no cinch	12	31.22	4.34			23.40	38.22
	Sarpe with cinch	12	28.46	3.04			24.87	35.43
NaCCan	Marpe	12	23.21	2.26	**0.040**	AB	19.61	28.14
	Sarpe no cinch	12	24.57	1.83		B	21.28	27.11

	Sarpe with cinch	12	22.45	1.90		A	19.37	25.93
NaFMol	Marpe	12	22.42	2.58	0.100		18.23	28.77
	Sarpe no cinch	12	26.03	5.69			18.55	36.59
	Sarpe with cinch	12	24.87	3.26			20.85	31.96
NaFCan	Marpe	12	16.60	1.90	0.605		14.56	20.90
	Sarpe no cinch	12	17.60	3.40			14.09	23.82
	Sarpe with cinch	12	17.18	1.61			14.43	19.35
NW	Marpe	11	35.31	3.30	0.340		31.13	41.08
	Sarpe no cinch	12	36.86	4.83			30.98	43.99
	Sarpe with cinch	12	34.59	2.96			31.21	40.86
CA	Marpe	12	26.56	2.79	0.916		23.13	33.38
	Sarpe no cinch	12	26.83	2.77			22.61	31.00
	Sarpe with cinch	12	27.06	3.11			23.26	34.74

Table IV. Treatment effects. Intragroup analysis (*95% Confidence Interval)*

		Mean	*S.D.*	*Lower*	*Upper*	*Min*	*Max*	*t*	*p*
MARPE	D66S	5.82	2.03	4.53	7.11	2.20	8.25	9.922	**0.000**
	D66I	0.43	0.79	-0.07	0.93	-0.53	2.23	1.884	0.086
	MxMol	3.20	1.92	1.98	4.42	-0.04	6.98	5.790	**0.000**
	NaCMol	2.80	1.88	1.61	4.00	-0.40	5.56	5.168	**0.000**
	NaCCan	2.34	1.98	1.09	3.60	-0.67	5.82	4.104	**0.002**
	NaFMol	3.46	1.95	2.22	4.70	1.12	8.23	6.162	**0.000**
	NaFCan	3.02	1.29	2.20	3.83	0.43	4.91	8.134	**0.000**
	NW	2.03	0.55	1.64	2.43	1.01	3.06	11.631	**0.000**
	CA	0.78	0.53	0.44	1.12	-0.02	1.93	5.072	**0.000**
SARPE no cinch	D66S	7.71	1.23	6.92	8.49	6.19	10.20	21.668	**0.000**
	D66I	0.68	1.78	-0.45	1.81	-0.79	5.65	1.333	0.210
	MxMol	1.16	1.40	0.27	2.05	-1.03	3.90	2.864	**0.015**
	NaCMol	1.71	1.14	0.99	2.44	0.11	3.69	5.224	**0.000**
	NaCCan	1.17	1.28	0.36	1.99	-0.48	3.78	3.172	**0.009**
	NaFMol	0.67	2.20	-0.73	2.07	-3.29	3.54	1.059	0.312
	NaFCan	2.44	2.62	0.77	4.10	0.21	9.67	3.217	**0.008**
	NW	1.25	1.52	0.28	2.21	-0.86	4.90	2.851	**0.016**
	CA	0.32	0.34	0.10	0.53	-0.06	1.00	3.221	**0.008**
SARPE with cinch	D66S	7.66	2.09	6.33	8.98	2.53	11.47	12.716	**0.000**
	D66I	0.95	1.74	-0.15	2.06	-0.80	4.64	1.893	0.085
	MxMol	1.22	1.85	0.50	2.39	-2.10	4.11	1.850	**0.043**
	NaCMol	1.10	0.94	0.50	1.70	-0.12	3.00	4.030	**0.002**
	NaCCan	0.63	0.58	0.26	1.01	-0.06	1.86	3.768	**0.003**
	NaFMol	0.43	1.59	-0.58	1.43	-3.07	2.81	0.932	0.371

NaFCan	2.96	1.83	1.80	4.13	-0.02	6.34	5.605	**0.000**
NW	1.24	1.05	0.58	1.91	-0.20	2.56	4.121	**0.002**
CA	-0.10	0.73	-0.56	0.37	-1.05	1.40	-0.469	0.648

Table V. Treatment effects. Comparison between groups

	Group	*N*	*Mean*	*Anova*		*S.D.*	*Min*	*Max*
D66S	Marpe	12	5.82	**0.025**	A	2.03	2.20	8.25
	Sarpe no cinch	12	7.71		B	1.23	6.19	10.20
	Sarpe with cinch	12	7.66		B	2.09	2.53	11.47
D66I	Marpe	12	0.43	0.698		0.79	-0.53	2.23
	Sarpe no cinch	12	0.68			1.78	-0.79	5.65
	Sarpe with cinch	12	0.95			1.74	-0.80	4.64
MxMol	Marpe	12	3.20	**0.010**	B	1.92	-0.04	6.98
	Sarpe no cinch	12	1.16		A	1.40	-1.03	3.90
	Sarpe with cinch	12	1.22		A	1.85	-2.10	4.11
NaCMol	Marpe	12	2.80	**0.016**	B	1.88	-0.40	5.56
	Sarpe no cinch	12	1.71		AB	1.14	0.11	3.69
	Sarpe with cinch	12	1.10		A	0.94	-0.12	3.00
NaCCan	Marpe	12	2.34	**0.017**	B	1.98	-0.67	5.82
	Sarpe no cinch	12	1.17		AB	1.28	-0.48	3.78
	Sarpe with cinch	12	0.63		A	0.58	-0.06	1.86
NaFMol	Marpe	12	3.46	**0.001**	B	1.95	1.12	8.23
	Sarpe no cinch	12	0.67		A	2.20	-3.29	3.54
	Sarpe with cinch	12	0.43		A	1.59	-3.07	2.81
NaFCan	Marpe	12	3.02	0.734		1.29	0.43	4.91
	Sarpe no cinch	12	2.44			2.62	0.21	9.67
	Sarpe with cinch	12	2.96			1.83	-0.02	6.34
NW	Marpe	11	2.03	0.200		0.55	1.01	3.06
	Sarpe no cinch	12	1.25			1.52	-0.86	4.90
	Sarpe with cinch	12	1.24			1.05	-0.20	2.56
CA	Marpe	12	0.78	**0.002**	B	0.53	-0.02	1.93
	Sarpe no cinch	12	0.32		AB	0.34	-0.06	1.00
	Sarpe with cinch	12	-0.10		A	0.73	-1.05	1.40

4 CONSIDERAÇÕES FINAIS

Conclui-se que o sucesso na abertura da sutura palatina mediana com MARPE em pacientes com maturação óssea avançada está relacionado com a idade do paciente e à espessura óssea palatina nas regiões de 12 a 16 mm atrás do forame incisivo. Dessa maneira, quanto mais velho for o paciente, menores as taxas de sucesso e quanto maior a espessura óssea nas regiões de 12 a 16 mm atrás do forame incisivo maiores as taxas de sucesso. A densidade óssea da sutura palatina mediana não mostrou ser um fator relevante quanto ao sucesso deste procedimento.

Quando comparado com a expansão maxilar assistida cirurgicamente (SARPE), o MARPE apresentou maiores mudanças nasomaxilares, principalmente na região posterior (molar) da cavidade nasal, tornando-se, desta forma, um procedimento indicado para o tratamento da atresia maxilar em adultos como alternativa ao tratamento cirúrgico.

Tanto a técnica MARPE quanto SARPE com e sem sutura de base alar podem promover o aumento da largura do tecido mole nasal após a expansão, não havendo diferenças significativas entre os grupos na quantidade desse aumento.

REFERÊNCIAS*

1. Haas AJ. The treatment of maxillary deficiency by opening the midpalatal suture. Angle Orthod. 1965; 35: 200-17.

2. Bishara SE, Staley RN. Maxillary expansion: clinical implications. Am J Orthod Dentofac Orthop. 1987; 91(1): 3-14.

3. Angell EH. Treatment of irregularity of the permanent or adult teeth. Part I. Dent Cosmos. 1860; 1(10): 540-4

4. McNamaraa JA. Maxillary transverse deficiency. Am J Orthod Dentofac Orthop. 2000; 117(5): 567–70.

5. Handelman C. Palatal expansion in adults: the nonsurgical approach. Am J Orthod Dentofac Orthop. 2011; 140(4): 462–8.

6. Garib DG, Henriques JFC, Janson G, de Freitas MR, Fernandes AY. Periodontal effects of rapid maxillary expansion with tooth-tissue-borne and tooth-borne expanders: A computed tomography evaluation. Am J Orthod Dentofac Orthop. 2006; 129(6): 749–58.

7. Garrett BJ, Caruso JM, Rungcharassaeng K, Farrage JR, Kim JS, Taylor GD. Skeletal effects to the maxilla after rapid maxillary expansion assessed with cone-beam computed tomography. Am J Orthod Dentofac Orthop. 2008; 134(1): 8.e1-8.e11.

8. Cureton SL, Cuenin M. Surgically assisted rapid palatal expansion: orthodontic preparation for clinical success. Am J Orthod Dentofac Orthop. 1999; 116(1): 46–59.

9. Choi S-H, Shi K-K, Cha J-Y, Park Y-C, Lee K-J. Nonsurgical miniscrew-assisted rapid maxillary expansion results in acceptable stability in young adults. Angle Orthod. 2016; 86(5): 713–20.

10. Lee K-J, Park Y-C, Park J-Y, Hwang W-S. Miniscrew-assisted nonsurgical palatal expansion before orthognathic surgery for a patient with severe mandibular prognathism. Am J Orthod Dentofac Orthop. 2010; 137(6): 830–9.

11. Lim H-M, Park Y-C, Lee K-J, Kim K-H, Choi YJ. Stability of dental, alveolar, and skeletal changes after miniscrew-assisted rapid palatal expansion. Korean J. Orthod. 2017; 47(5): 313–22.

12. Baccetti T, Franchi L, McNamara JA. An improved version of the cervical vertebral maturation (CVM) method for the assessment of mandibular growth. Angle Orthod. 2002; 72(4): 316-23.

13. Cevidanes L, Oliveira AEF, Motta A, Phillips C, Burke B, Tyndall D. Head Orientation in CBCT-generated Cephalograms. Angle Orthod. 2009; 79(5): 971–7.

* De acordo com o Guia de Trabalhos Acadêmicos da FOAr, adaptado das Normas Vancouver. Disponível no site da Biblioteca: http://www.foar.unesp.br/Home/Biblioteca/guia-de-normalizacao-atualizado.pdf

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

ANEXO A - CERTIFICADO DO COMITÊ DE ÉTICA

UNESP - FACULDADE DE ODONTOLOGIA - CAMPUS ARARAQUARA

PARECER CONSUBSTANCIADO DO CEP

DADOS DO PROJETO DE PESQUISA

Título da Pesquisa: Avaliação tomográfica da expansão rápida da maxila assistida cirurgicamente (ERMAC) e por mini-implantes (ERMAMI) em indivíduos com maturação óssea avançada.

Pesquisador: Ary dos Santos Pinto

Área Temática:

Versão: 1

CAAE: 12643419.1.0000.5416

Instituição Proponente: Faculdade de Odontologia de Araraquara - UNESP

Patrocinador Principal: Financiamento Próprio

DADOS DO PARECER

Número do Parecer: 3.331.766

Apresentação do Projeto:

O projeto foi bem descrito e esclarece que a expansão rápida da maxila (ERM) é um método utilizado para tratar a constrição da maxila, mordida cruzada posterior, discrepâncias no comprimento do arco em pacientes em crescimento. Contudo, a idade é um fator muito importante na ERM e em adultos, devido à maturação das suturas palatina mediana e resistência do pilar zigomático, a resposta à expansão palatal com ERM é menos bem sucedida. A ERM assistida cirurgicamente (ERMAC) tem sido frequentemente utilizada para superar estas limitações. No entanto, os pacientes tendem a relutar em submeter-se a múltiplos procedimentos cirúrgicos e a demanda para o tratamento não cirúrgico tem aumentado. Assim, a técnica de expansão rápida da maxila assistida por mini-implantes (ERMAMI) tem sido utilizada como abordagem clinicamente eficaz e estável para a correção não cirúrgica da discrepância transversal em pacientes adultos. Até o momento nenhum estudo na literatura comparou as diferenças do efeito das duas técnicas para correção da deficiência transversal de maxila. Então, o presente projeto tem como objetivo utilizar tomografias computadorizadas de feixe cônico (TCFC) para comparar as alterações dentárias, esqueléticas maxilares e de tecido mole nasal em pacientes que foram tratados com ERMAMI e com ERMAC por meio de duas abordagens cirúrgicas diferentes.

Objetivo da Pesquisa:

Avaliar, por meio de tomografias computadorizadas, as alterações dentárias, esqueléticas, de tecido mole nasal e nas vias aéreas superiores produzidas pela expansão rápida da maxila assistida por mini-implantes ortodônticos (ERMAMI) realizada em pacientes que já atingiram a maturidade óssea e compará-los aos efeitos encontrados com a expansão rápida da maxila assistida cirurgicamente (ERMAC).

Avaliação dos Riscos e Benefícios:
Riscos:
Não há risco de ocorrência de dano uma vez que todos pacientes incluídos na amostra já finalizaram seu tratamento. Os riscos previstos para a pesquisa são mínimos, uma vez que serão usados os exames tomográficos necessários para o planejamento e avaliação do tratamento já finalizado (estudo retrospectivo).Para minimizar os riscos de constrangimento pelo acesso aos dados do prontuário clínico, o pesquisador responsável garantirá o sigilo das informações confidenciais, zelando pela privacidade do paciente de forma que sua identidade não será revelada de forma
alguma quando a pesquisa for exposta em congressos ou em publicações científicas.

Benefícios:
Baseado nos resultados deste estudo, ao realizar o planejamento, diagnóstico e tratamento das atresias maxilares será possível identificar quais variáveis esqueléticas e dentárias que podem influenciar a expansão rápida maxilar . Os resultados poderão indicar quais mudanças esperadas nos tecidos moles nasal e vias aéreas superiores em indivíduos com maturidade esquelética avançada e em função da técnica adotada (utilizando miniimplantes ou cirurgicamente assistida), e a correlação dos resultados com a taxa de densidade da sutura palatina.

Comentários e Considerações sobre a Pesquisa:
O projeto trará contribuição para a área ao qual se aplica.

Considerações sobre os Termos de apresentação obrigatória:
Todos os termos foram apresentados.

Conclusões ou Pendências e Lista de Inadequações:
Não existem pendências.

Considerações Finais a critério do CEP:
Protocolo APROVADO em reunião de 17 de Maio de 2019.
O pesquisador deverá encaminhar relatórios parciais a cada 01 (um) ano até o prazo final da pesquisa, quando deverá encaminhar o relatório final.

UNESP - FACULDADE DE ODONTOLOGIA - CAMPUS ARARAQUARA

Continuação do Parecer: 3.331.766

Este parecer foi elaborado baseado nos documentos abaixo relacionados:

Tipo Documento	Arquivo	Postagem	Autor	Situação
Informações Básicas do Projeto	PB_INFORMAÇÕES_BÁSICAS_DO_PROJETO_1337414.pdf	23/04/2019 15:31:49		Aceito
Outros	autorizacao_2.pdf	23/04/2019 15:31:00	Ary dos Santos Pinto	Aceito
Projeto Detalhado / Brochura Investigador	projeto_.pdf	23/04/2019 14:44:03	Adriana Souza de Jesus	Aceito
Outros	uso_dolphin.pdf	23/04/2019 14:31:43	Adriana Souza de Jesus	Aceito
Outros	autorizacao_1.pdf	23/04/2019 14:30:47	Adriana Souza de Jesus	Aceito
Declaração de Pesquisadores	Termo_cumprimento_das_normas.pdf	23/04/2019 14:29:52	Adriana Souza de Jesus	Aceito
TCLE / Termos de Assentimento / Justificativa de Ausência	Dispensa_TCLE.pdf	23/04/2019 14:28:18	Adriana Souza de Jesus	Aceito
Orçamento	orcamento_financeiro.pdf	23/04/2019 14:27:35	Adriana Souza de Jesus	Aceito
Cronograma	Cronograma.pdf	23/04/2019 14:27:00	Adriana Souza de Jesus	Aceito
Folha de Rosto	folha_de_rosto.pdf	23/04/2019 14:26:30	Adriana Souza de Jesus	Aceito

Situação do Parecer:
Aprovado

Necessita Apreciação da CONEP:
Não

ARARAQUARA, 17 de Maio de 2019

Assinado por:
Andréa Gonçalves
(Coordenador(a))

Endereço: HUMAITA 1680
Bairro: CENTRO **CEP:** 14.801-903
UF: SP **Município:** ARARAQUARA
Telefone: (16)3301-6459 **E-mail:** cep@foar.unesp.br

Não autorizo a publicação deste trabalho pelo prazo de 2 anos após a data de defesa

Araraquara, 18 de fevereiro de 2020.

Adriana Souza de Jesus