UNIVERSIDADE DE SÃO PAULO
FACULDADE DE ODONTOLOGIA DE BAURU

ELOÁ CRISTINA PASSUCCI AMBROSIO

Use of 3D stereophotogrammetry for volumetric analyses and image superimposition of dental arches before and after surgery of individuals with unilateral and bilateral cleft lip and palate

Uso da Esterefotogrametria 3D para análises volumétricas e sobreposição de imagens dos arcos dentários pré e pós–cirurgias de pacientes com fissura labiopalatina unilateral e bilateral

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Tese constituída por artigos apresentada à Faculdade de Odontologia de Bauru da Universidade de São Paulo para obtenção do título de Doutor em Ciências no Programa de Ciências Odontológicas Aplicadas, na área de concentração Odontopediatria.

Orientadora: Profa. Dra. Thais Marchini de Oliveira Valarelli

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ERRATA

FOLHA DE APROVAÇÃO

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Dedico este trabalho aos meus avôs Nelson (*in memorian*) e Dino (*in memorian*). O primeiro não tive a oportunidade de conhecer nem abraçar, pois foi embora antes do meu nascimento, mas para mim sempre é a estrela mais brilhante na imensidão azul do céu que ilumina as minhas noites. Enquanto o Dino tive o prazer de conviver até 2018, com a sua personalidade peculiar e seu olhar carinhoso sempre teve minha admiração e respeito.

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niente”.

“Fa tutto con il cuore... oppure non fare niente”.

Provérbio italiano

ABSTRACT

Use of 3D stereophotogrammetry for volumetric analyses and image superimposition of dental arches before and after surgery of individuals with unilateral and bilateral cleft lip and palate

This thesis aimed to present four scientific articles. Article 1: to use new three–dimensional (3D) anthropometric analyses to verify the post–surgical effects on the maxillary segments of children with unilateral cleft lip and palate. The sample was composed by 150 digitized dental models with unilateral complete cleft lip (UCL) and unilateral cleft lip and palate (UCLP). The impressions were taken before cheiloplasty (T1), after cheiloplasty (T2), and after palatoplasty (T3). Linear measures (I–C; I–C'; I–T; I–T') were analysed. The intergroup analysis showed that the measures I–C' and I–T' demonstrated a reduction of the dental arches growth of UCLP group. The new 3D anthropometric analysis showed that the development of the maxillary segments changed after cheiloplasty. Article 2: to evaluate the volumetric, linear, palatal surface area, and the dental arch superimposition of participants with bilateral complete cleft lip (BCL) and bilateral cleft lip and palate (BCLP) surgically treated. The sample was composed by 136 digitized dental models evaluated before cheiloplasty (T1), after cheiloplasty (T2), and after palatoplasty (T3). Volume, superimposition, area and linear (I–C; I–C'; C–C'; I–T; I–T'; T–T') measurements were evaluated. The intergroup analysis revealed that C–C′, T–T′, I–C′, and I–C were significantly smaller in BCLP group, whereas the volume, superimposition, and area were statistically similar between participants. The comparison between bilateral orofacial clefts showed reduction in the transversal and anteroposterior linear measurements, but not in the area, volume and superimposition. Article 3: to analyse whether the novel method of 3D–3D superimposition can quantify the specific characteristics of the dental arches before and after cheiloplasty in children with cleft lip and palate. The stereophotogrammetry system software analysed the 3D–3D superimpositions in two groups of matches (same participant) and one group of mismatches (different participant). The differences were evaluated by Root Mean Square (RMS). RMS was significantly greater in mismatches than in matches groups. 3D–3D superimposition can quantify the individual characteristics of the dental arches of children with unilateral cleft lip and palate submitted to cheiloplasty. Article 4: to evaluate the effects of treatment protocols on the dental arches of children with cleft lip and palate treated

with or without pre– and post–surgical orthopedics (PSO). The sample comprised 96 digitized dental models divided into: Group 1 (G1) – children treated by Hotz plate; Group 2 (G2) – children treated with nasoalveolar molding (NAM); and Group 3 (G3) – children treated without PSO. The evaluated treatment times were: T1 – pre–surgical time and T2 – post–operative time. The following measurements were obtained: intercanine, intertuberosity, anterior and total intrasegment, anterior and total intersegment; cleft (C Area) and segments area (S Area); and angular measurements: anterior greater segment (∠GCT); posterior greater segment; and posterior smaller segment with the use of software. Intergroup analysis showed that G3 had a smaller percentage growth for S Area, C Area, and ∠GCT than children treated with PSO. Pre– and post–surgical orthopedics reduced the residual effects produced by the healing tension of the lip on the dental arch.

Keywords: Cleft lip. Cleft palate. Dental arch. Imaging, Three–dimensional. Anthropometry.

RESUMO

Uso da Esterefotogrametria 3D para análises volumétricas e sobreposição de imagens dos arcos dentários pré e pós–cirurgias de pacientes com fissura labiopalatina unilateral e bilateral

Esta tese teve o propósito de apresentar 4 artigos científicos. Artigo 1: utilizar novas análises antropométricas tridimensionais (3D) para avaliar os efeitos pós–cirúrgicos nos segmentos palatinos de crianças com fissura labiopalatina. Compôs–se a amostra com 150 modelos dentários digitalizados com fissuras unilaterais, completa de lábio (FUCL) e lábio e palato (FULP). As moldagens foram efetuadas, antes da queiloplastia (T1), após a queiloplastia (T2) e após a palatoplastia (T3). Analisou–se medidas lineares (I–C; I–C'; I–T; I–T'). Na análise intergrupo, as medidas I–C' e I–T' demonstraram uma redução significativa no grupo FULP. Assim, a nova análise 3D indicou mudança no desenvolvimento do palato após a queiloplastia. Artigo 2: avaliar volume, medidas lineares, área e sobreposição palatina em participantes com fissuras bilaterais, completa de lábio (FBCL) e lábio e palato (FBLP) tratados cirurgicamente. Compôs–se a amostra com 136 modelos dentários digitalizados avaliados antes da queiloplastia (T1), após a queiloplastia (T2) e após a palatoplastia (T3). Volume, sobreposição, área e medidas lineares foram quantificadas (I–C; I–C'; C–C'; I–T; I–T'; T–T'). Na análise intergrupos, as medidas C–C′, T–T′, I–C′ e I–C foram significativamente menores no grupo FBLP, enquanto o volume, a sobreposição e a área foram semelhantes entre os participantes. Assim, a comparação entre os grupos verificou–se redução das medidas lineares transversais e ântero–posteriores, mas não da área, volume e sobreposição. Artigo 3: analisar se o método, sobreposição 3D–3D, é capaz de quantificar as características específicas dos arcos dentários antes e após a queiloplastia em crianças com fissura unilateral labiopalatina. A sobreposição 3D–3D foi avaliada pelo software do sistema de estereofotogramtetria em três grupos, em que dois deles a análise foi efetuada em um mesmo participante, e o terceiro, a sobreposição foi realizada entre participantes diferentes. As diferenças foram avaliadas pelo Root Mean Square (RMS). RMS foi significativamente maior no grupo em que a sobreposição foi realizada entre pessoas diferentes. Conclui–se que, a sobreposição 3D–3D contribuiu na quantificação das características individuais dos arcos dentários de crianças com fissura unilateral labiopalatina submetidas a queiloplastia. Artigo 4: avaliar os efeitos dos protocolos de tratamento nos arcos dentários de crianças com fissura labiopalatina tratadas ou não com Ortopedia pré e

pós–cirúrgica (OPC). Amostra foi composta por 96 modelos dentários digitalizados divididos em Grupo 1 (G1) participantes tratados com placa de Hotz, Grupo 2 (G2) participantes tratados com placa de moldagem nasoalveolar e Grupo 3 (G3) sem OPC. Foram avaliados em Tempo 1 (T1), pré–operatório e Tempo 2 (T2) pós–operatório. Por meio de um software quantificou–se medidas lineares (intercanino, intertuberosidade, intrasegmento anterior e total, intersegmento anterior e total), áreas da fissura (Área F) e dos segmentos (Área S), além de medidas angulares, anterior do segmento maior (∠GCT) e posteriores dos segmentos maior e menor. Na análise intergrupo, G3 apresentou os menores percentuais dos parâmetros Área S, Área F e ∠GCT em comparação aos participantes tratados com OPC. Conclui–se que, a Ortopedia pré e pós–cirúrgica reduziu os efeitos residuais decorrentes da tensão cicatricial do lábio sobre o arco dentário.

Palavras–chave: Fenda Labial. Fissura Palatina. Arco Dental. Imageamento Tridimensional. Antropometria.

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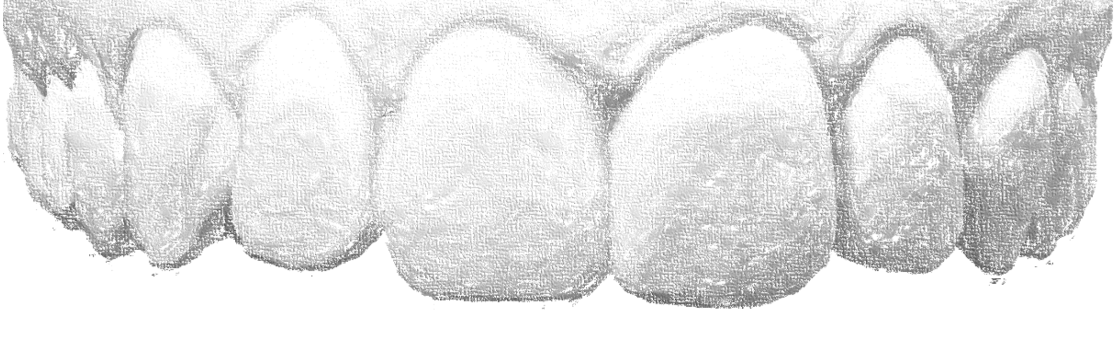
1 *Introduction*



1 INTRODUCTION

The craniofacial growth of individuals with orofacial cleft has been extensively studied due to its congenital nature affecting anatomy, function, and esthetics. Individuals with cleft lip and palate frequently have hypoplasic maxillary development caused by either the intrinsic tissue deficiency or iatrogenic factors (Park et al., 2015). Commonly, the anthropometric studies aimed to quantify the palate development at pre– and post–surgical periods (Carrara et al., 2016; Sakoda et al., 2017; Ambrosio et al., 2018a).

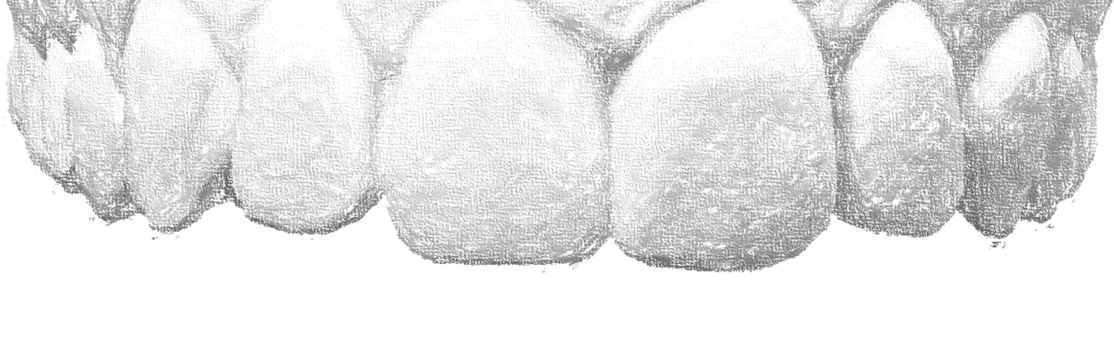
At the important periods of the rehabilitative protocols, the anthropometric analyses of the maxilla can be performed by means of image examinations as lateral radiograph and computed tomography (Saperstein et al., 2012; Kuijpers et al., 2014; Antonarakis et al., 2016). However, not all anatomic points can be determined on radiographs due to the dysmorphic anatomy of the cleft (Bishara et al., 1976). Another fact is to assure the safe of diagnosis protocols not employing ionizing radiation, mainly considering that the rehabilitative protocol of individuals with cleft palate takes place in the first years of life and continues up to the skeletal maturity (Kuijpers et al., 2014).

Alternative tools have been used and recommended to analyse the anthropometry of the maxilla in individuals with craniofacial anomalies, such as the three–dimensional (3D) scanner and stereophotogrammetry system (Sforza et al., 2012; Carrara et al., 2016; De Menezes et al., 2016; Jorge et al., 2016; Sakoda et al., 2017; Ambrosio et al., 2018a). This equipment can be frequently used as method for digitized image acquisition of the anatomy, thus enabling comprehensive longitudinal follow–up.

The possibility of early following–up of changes in dental arches allows that the multidisciplinary team involved in the rehabilitative process evaluate the cases individually, attempting to overcome the challenges (Mello et al., 2013) with the aid of different accurate software (Sforza et al., 2012; Pucciarelli et al., 2015; De Menezes et al., 2016). It is mandatory that the professionals involved in the rehabilitative treatment of individuals with cleft lip and palate know about the dimensional changes of dental arches because such alterations influence on treatment outcomes (Freitas et al., 2012).

The literature lacks studies on the comparison of the longitudinal anthropometry of children with unilateral and bilateral cleft lip and palate (Lo et al., 2003; Mello et al., 2013; Fernandes et al., 2015). Therefore, this study was aim to evaluate the dental arch dimensions to provide information on the aspects relate to the lack of maxillary growth due to the rehabilitative process in children with cleft lip and palate.

2 *Articles*



2 ARTICLES

2.1 ARTICLE 1

Post–surgical effects on the maxillary segments of children with oral clefts: New three–dimensional anthropometric analysis. Ambrosio ECP, Sforza C, De Menezes M, Carrara CFC, Machado MAAM, Oliveira TM. J Craniomaxillofac Surg. 2018 Sep;46(9):1511–1514.

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Post-surgical effects on the maxillary segments of children with oral clefts: New three-dimensional anthropometric analysis

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A B S T R A C T

This study aimed to use new three-dimensional (3D) anthropometric analyses to verify the post-surgical effects on the maxillary segments of children with unilateral cleft lip and palate. The sample was composed by digitized dental models of 60 children with unilateral complete cleft lip and alveolus (UCLA) and complete unilateral cleft lip and palate (UCLP). The impressions were taken before cheiloplasty (T1), after cheiloplasty (T2), and after palatoplasty (T3). The 3D anthropometric analyses of digitized dental casts were obtained through a specific software. Intragroup changes were applied paired *t* test and Wilcoxon test (UCLA group) and for the UCLP group, repeated-measures analyses of variance followed by the Tukey test. For intergroup analyses, an independent *t* test and Mann–Whitney test were used. The palatal dimensional changes of UCLA group showed that the distances I–C, I–T′, and I–T significantly increased after cheiloplasty ($p = 0.0002$, $p = 0.0007$ and $p < 0.0001$, respectively). In the UCLP group, the I–C′ distance statistically decreased in the post-surgical periods ($p < 0.0001$), while the I–T distance increased ($p < 0.0001$). The I–C distance increased after cheiloplasty ($p < 0.0001$). The I–T′ distance increased between T2 and T3 with statistically significant differences ($p = 0.0037$). The intergroup analysis of palatal development (T2-T1) showed that the distances I–C′ and I–T′ demonstrated a reduction of the dental arches growth of UCLP group compared with the UCLA group, with statistically significant differences. The new 3D anthropometric analysis showed that the development of the maxillary segments changed after surgical repair. The UCLP group demonstrated a reduction of the dental arches growth compared with the UCLA group.

1. Introduction

In dentistry, researchers use digital anthropometry to analyze the dental arch development of children with cleft lip and palate (CLP) undergoing reparative plastic surgeries such as cheiloplasty and palatoplasty (Sakoda et al., 2017; Falzoni et al., 2016; Jorge et al., 2016). These surgical procedures are indispensable methods for the anatomic and functional rehabilitation performed usually at 3 months (cheiloplasty) and 12 months (palatoplasty) of life (Freitas et al., 2012).

Surgery improves the physiological and psychological aspects of these children; however, the maxilla development is influenced not only by the characteristics of the congenital defects (Chiu et al., 2011; Zhang et al., 2015), but also by the surgical procedures carried out in early childhood (Falzoni et al., 2016; Shi & Losee, 2015; Zhang et al., 2015). The evidence of changed maxillary growth could be analyzed through dental casts with the benefit of performing a longitudinal following-up of the rehabilitative protocol (Fernandes et al., 2015) without exposure to ionizing radiation.

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2.2 ARTICLE 2

Prospective cohort 3D study of dental arches in children with bilateral orofacial cleft: Assessment of volume and superimposition. Ambrosio ECP, Sforza C, de Menezes M, Carrara CFC, Soares S, Machado MAAM, Oliveira TM. Int J Paediatr Dent. 2020 Sep 24.

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ORIGINAL ARTICLE

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Prospective cohort 3D study of dental arches in children with bilateral orofacial cleft: Assessment of volume and superimposition

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Abstract

Background: Cohort studies have evaluated dental arches of children.

Aim: To evaluate the volumetric, linear, palatal surface area, and the dental arch superimposition of participants with bilateral complete cleft lip (BCL) and bilateral cleft lip and palate (BCLP) surgically treated in a specialized hospital.

Design: One hundred and thirty six digitized dental models evaluated before cheiloplasty (T1), after cheiloplasty (T2), and after palatoplasty (T3). The stereophotogrammetry software analysed the volume, palate superimposition, linear, and area measurements.

Results: In BCL group, at T2, C–C′, T–T′, area, and volume significantly increased ($P = .000$, $P < .000$, $P = .010$ e $P = .003$, respectively). In BCLP group, the comparison T3 × T1 showed that C–C′ decreased, whereas T–T′ and the area increased ($P < .000$, $P < .000$, $P = .000$). The volume increased at T2, but decreased at T3 ($P < .000$) in participants with BCLP. The intergroup analysis revealed that C–C′, T–T′, I–C′, and I–C were significantly smaller in participants with BCLP ($P < .000$, $P = .016$, $P = .001$ e $P = .020$, respectively), whereas the volume, superimposition, and area were statistically similar between groups ($P > .05$).

Conclusion: The comparison between bilateral orofacial clefts showed reduction in the transversal and anteroposterior linear measurements, but not in the area and volume, which was confirmed by the superimposition of the dental arches.

KEYWORDS
growth and development, oral medicine/oral surgery, syndromes head and neck/cleft lip and palate

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Both articles 3 and 4 were written according to the submission guidelines of the corresponding journals.

2.3 ARTICLE 3

A novel innovative method to assess maxillary arch morphology in oral cleft infants: 3D–3D superimposition technique. *Brazilian Dental Journal*.

Abstract

The dental arches, fingerprints, and DNA have specific individual characteristics of each person. The biological (evolution and anatomic variations) and forensic (human identification) anthropologic analyses can use both of them. This study analysed whether the novel method of 3D–3D superimposition can quantify the specific characteristics of the dental arches before and after cheiloplasty in children with unilateral cleft lip and palate. Children with unilateral complete cleft lip (UCL) and unilateral cleft lip and palate (UCLP) participated in the study. The impressions of the dental arches were executed 1 day before and 1 year after cheiloplasty. A 3D laser scanner digitized the dental models and the stereophotogrammetry system software analysed the 3D–3D superimpositions in two groups of matches (same child, UCL and UCLP) and one group of mismatches (different individuals). The differences were evaluated by Root Mean Square (RMS) and expressed in millimeters (mm). Kruskal–Wallis test followed by post–hoc Dunn test and Mann–Whitney test were assessed to compare the groups (α=5%). RMS was 1.34 mm (± 0.37) in UCL group, 1.41 mm (± 0.32) in UCLP group, and 3.38 mm (± 1.28) in mismatches group. RMS was significantly greater in mismatches than in matches groups ($p<0.0001$). No statistically significant differences occurred between genders. 3D–3D superimposition aided in the quantification of the individual characteristics of the dental arches of children with unilateral cleft lip and palate submitted to cheiloplasty.

Keywords: Dental arch. Cleft lip. Cleft palate. Imaging three–dimensional. Innovation.

Introduction

Both biological (evolution and anatomic variations) and forensic (human identification) anthropologic analyses of the dental arches are commonly performed by two–dimensional (2D) comparisons such as linear and angular parameters, silhouette, and surface (area) measurements. However, currently, devices are capable of scanning and virtually reconstructing the dental arches in three–dimensions (3D), taking the comparative analyses of the anatomic structures to another level (1–8).

3D acquisition and reconstruction of the dental arches can be executed through optical equipment, such as either intraoral or fixe laser scanner. In newborn children with cleft lip and palate, the use of the intraoral scanner is difficult because the intraoral scanner point does not match the size of the mouth of these children; the scanner is unable to capture and process the light source projection in the cleft area; and involuntary or voluntary movements of the child make the scanning of the palate take longer. In these situations, the fixe laser scanner is the equipment of choice.

Thus, nowadays, it is possible to perform comparative analyses by using 3D–3D superimposition through the use of devices capable of capturing and reconstructing the objects in three–dimensions. This has been largely used in forensic area for human identification (8, 9), but little in the human evolutive anthropometry (1). In evolutive anthropometry, 3D–3D superimposition may help to understanding the development of the dental arches with congenital alterations after a given treatment protocol. Notwithstanding, the literature lacks studies on the individuality of clefted dental arches through 3D–3D superimposition, by means of the quantitative and chromatic analysis, at the first year of life. Thus, this study aimed to analyse whether the novel method of 3D–3D superimposition can quantify the specific characteristics of the dental arches before and after cheiloplasty in children with unilateral cleft lip and palate.

Material and Methods

This study was submitted and approved by the Institutional Review Board under protocols number CAAE 77285417.0.3001.5441.

Healthy children with unilateral complete cleft lip (UCL) and unilateral complete cleft lip and palate (UCLP) enrolled in a craniofacial hospital (Hospital for Rehabilitation of Craniofacial Anomalies, University of São Paulo) participated in this study and were divided into two groups of matches (same child, UCL and UCLP) and one group of mismatches (different individuals). Moreover, in every group, the children should be operated by the same plastic surgeon. Children with other congenital alterations, the rehabilitative treatment already initiated, and absent dental models were excluded from the study.

The sample size calculation was performed using a pilot study with Root Mean Square (RMS) standard deviation of 0.30 mm, with level of significance of 5%, test power of 80%, and a minimum clinically detectable difference of 0.28 mm. The minimum sample size of each group was calculated in 19 children.

The participants of the study were divided into three groups: UCL group – all children had unilateral complete cleft lip; UCLP group – all children had unilateral cleft lip and palate; mismatches group – children with unilateral cleft lip and palate. UCL and UCLP groups were denominated “matches groups”, that is, the dental arch superimposition occurred for the same child. In the mismatches group, superimposition occurred between different children.

The impressions of the dental arches were executed before (T1 – presurgical) and after (T2 – postsurgical) cheiloplasty. The impression tray size was previously chosen according to the palatal dimension. To seal the vestibule bottom, wax was added to the tray. All children impressions were made with condensation silicon (Perfil, Vigodent S/A Indústria e Comércio, Rio de Janeiro, Brazil), mixed according to the manufacturer’s instruction.

During the impression procedure, all children should be awakened and sitting on the mother/father’s lap. The pediatric dentist was positioned behind the child’s head. The pediatric dentist left hand was introduced on the child’s mouth and with the aid of thumb the mouth was kept open. With the right hand, the pediatric dentist introduced the tray towards the palate, kept in position for a few seconds until the material’s setting. After that, the tray was removed, the impression quality evaluated regarding the reliable copy of the palate, that is, from the anterior to the retromolar area of the cleft, and correct vestibule depth. In the laboratory, white orthodontic gypsum was casted (Pasom, Gold Star Brasil Ind. e Com., Mairiporã, Brazil). After the gypsum setting, the molds were cut with the aid of standardized templates (6, 7).

All dental casts were digitized through 3D laser scanner (3Shape's R700^{TM} Scanner, Copenhagen K Denmark; Accuracy < 20 microns) connected to a computer. The scanner accuracy was tested by previous study (10). A non–destructive scanning lasts between 60 and 75 seconds. The dental cast was fixed onto a platform inside the device. During the scanning, the platform moved towards three mechanical axes (rotation of 360°, translation and inclination) so that the laser reached all the cast surface. Two cameras captured the reflected laser. The digitized dental model was obtained by the capture of the points of the dental cast surface by software (ScanItOrthodontics™, 3Shape A/S, Copenhagen K, Denmark). These points were automatically organized in triangle, forming a cloud of points. The digitized dental model was saved in Standard Triangle Language format (.STL) (6, 7, 10).

The analyses of the 3D–3D superimposition were performed through stereophotogrammetry system software (Mirror imaging software, Canfield Scientific Inc., Fairfield, NJ, USA) into two phases. The first phase comprised the manual marking of the dental arches at T1 and T2 by contouring the vestibule bottom limited by the cleft and soft palate (11). Then, the automatic spatial alignment was performed between the dental molds to reach a better combination between their surfaces. This phase mathematically superimposes the smallest distance, point–by–point, between the molds. The software calculated the RMS related to the distance between the surfaces. Also, this procedure provided a chromatic map of the changes between the pre– and post–operative scanning. The green color indicates an unchanged area, while the colors blue, yellow, and red are discordant areas. The blue color indicates the positive difference, while the yellow and red colors, negative difference (8, 12, 13) – Figure 1.

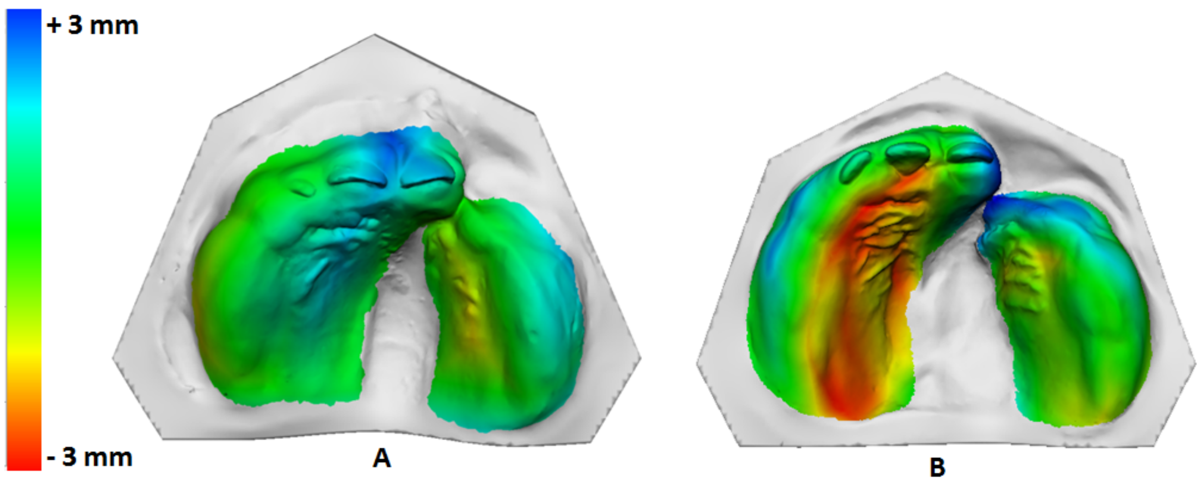

Figure 1 – Chromatic visualization of the superimpositions. A) Example of match. B) Example of mismatch.

The data were analysed by GraphPad Prism software (Prism 5 for Windows – Version 5.0 – GraphPad software., Inc. San Diego, CA, USA). To test the normality, Shapiro–Wilk test was applied. Paired t test and Dahlberg formula evaluated the intraexaminer reliability, which was executed in 20 models, measured again after two weeks (1, 3). Kruskal–Wallis test followed by post–hoc Dunn test was applied to compare three groups independent sample groups, that is, UCL group, UCLP group and mismatches group. Mann–Whitney test was used to assess the differences between genders. The level of significance was α = 5%.

Results

The UCL group was composed by 21 children (10 boys and 11 girls), UCLP by 20 children (14 boys and 6 girls), and in the case of mismatches by 20 children (10 boys and 10 girls). At T1 and T2, children had 0.34 (± 0.07) and 1.28 (± 0.22) years–old, respectively. The intraexaminer reliability showed no statistically significant differences (p=0.874). Dahlberg formula indicated a random error of 0.020.

In UCL group, RMS was 1.34 mm (± 0.37), in UCLP it was 1.41 mm (± 0,32), and in the mismatches group it was 3.38 mm (± 1.28) (Figure 2). There were statistically significant differences between matches x mismatches (Kruskal–Wallis test followed by post–hoc Dunn test, p<0.0001) – Figure 2.

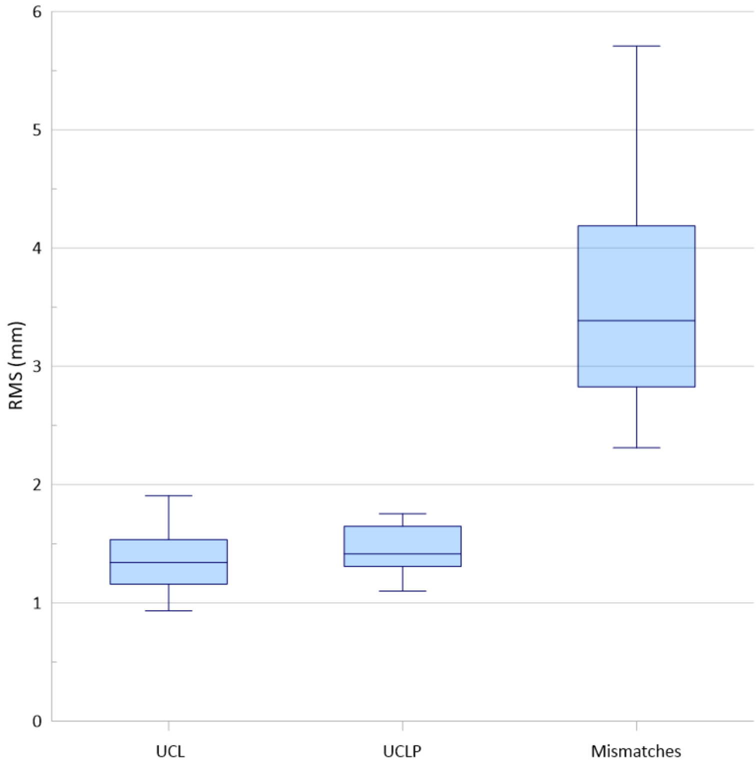

Figure 2 – Box plot of Root Mean Square (RMS) values of groups UCL, UCLP, and Mismatches.

In UCL group, boys had an RMS equal to 1.29 mm (± 0.31) and girls equal to 1.42 mm (± 0.44). In UCLP group, boys exhibited an RMS equal to 1.38 mm (± 0.42) and girls equal to 1.46 mm (± 0.24), while in the mismatches group, boys exhibited RMS equal to 3.41 mm (±1.12) and girls equal to 3.38 mm (± 1.55) (Figure 3). No statistically significant differences occurred between genders for each group (Mann–Whitney test, UCL p=0.860; UCLP p=0.536; mismatches p=0.970) – Figure 3.

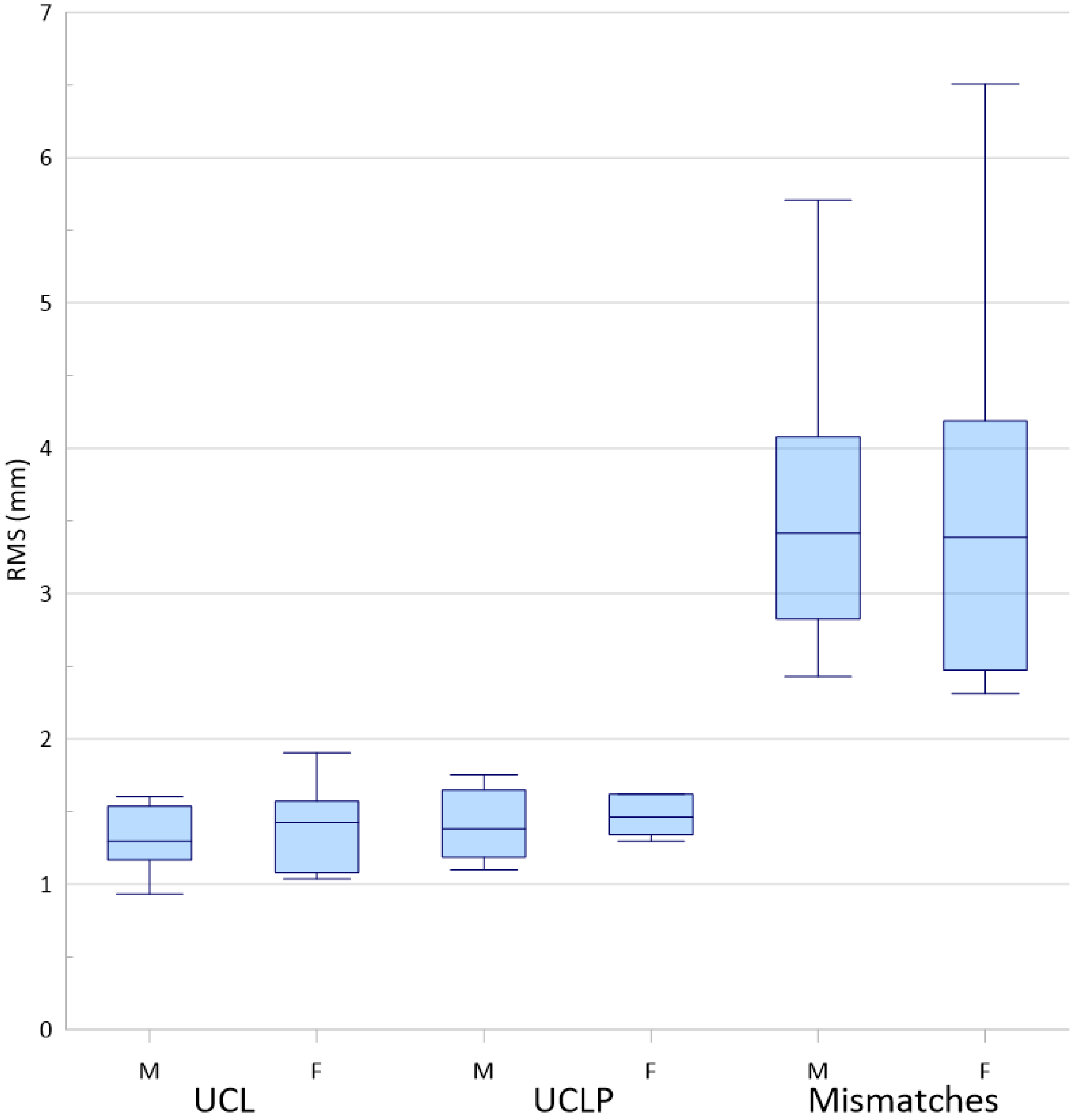

Figure 3 – Box plots of Root Mean Square (RMS) values between genders for each group: UCL, UCLP, and Mismatches (M: male; F: female).

Discussion

Commonly, dental arches of children with craniofacial anomalies are analysed through digitized dental casts by transversal and longitudinal studies. With different purposes, the scientific articles have been applying similar methodologies to quantify linear measurements and palatal surface area (1–7). The analysis of the distance between the digitized palatal surfaces is a novel approach in Pediatric Dentistry for children with oral clefts. Thus, this is the first study to evaluate whether 3D–3D superimposition can analyse anthropometrically the specific characteristics of children with unilateral cleft lip and palate the first years of life, before and after cheiloplasty.

The intergroup comparison revealed a significantly greater RMS value for the group of mismatches than for the groups of matches (UCL and UCLP). The results of this study suggested that the dental arch anatomy had little influence on the morphometric analysis in case of matches. However, further studies are necessary to verify this assumption at other phases of the rehabilitative treatment in the same cleft phenotypes because the 2D analyses of the linear measurements and palatal surface area showed different outcomes (2–4). Visually, the chromatic maps of UCL and UCLP groups indicates a positive growth (blue) as well as unchanged areas (green) of the dental arches in the anterior region of the alveolar edge, possibly related to the bone remodeling due to the eruption of the central incisors. However, in the mismatches group, the chromatic maps showed disagreement on the surfaces by colors blue, yellow, and red.

The intragroup comparison of the genders showed no statistically significant differences ($p<0.05$). The difference of the measurements between boys and girls has been discussed in the literature because studies on children with oral clefts indicate either significant differences (14) or similar results (15). The lack of literature consensus may be related with either the number of participants or the methodology used in the morphometric analysis. Although this present study attempted to assure homogeneous groups concerning to gender, UCLP group had more boys than girls. This would be probably because UCLP affects more males than females, as described in other anthropometric studies (3–5, 11).

In craniofacial anomalies, 3D–3D superimposition is commonly applied to analyse the face regarding the influence of involuntary facial expressions (16), pre– and post–surgical asymmetry (17, 18) and growth (17, 19). Concerning the analysis of the digitized models, some studies analysed the chromatic map of the dental arches of children with oral clefts but not quantitatively described RMS (20–22).

We highlight that the smallest point–to–point distances between the superimposed molds showed negative and positive values and if only the arithmetic mean values are considered, the results would be the mean values of the distances. RMS is a more complete approach because it evaluates the mean square root of the point–to–point distances between the digital casts, that is, all values are positive (23). From that point of view, RMS calculation is an advantage of this present study because it proposes a novel analysis for anthropometric studies of dental arches before and after surgery.

The clinical impact of RMS can be analysed by two perspectives: biological and forensic anthropology of the dental arches. The biological analysis of the RMS showed the three–dimensional growth of the palate of children submitted to cheiloplasty. Generally, the evolutive analyses of the palate have been performed by 2D anthropometry, although the dental arches are anatomic structures with three–dimensions (height, depth, and width). The 2D analyses may not provide the real palate growth. In this context, a positive RMS value greater than zero indicated 3D growth of the dental arches (1). Moreover, the statistical similarity between UCL and UCLP groups exhibited that 3D growth occurred in both groups comparably. According to previous studies, the 2D analyses would show different outcomes (2–4).

In forensic anthropology, RMS quantitative values may contribute for human identification studies. The palatal superimposition of the same child (matches group – UCL and UCLP) revealed the smallest RMS values. The rationale behind this fact is the many coincident anatomic areas of the superimposition even when the scanning occurred at different time periods, but in the same child. On the other hand, the mismatches group showed RMS value 2.5 times greater than the other groups, because the anatomic discrepancy between different children. Although the superimposition of these individuals occurred using the same criteria (gender and cleft side), it is clear that each individual has intrinsic characteristics. Thus, the statistically significant differences among UCL group, UCLP group, and mismatches group indicated that RMS is a parameter that would help in forensic analyses for “ante mortem” and “post mortem” recognition of people (8, 9, 12, 13).

The limitations of this present study include the absence of groups underwent active or passive pre–cheiloplasty orthopedics and pre– and post–palatoplasty comparisons. Thus, further studies are necessary considering other cleft types before and after bone graft surgery and the phases before and after orthodontic treatment. The aim is always to obtain data to understand about the specificity of the anatomic features of individuals with oral clefts and thus delineate better rehabilitative protocols.

3D–3D superimposition can quantify the individual characteristics of the dental arches of children with unilateral cleft lip and palate submitted to cheiloplasty.

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2.4 ARTICLE 4

Effects of pre– and post–surgical orthopedics on dental arches of children with cleft lip and palate: comparison between protocols at the first year of life. *International Journal of Oral and Maxillofacial Surgery.*

Abstract

This study aimed to evaluate the effects of treatment protocols on the dental arches of children with cleft lip and palate treated with or without pre– and post–surgical orthopedics (PSO). The sample comprised 96 digitized dental models divided into: Group 1 (G1) – children treated by Hotz plate; Group 2 (G2) – children treated with nasoalveolar molding (NAM); and Group 3 (G3) – children treated without PSO. The evaluated treatment times were: T1 – pre–surgical time (104 days after birth) and T2 – post–operative time (359 days after birth). With the aid of software, the following measurements were obtained: intercanine and intertuberosity distances, anterior and total intrasegment, anterior and total intersegment lengths; the cleft area (C Area) and the area of the segments (S Area); and angular measurements: anterior greater segment (∠GCT); posterior greater segment (∠CTT'); and posterior smaller segment (∠C'T'T). Paired t test, ANOVA/Tukey test, and Pearson correlation coefficient were used for comparison ($\alpha=5\%$). Intergroup analysis of the growth changes showed that G3 had a smaller percentage growth for S Area ($p=.013$), C Area ($p=.012$), and ∠GCT ($p=.002$) than children treated with PSO. The analysis of palatal symmetry revealed that G3 exhibited the worst asymmetry of the dental arches at T2 ($p<.001$). Pre– and post–surgical orthopedics reduced the residual effects produced by the healing tension of the lip on the dental arch, mainly in the anterior area of the palate.

Keywords: Cleft Lip. Cleft palate. Orthopedics. Surgery, Plastic. Imaging, Three–Dimensional.

Introduction

Notwithstandig the variety of investigations cleft lip and palate treatment protocols have been studied and updated worldwide to significantly improve the quality of life of the patients (Kongprasert et al., 2019; Carrara et al., 2016). Not only the literature lacks consensus on the surgical techniques and the period to execute the primary plastic surgeries of the lip (cheiloplasty) and palate (palatoplasty), but also there are protocols that include only surgical treatments in the first year of life (Ambrosio et al., 2020; Mello et al., 2019; Ambrosio et al., 2018a; Ambrosio et al., 2018b; Carrara et al., 2016) or others using Pre–surgical Orthopedics (PSO) with intra/extraoral appliances before cheiloplasty (Galassi et al., 2021; Shety et al., 2017; Cerón–Zapata et al., 2016; Jorge et al., 2016).

Because of the lack of a unique treatment protocol among the rehabilitative centers, the lack of consensus in the literature, and the constant searching for a better quality of life for the patients, this study aimed to evaluate the effects of the treatment protocols on the dental arches of children with unilateral cleft lip and palate treated with or without pre– and post–surgical orthopedics at the first year of life.

Material and methods

This study was submitted and approved by the Institutional Review Board.

Inclusion criteria were children with unilateral cleft lip and palate enrolled in the Fundaciòn Clínica Noel – FCN – (Colombia) and in the Hospital for Rehabilitation of Craniofacial Anomalies– HRAC/USP – (Brazil), submitted to cheiloplasty at 3 months of life by Millard's technique. Children with other anomalies, systemic impairment, and defective dental models were excluded from the sample.

Sample size considered a standard deviation of 2.28 mm in the intertuberosity distance, α=5%, test power of 80%, and the minimum detected clinical difference of 2.5 mm (Jorge et al., 2016). The minimum size of each sample group was of 14 children.

The children were divided into three groups according to the treatment protocols:

- Group 1 (G1) – children treated by PSO with Hotz plate in Colombia (FCN), monthly evaluated; Group 2 (G2), children treated by PSO with nasoalveolar molding plate (PNAM) in Colombia (FCN), evaluated at every week. Both G1 and G2 started PSO treatment at the first month of life until cheiloplasty (3 months). After cheiloplasty, both G1 and G2 worn Hotz plate, changing it at every two months (Cerón–Zapata et al., 2016).

- Group 3 (G3) – children treated without PSO, undergone cheiloplasty in Brazil (HRAC/USP) (Freitas et al., 2012).

All groups had digitized dental molds evaluated at the following study times: T1 – before cheiloplasty (3 months) and T2 after cheiloplasty 12 months.

The dental cast molds were digitized through stereophotogrammetry (Canfield Scientific, Inc., Fairfield, NJ) and analysed by software (Mirror imaging software, Canfield Scientific Inc., Fairfield, NJ, USA). Reproducibility and accuracy of the stereophotogrammetry system were checked both in the image acquisition and measurement evaluation and agreed with previous studies (Sforza et al., 2012; De Menezes et al., 2016; Gibelli et al., 2018).

The anatomic points were manually marked on the digitized models with the aid of the software, according to the previous studies (Jaklová et al., 2021; Ambrosio et al., 2020; Ambrosio et al., 2018a; Ambrosio et al., 2018b; Park et al., 2017; Carrara et al., 2016). The following measurements were evaluated: intercanine distance (C–C'), intertuberosity distance (T–T'), anterior intrasegment length (I–C), anterior intersegment length (I–C'), total intrasegment length (I–T), and total intersegment length (I–T'). All linear measurements were quantified in millimeters (mm). These angular parameters were measured: posterior angle of the greater (∠CTT') and smaller palatal segments (∠C'T'T), and anterior angle of the greater palatal segment (∠GCT). All angular measurements were quantified in degrees (°) (Figure 1A).

The area of the palatal surface was measured, as follows: cleft area (C Area) and area of the smaller (S1 Area) and greater palatal segments (S2 Area). To make comparisons easy, S Area was the sum of the areas of both segments (S1 Area + S2 Area). All measurements of the areas were quantified in squared millimeters (mm^2) (Figure 1B).

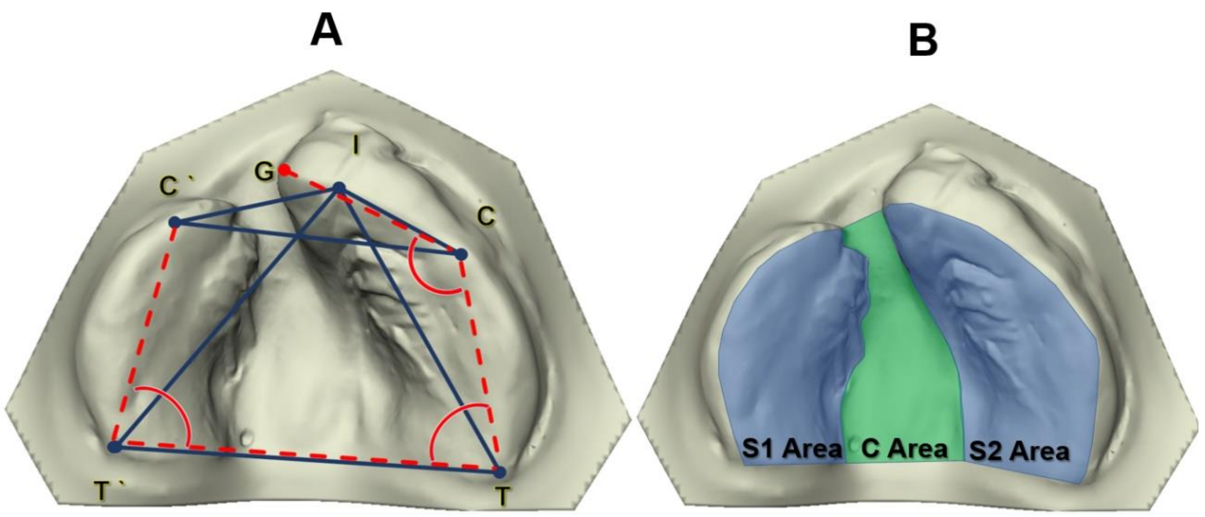

Figure 1 – Anatomic points and parameters analysed on the palate. A) Linear measurements; Intercanine distance (C–C'): transversal line between the eruption points of the primary canine; Intertuberosity distance (T–T'): transversal line between the left and right tuberosity; anterior intrasegment length (I–C): line from the interincisive point to the eruption point of the canine in the greater palatal segment; anterior intersegment length (I–C'): line from the interincisive point to the eruption point of the canine in the smaller palatal segment; total intrasegment length (I–T): line between the interincisive point and the tuberosity in the greater palatal segment; and total intersegment length (I–T'): line between the interincisive point and the tuberosity in the smaller palatal segment. Angular measurements: posterior of greater palatal segment (∠CTT'): angle between the eruption point of the canine and the tuberosity in the greater and smaller palatal segments, with the intersection point in the greater palatal segment; posterior of the smaller palatal segment (∠C'T'T): angle between the eruption point of the canine and the tuberosity in the greater and smaller palatal segments, with the intersection point in the smaller palatal segment; anterior of greater palatal segment (∠GCT): angle formed by the most anterior point in the greater palatal segment, canine eruption point and the tuberosity. B) S1 Area and S2 Area, respectively the area of the smaller and greater palatal segments, marked by the intertuberosity distance as posterior limit, by passing the palatal segment through the alveolar crest, and the cleft as mesial limit. C Area: cleft area, marked by the intertuberosity distance as posterior limit; palatal segments as lateral limits; and cleft width as anterior limit.

Growth Rate (GR)

The palatal growth rate was quantified in percentage (%) and evaluated for all study parameters (linear, angular, and area measurements), according to the following formula:

$$GR = \frac{(\text{Parameter T2} - \text{Parameter T1})}{\text{T1}} \times 100$$

Statistical analysis

All statistical analyses were performed by GraphPad Prism software (Prism 5 for Windows – Version 5.0 – GraphPad software., Inc.), with a level of significance of 5%. Data normality was evaluated by Shapiro–Wilk test. Wilcoxon test and Dahlberg's formula tested the methodology reliability in 1/3 of the sample, twice, with a two–weeks interval. Intragroup comparisons were made by paired t test, while ANOVA followed by Tukey test evaluated the intergroup comparisons of the growth rate. Pearson correlation matrix analysed the coefficients between the measurements. Data are presented as mean and standard deviation.

Results

Sample comprised 96 digitized dental models of 16 children per group. All children had the impressions taken at 104 days after birth (≅3 months) at T1 and 359 days after birth (≅12 months) at T2.

The analysis of the reliability indicated that the measurements were adequately reproducible (p=0.869 and Dahlberg's formula=0.586).

Group 1 showed a significant reduction of the following parameters C–C', C Area, and ∠C'T'T. However, G1 exhibited growth in the following dimensions T–T', I–T, I–C, and S Area. In Group 2, C–C' and the angles ∠CTT' and ∠C'T'T decreased at T2, while T–T' and S Area increased in this same period. C–C', I–C', C Area, and ∠GCT reduced at T2, in Group 3, but T–T', I–T, I–C, and S Area increased in the same period (Table 1).

Table 1 – Intragroup comparisons of the palatal parameters (Paired t test).

Parameters	Units	T1		T2		*P*
Group 1		Mean	SD	Mean	SD	
C–C'	mm	31.38	4.07	28.11	2.61	**.001 ***
T–T'	mm	34.19	2.54	35.44	3.06	**.015 ***
I–T	mm	28.56	2.83	30.57	2.38	**.027 ***
I–T'	mm	34.94	2.38	34.92	1.9	.978
I–C	mm	12.01	3.39	13.65	1.81	**.048 ***
I–C'	mm	22.14	3.71	20.57	3.74	.097
S Area	mm²	930.42	110.45	1138.69	96.23	**<.001 ***
C Area	mm²	329.27	90.89	228.8	39.63	**<.001 ***
∠CTT'	°	84.71	5.93	82.37	5.72	.223
∠C'T'T	°	81.57	8.22	75.85	7.08	**.044 ***
∠GCT	°	118.79	9.93	116.79	8.08	.413
Group 2						
C–C'	mm	29.63	2.21	25.98	2.18	**<.001 ***
T–T'	mm	33.52	2.81	35.23	2.6	**.004 ***
I–T	mm	29.15	3.05	29.71	2.82	.456
I–T'	mm	33.06	3.13	33.02	2.44	.964
I–C	mm	12.52	2.92	13.26	2.01	.240
I–C'	mm	18.6	3.16	17.35	3.35	.145
S Area	mm²	836.76	142.75	999.54	175.99	**<.001 ***
C Area	mm²	236.66	76.78	199.82	98.99	.079
∠CTT'	°	82.45	5.38	78.1	3.64	**.008 ***
∠C'T'T	°	79.95	5.46	75.17	4.58	**.002 ***
∠GCT	°	112.78	8.89	110.14	8.59	.129
Group 3						
C–C'	mm	26.68	2.95	25.18	2.31	**.002 ***
T–T'	mm	33.24	2.52	35.77	2.43	**.008 ***
I–T	mm	30.34	1.7	31.89	2.66	**.040 ***
I–T'	mm	34.57	3.06	34.5	3.14	.910
I–C	mm	12.75	2.15	14.39	2	**<.001 ***
I–C'	mm	17.65	4.09	14.57	2.67	**<.001 ***
S Area	mm²	915.16	110.17	1000.82	105.98	**.001 ***
C Area	mm²	251.03	92.55	143.34	63.65	**<.001 ***
∠CTT'	°	82.32	7.36	79.95	4.81	.073
∠C'T'T	°	74.61	6.32	71.45	3.02	.064
∠GCT	°	119.02	5.51	107.82	5.38	**<.001 ***

SD: Standard Deviation.
* Statistically significant difference.

The three groups had different palatal growth changes in the analysed study period. Significant differences were found for C–C' distance, S and C areas, and <GCT angle. Post–hoc Tukey test revealed that G2 had a larger reduction in C–C' than G3. In the analysis of S Area, G3 had a smaller growth than G1. The comparison of C Area found a greater reduction in G3 than inG2. ∠GCT had the greater reduction in G3 (Table 2).

Table 2 – Intergroup comparisons of the palatal growth (%) – ANOVA and Tukey test.

Parameters	Group 1		Group 2		Group 3		*P*
	Mean	SD	Mean	SD	Mean	SD	
C–C'	-9.62 [AB]	9.45	-12.26 [A]	4.96	-5.26 [B]	5.86	**.024 ***
T–T'	3.68	5.46	5.33	6.47	8.14	10.8	.283
I–T	8.19	13.19	2.52	10.95	5.26	9.41	.372
I–T'	0.28	7.32	0.45	9.07	0.03	7.01	.988
I–C	21.69	37.37	10.15	26.58	13.82	10.89	.477
I–C'	-6.06	14.05	-5.71	17.85	-16.06	11.29	.087
S Area	26.13 [A]	25.63	21.01 [AB]	17.44	11.30 [B]	15.37	**.013 ***
C Area	-27.03 [AB]	16.32	-13.99 [A]	30.54	-40.05 [B]	21.89	**.012 ***
∠CTT'	-2.37	8.79	-4.96	6.56	-2.51	5.74	.519
∠C'T'T	-6.18	12.14	-5.74	6.34	-3.66	8.41	.716
∠GCT	-1.28 [A]	7.84	-2.18 [A]	5.63	-9.23 [B]	6	**.002 ***

SD: Standard Deviation.
*Statistically significant difference.
Different superscript letters show significant mean values.

The analysis of palatal symmetry showed that before cheiloplasty (T1), only children of G3 group had an asymmetric palate. At T2, all groups showed asymmetry (Table 3).

Table 3 – Intragroup comparisons of palatal symmetry (Paired t test).

Stages	Units	Group 1					Group 2					Group 3				
		∠CTT'		∠C'T'T		*P*	∠CTT'		∠C'T'T		*P*	∠CTT'		∠C'T'T		*P*
		Mean	SD	Mean	SD		Mean	SD	Mean	SD		Mean	SD	Mean	SD	
T1	°	84.71	5.93	81.57	8.22	.211	82.45	5.38	79.95	5.46	.078	82.32	7.36	74.61	6.32	**.001 ***
T2	°	82.37	5.72	75.85	7.08	**.002 ***	78.1	3.64	75.17	4.58	**.001 ***	79.95	4.81	71.45	3.02	**<.001 ***
∆=T1-T2	°	2.34	7.36	5.71	10.39	.159	4.34	5.78	4.78	5.20	.794	2.36	4.93	3.16	6.32	.628
GR	%	-2.37	8.79	-6.18	12.14	.157	-4.96	6.56	-5.74	6.34	.703	-2.51	5.74	-3.66	8.41	.576

SD: Standard Deviation.
*Statistically significant difference.
GR: Growth Rate

Correlation between the palatal parameters

Strong positive correlations were: C–C’ *vs* I–C’ and I–T *vs* I–C. Moderate negative correlations were I–T *vs* I–C’, I–T vs ∠GCT, I–C *vs* I–C’, and I–C *vs* ∠GCT (Figure 2).

C-C’											1.0
0.198	T-T’										0.8
-0.146	0.063	I-T									0.6
0.356	0.139	0.275	I-T’								0.4
-0.033	0.158	0.756	0.139	I-C							0.2
0.743	0.113	-0.314	0.502	-0.328	I-C’						0
0.343	-0.109	0.252	0.362	0.215	0.244	S Area					-0.2
0.566	0.049	-0.215	0.354	-0.209	0.600	0.255	C Area				-0.4
0.035	0.027	-0.308	0.113	-0.300	0.231	0.125	0.302	∠GCT			-0.6
0.051	-0.163	0.011	0.029	-0.100	0.112	0.160	0.162	0.105	∠T’TC		-0.8
-0.001	-0.037	-0.009	-0.038	-0.104	-0.055	0.075	0.016	-0.122	0.408	∠C’T’T	-1.0

Figure 2 – Pearson Correlation Coefficient Matrix between the palatal parameters (Right superior corner displays the coefficients as colors, while the left inferior corner displays the coefficients as numbers).

Discussion

Pre– and post–surgical orthopedics can be part of the cleft lip and palate rehabilitative treatment, in which the use of the intra/extraoral appliance can guide the development and prevent the collapse of the palatal bone segments, resulting in the continue and slow reduction of the cleft width prior to the primary lip and palate surgeries (Galassi et al., 2021; Shetty et al., 2017; Céron–Zapata et al., 2016, Jorge et al., 2016; Sasaguri et al., 2014; Huang et al., 2002). This is the first study on the longitudinal analysis of the palate during the first year of life considering three treatment protocols in two rehabilitative centers. Thus, the data contribute for the understanding of the influence of the treatment protocol choice on the development of the dental arch in children with cleft lip and palate.

Hotz plate is a passive orthopedic approach, which acts as a template for the dental arch shape (Cerón–Zapata et al., 2016, Jorge et al., 2016; Sasaguri et al., 2014; Huang et al., 2002). In G1, this appliance was evaluated every month (before cheiloplasty) and indicated for those children living far from the rehabilitative center. The use of the Hotz plate (G1) showed a reduction of C–C’ distance and an increase of T–T distance’, which agrees with other studies (Jorge et al., 2016). However, other investigators showed that the increase in T–T´ and I–C distances was also found in individuals treated without post–surgical orthopedics (Huang et al., 2002). The lack of a significant reduction in ∠GCT (anterior angle of the greater palatal segment) indicates a positive outcome of this treatment protocol. Hotz plate supported the dental arch by resisting to the continue pressure exerted by the lip healing tissue on the anterior region of the palate which avoided the collapse of the palatal segments (Sasaguri et al., 2014). Although the literature lacks studies on the evaluation of S Area and C Area in children treated with either passive or active PSO, these data confirm that the palatal surface area was not inhibited by the continuous use of the intraoral appliances.

PNAM is an active orthopedic approach that aligns the palatal segments and molds the nasal cartilage before lip repair (Shetty et al., 2017). This appliance maintenance should be taken at every week, thus, PNAM was indicated for children living closer to the rehabilitative center. The longitudinal analysis of G2 (PNAM) showed a significant reduction of ∠CTT’ and ∠C’T’T, which indicates the change in dental arch shape, probably a consequence of the correction of the palatal segments due to the active treatment of PNAM (Shetty et al., 2017). Similar to the children treated by Hotz plate, children treated by PNAM (G2) had an increase of T–T’. These results suggest that regardless of the PSO choice (passive or active), the posterior transversal growth was not affected in the first year of life, which disagrees with the study by Krammer et al., 1994.

The exclusively surgical protocol (without orthopedic treatments) is used in some rehabilitative centers with different surgical techniques, age, and timing for palate surgery. G3 was composed of children treated only by cheiloplasty, which is the treatment protocol of the institution (Freitas et al., 2012). At T2, the children of G3 exhibited a significant decrease of the parameters of the anterior area of the palate (C–C’, I–C’, and ∠GCT), agreeing with previous studies (Jaklová et al., 2021; Ambrosio et al., 2018b, Carrara et al., 2016). Also, this group showed the smallest mean value of the angles ∠CTT’ and ∠C’T’T and the smallest growth of T–T’, I–T, I–C, and S Area.

This corroborates other studies (Jaklová et al., 2021; Kongprasert et al., 2019; Ambrosio et al., 2018a, Ambrosio et al., 2018b; Sasaguri et al., 2014). Generally, G3 had a greater inhibition of the parameters evaluated in the anterior region of the palate, because the palatal segments are more susceptible to the lip healing tissue forces.

The reduction of the C–C' distance was a common finding in all groups, that is, regardless of the treatment choice. Other authors reported similar findings in the same cleft phenotype with different treatment protocols (Ambrosio et al., 2018, Jorge et al., 2016; Carrara et al., 2016; Sasaguri et al., 2014). It is noteworthy that G2 had the greatest reduction in this parameter. The rationale behind this fact is that PNAM exerts greater pressure on the alveolar segments mimicking the pressure of the operated lip on the palatal segments, resulting in anterior alveolar constriction (Shetty et al., 2017). The slow reduction of the cleft width during the PSO treatment is expected and aids in reducing the future lip healing tension on the anterior palate. The statistical similarity in the comparison of the C–C' distance between G1 *vs* G3 was also reported by literature (Jorge et al., 2016). The I–C' length exhibited little reduction in G2, probably because the molding was focused on the alveolus close to the cleft defect to stimulate the bone segment growth and avoid the dental arch collapse (Shetty et al., 2017). The ∠GCT angle and the I–C' distance had greater reductions in G3 probably because these children were not treated with PSO. Based on the aforementioned discussion, we highlighted that the post–surgical use of Hotz plate plays an important role in preventing the mesial collapse between the palatal segments, caused by the muscular forces of the lip. The post–surgical use of the Hotz plate also prevent the tongue insertion in the cleft which can influence the inclination of the segments (Mishima et al., 2000).

This study also evaluated the palatal symmetry according to the methodology proposed by Park et al., 2017, that is, by the comparison of the angles ∠CTT' and ∠C'T'T. The data indicated that before cheiloplasty (T1), only the groups treated by PSO showed symmetry. Notwithstanding, after cheiloplasty, all groups showed asymmetry. The palatal symmetry at the first year of life has been little analysed by the literature. Thus, the literature lacks consensus on the possible effects of the orthopedic treatment on the palate symmetry (Shetty et al., 2017; Adali et al., 2012).

This present study showed a strong positive correlation between C–C' *vs* I–C' and I–T *vs* I–C. The directly proportional linear relation between the parameters C–C' *vs* I–C' occurred because the three anatomic points (C, I, C') are located in the anterior region of the palate and consequently directly influenced by the post–cheiloplasty tension. From the opposite side, I–T *vs* I–C showed a continuous growth also because they were located in the same palatal segment. The moderate inversely proportional correlations were I–T *vs* I–C', I–T vs ∠GCT, I–C *vs* I–C', and I–C *vs* ∠GCT. The approximation of the greater and smaller palatal segments occurred regardless of the treatment protocol and explains the correlation between I–T *vs* I–C' and I–C *vs* I–C'. The correlations between I–T *vs* ∠GCT and I–C *vs* ∠GCT were caused by the flexion of the anterior part of the greater palatal segment after cheiloplasty, despite of the linear growth of the lengths in the same segment. The literature lacks studies on the correlation of these parameters in the analysis of dental arches (Monga et al., 2020). Further studies are necessary to provide information on the interaction of the dimensions and the development of the dental arches, regardless of the treatment protocols.

The results of present study evidenced the benefits of the pre– and post–surgical orthopedics at the first year of life. As the literature lacks consensus on the long–term benefits (Galassi et al., 2021; Shetty et al., 2017; Sasaguri et al., 2014; Nakamura et al., 2009), further studies are necessary to correlate the occlusal index at five years–old and the cleft width to the quantitative and qualitative analyses of the lip healing tissue of each treatment protocol. These data will contribute to the understanding of the long–term effects of the orthopedic approach. The limitations refer to different plastic surgeons because children were from different countries, in addition to the lack of analysis after palatoplasty.

Conclusion

Pre– and post–surgical orthopedics reduced the residual effects produced by the healing tension of the lip on palate. The post–cheiloplasty palatal asymmetry is softened by the lack of collapse between the anterior region of the palatal segments, confirmed by the anthropometric analyses.

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3 *Discussion*

3 DISCUSSION

This chapter is presented with considerations about the scientific articles mentioned above:

Article 1 – Post–surgical effects on the maxillary segments of children with oral clefts: New three–dimensional anthropometric analysis

- The software to be used in this study shows accuracy, assuring the validation of the anthropometric analysis. The use of linear measurements through landmarks has been largely used to quantify the development of 3D images of dental arches.
- The analysis of the new 3D anthropometric analysis of the dental arch was able to assess and monitor the development of the palate in both groups.

Article 2 – Prospective cohort 3D study of dental arches in children with bilateral orofacial cleft: Assessment of volume and superimposition

- The volume analysis is an important marker to monitor the palatal development and quantify the therapeutic effects on the dental arch, without using ionizing radiation. The analysis of the superimposition is a complete anthropometric analysis because it points out the 3D growth or retraction at sagittal and transversal directions. This is an innovative method of the pre– and post–operative surgical evaluation by enabling the anatomic comparison of the palatal surface due to the colour indication of growth (blue) and retraction (red) regions.
- The literature suggests many factors for the changes in dental arch development in individuals with cleft lip and palate, such as: presence of cleft in secondary palate in individuals with BCLP, cleft width, and the iatrogenic effects of the rehabilitative surgeries. Moreover, individuals with BCLP do not have the median palatal suture, whereas individuals with BCL do.

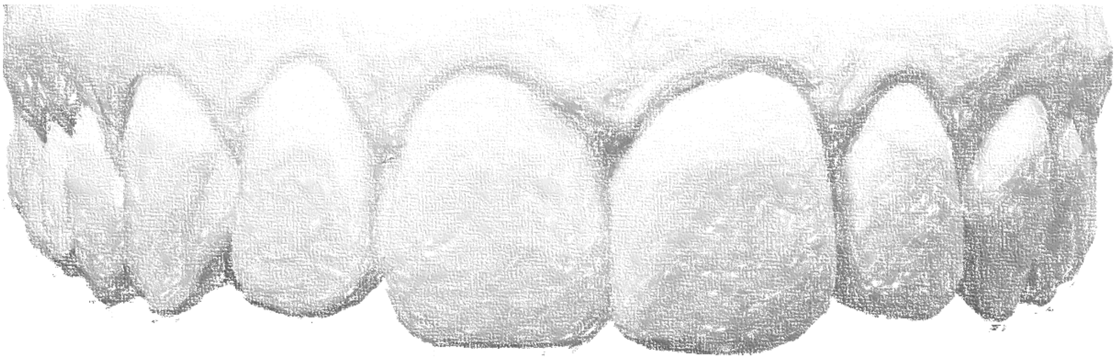
Article 3 – A novel innovative method to assess maxillary arch morphology in oral cleft infants: 3D–3D superimposition technique

- In craniofacial anomalies, 3D–3D superimposition is commonly applied to analyse the face regarding the influence of involuntary facial expressions, pre– and post–surgical asymmetry, and growth. Concerning the analysis of the digitized models, some studies analysed the chromatic map of the dental arches of children with oral clefts but not quantitatively described Root Mean Square (RMS).
- We highlight that the smallest point–to–point distances between the superimposed molds showed negative and positive values and if only the arithmetic mean values are considered, the results would be the mean values of the distances. RMS is a more complete approach because it evaluates the mean square root of the point–to–point distances between the digital casts, that is, all values are positive. From that point of view, RMS calculation is an advantage of this present study because it proposes a novel analysis for anthropometric studies of dental arches before and after surgery.

Article 4 – Effects of pre– and post–surgical orthopedics on dental arches of children with cleft lip and palate: comparison between protocols at the first year of life

- The rationale behind this fact is that PNAM exerts greater pressure on the alveolar segments mimicking the pressure of the operated lip on the palatal segments, resulting in anterior alveolar constriction. The slow reduction of the cleft width during the PSO treatment is expected and aids in reducing the future lip healing tension on the anterior palate.
- We highlighted that the post–surgical use of Hotz plate plays an important role in preventing the mesial collapse between the palatal segments, caused by the muscular forces of the lip.

4 Conclusions



4 CONCLUSIONS

Conclusion Article 1 – The new 3D anthropometric analysis showed that the development of the maxillary segments changed after the repair surgeries. The UCLP children demonstrated a reduction of the dental arches growth compared with the UCL children.

Conclusion Article 2 – The comparison between bilateral orofacial clefts showed reduction in the transversal and anteroposterior linear measurements, but not in the area and volume, which was confirmed by the superimposition of the palate.

Conclusion Article 3 – 3D–3D superimposition can quantify the individual characteristics of the dental arches of children with unilateral cleft lip and palate submitted to cheiloplasty.

Conclusion Article 4 – Pre– and post–surgical orthopedics reduced the residual effects produced by the healing tension of the lip on palate. The post–cheiloplasty palatal asymmetry is softened by the lack of collapse between the anterior region of the palatal segments, confirmed by the anthropometric analyses.

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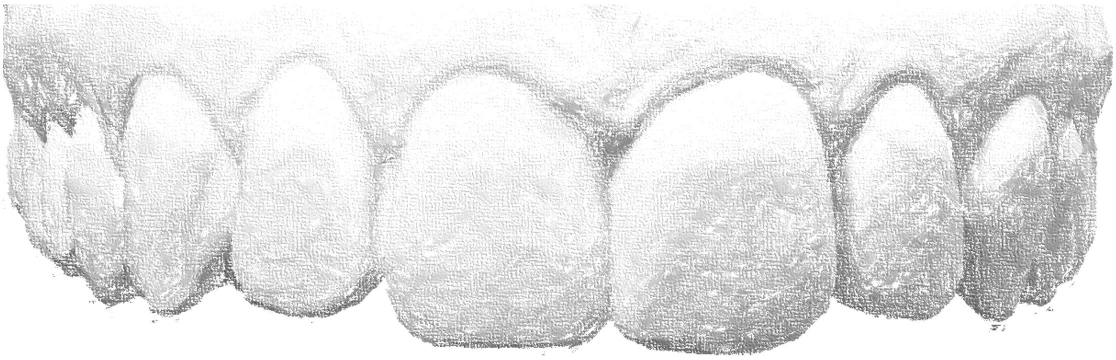
Annexes



ANNEXES

USP - FACULDADE DE ODONTOLOGIA DE BAURU DA USP

PARECER CONSUBSTANCIADO DO CEP

DADOS DO PROJETO DE PESQUISA

Título da Pesquisa: Uso da Esterefotogrametria 3D para análises volumétricas e sobreposição de imagens dos arcos dentários pré e pós-cirurgias de pacientes com fissura labiopalatina unilateral e bilateral.

Pesquisador: Eloá Cristina Passucci Ambrosio

Área Temática:

Versão: 2

CAAE: 77285417.0.0000.5417

Instituição Proponente: Universidade de Sao Paulo

Patrocinador Principal: Financiamento Próprio

DADOS DO PARECER

Número do Parecer: 2.390.098

Apresentação do Projeto:

O projeto de pesquisa "Uso da Esterefotogrametria 3D para análises volumétricas e sobreposição de imagens dos arcos dentários pré e pós-cirurgias de pacientes com fissura labiopalatina unilateral e bilateral" apresenta como pesquisador responsável Eloá Cristina Passucci Ambrosio e como integrante da equipe a orientadora Thais Marchini de Oliveira. O propósito deste estudo é uma avaliação longitudinal antropométrica 3D para analisar as modificações dimensionais dos arcos dentários de crianças com fissuras labiopalatina unilateral e bilateral antes e após as cirurgias plásticas primárias. A amostra será composta por 250 modelos dentários digitalizados de crianças com fissura unilateral completa de lábio (Grupo 1), fissura bilateral completa de lábio (Grupo 2), fissura unilateral de lábio e palato (Grupo 3)e fissura bilateral de lábio e palato (Grupo 4). Os modelos dentários serão avaliados em 3 fases: 3 meses (Fase 1), 1 ano (Fase 2) e 2 anos de idade (Fase 3). As medidas das dimensões dos arcos dentários serão realizadas diretamente nas imagens tridimensionais de modelos dentários, digitalizados por meio de um sistema comercial de laser scanner, e as mensurações serão efetuadas por meio do software do sistema de estereofotogrametria. Serão obtidas mensurações lineares, superficiais, volumétricas e sobreposição de imagens dos arcos dentários pré e pós-cirúrgicas.

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USP - FACULDADE DE ODONTOLOGIA DE BAURU DA USP

Continuação do Parecer: 2.390.098

Objetivo da Pesquisa:

O propósito deste estudo é uma avaliação longitudinal antropométrica 3D para analisar as modificações dimensionais volumétricas dos arcos dentários de crianças com fissuras labiopalatina unilateral e bilateral antes e após as cirurgias plásticas primárias.

Avaliação dos Riscos e Benefícios:

Riscos:

Não se aplica, pois serão utilizados dados secundários existentes no HRAC/USP.

Benefícios:

Os benefícios esperados com o desenvolvimento do presente estudo constituem uma importante contribuição ao conhecimento do desenvolvimento e crescimento dos arcos dentários em crianças com fissura labiopalatina no que diz respeito às intervenções das cirurgias primárias realizadas em tenra infância.Isso contribui na melhora do tratamento para cada tipo de fissura.

Comentários e Considerações sobre a Pesquisa:

O projeto de pesquisa faz parte da linha de pesquisa dos envolvidos. A metodologia está bem descrita.

Considerações sobre os Termos de apresentação obrigatória:

Foram apresentados os termos de aquiescência, termos de divulgação dos resultados, folha de rosto, questionário e projeto detalhado.

Recomendações:

Sem recomendações. As alterações sugeridas foram acatadas pelo pesquisador.

Conclusões ou Pendências e Lista de Inadequações:

Sugiro aprovação

Considerações Finais a critério do CEP:

Esse projeto foi considerado APROVADO na reunião ordinária do CEP de 08/11/2017, com base nas normas éticas da Resolução CNS 466/12. Ao término da pesquisa o CEP-FOB/USP exige a apresentação de relatório final. Os relatórios parciais deverão estar de acordo com o cronograma e/ou parecer emitido pelo CEP. Alterações na metodologia, título, inclusão ou exclusão de autores, cronograma e quaisquer outras mudanças que sejam significativas deverão ser previamente comunicadas a este CEP sob risco de não aprovação do relatório final. Quando da apresentação deste, deverão ser incluídos todos os TCLEs e/ou termos de doação assinados e rubricados, se

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Continuação do Parecer: 2.390.098

pertinentes.

Este parecer foi elaborado baseado nos documentos abaixo relacionados:

Tipo Documento	Arquivo	Postagem	Autor	Situação
Informações Básicas do Projeto	PB_INFORMAÇÕES_BÁSICAS_DO_PROJETO_980876.pdf	19/10/2017 18:23:06		Aceito
Outros	aquiescencia_hrac_acervo_modelos.pdf	19/10/2017 18:22:48	Eloá Cristina Passucci Ambrosio	Aceito
Outros	oficio_respostas.pdf	19/10/2017 18:22:08	Eloá Cristina Passucci Ambrosio	Aceito
Outros	Questionario_tecnico.pdf	21/09/2017 18:26:41	Eloá Cristina Passucci Ambrosio	Aceito
Outros	Termo_de_compromisso_de_manuseio_de_informacoes_HRAC.pdf	21/09/2017 18:25:29	Eloá Cristina Passucci Ambrosio	Aceito
Outros	Termo_de_compromisso_de_tornar_publicos_os_resultados.pdf	21/09/2017 18:24:45	Eloá Cristina Passucci Ambrosio	Aceito
Outros	Declaracao_de_compromisso_do_pesq_com_os_resultados_FOB.pdf	21/09/2017 18:24:08	Eloá Cristina Passucci Ambrosio	Aceito
Outros	Termo_de_Aquiescencia_FOB.pdf	21/09/2017 18:22:44	Eloá Cristina Passucci Ambrosio	Aceito
Outros	Termo_de_Aquiescencia_hrac.pdf	21/09/2017 18:22:10	Eloá Cristina Passucci Ambrosio	Aceito
Folha de Rosto	Folha_de_rosto.pdf	21/09/2017 18:15:08	Eloá Cristina Passucci Ambrosio	Aceito
Projeto Detalhado / Brochura Investigador	Projeto_Pesquisa.docx	21/09/2017 18:14:18	Eloá Cristina Passucci Ambrosio	Aceito

Situação do Parecer:
Aprovado

Necessita Apreciação da CONEP:
Não

BAURU, 21 de Novembro de 2017

Assinado por:
Ana Lúcia Pompéia Fraga de Almeida
(Coordenador)

Endereço: DOUTOR OCTAVIO PINHEIRO BRISOLLA 75 QUADRA 9
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USP - HOSPITAL DE REABILITAÇÃO DE ANOMALIAS CRANIOFACIAIS

PARECER CONSUBSTANCIADO DO CEP

Elaborado pela Instituição Coparticipante

DADOS DO PROJETO DE PESQUISA

Título da Pesquisa: Uso da Esterefotogrametria 3D para análises volumétricas e sobreposição de imagens dos arcos dentários pré e pós-cirurgias de pacientes com fissura labiopalatina unilateral e bilateral.

Pesquisador: Eloá Cristina Passucci Ambrosio

Área Temática:

Versão: 2

CAAE: 77285417.0.3001.5441

Instituição Proponente: Hospital de Reabilitação de Anomalias Craniofaciais da USP

Patrocinador Principal: Financiamento Próprio

DADOS DO PARECER

Número do Parecer: 2.481.667

Apresentação do Projeto:

Segunda apresentação do estudo com co participação da FOB -USP, já aprovado pelo CEP da FOB.O propósito deste estudo é uma avaliação longitudinal antropométrica 3D para analisar as modificações dimensionais volumétricas dos arcos dentários de crianças com fissuras labiopalatina unilateral e bilateral antes e após as cirurgias plásticas primárias. A amostra será composta por 250 modelos dentários digitalizados de crianças com fissura
unilateral completa de lábio (Grupo 1), fissura bilateral completa de lábio (Grupo 2), fissura unilateral de lábio e palato (Grupo 3) e fissura bilateral de lábio e palato (Grupo 4). Os modelos dentários serão avaliados em 3 fases: 3 meses (Fase 1), 1 ano (Fase 2) e 2 anos de idade (Fase 3). As medidas das dimensões dos arcos dentários serão realizadas diretamente nas imagens tridimensionais de modelos dentários, digitalizados por meio de um sistema comercial de laser scanner, e as mensurações serão efetuadas por meio do software do sistema de estereofotogrametria. Serão obtidas mensurações lineares, superficiais, volumétricas e sobreposição de imagens dos arcos dentários pré e pós-cirúrgicas. Um examinador previamente treinado e calibrado realizará as análises. Será aplicado o Teste t pareado e a fórmula de Dalbergh para avaliar o erro da metodologia. O Teste t independente e a Análise de Variância, seguido do Teste de Tukey, para verificar as alterações ocorridas entre os grupos. Caso necessário, outros testes poderão ser

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aplicados. Será adotado nível de significância de 5% para que as diferenças sejam consideradas estatisticamente significativas.

Objetivo da Pesquisa:

O propósito deste estudo é uma avaliação longitudinal antropométrica 3D para analisar as modificações dimensionais volumétricas dos arcos dentários de crianças com fissuras labiopalatina unilateral e bilateral antes e após as cirurgias plásticas primárias.

Avaliação dos Riscos e Benefícios:

Segundo os autores

Riscos:

Não se aplica, pois serão utilizados dados secundários existentes no HRAC/USP.

Benefícios:

Os benefícios esperados com o desenvolvimento do presente estudo constituem uma importante contribuição ao conhecimento do desenvolvimento e crescimento dos arcos dentários em crianças com fissura labiopalatina no que diz respeito às intervenções das cirurgias primárias realizadas em tenra infância. Isso contribui na melhora do tratamento para cada tipo de fissura.

Comentários e Considerações sobre a Pesquisa:

Pesquisa com dados secundários (modelos de estudo de gesso) de crianças com fissuras labiopalatinas. A amostra será composta por 250 modelos digitais referente a 100 pacientes com fissura labiopalatina divididos em 4 grupos:

- Grupo 1 (G1) – 25 pacientes com fissura unilateral completa de lábio, sendo que as moldagens foram realizadas em 2 fases (F1, F2). Totalizando 50 modelos digitais;
- Grupo 2 (G2) – 25 pacientes com fissura bilateral completa de lábio, sendo que as moldagens foram realizadas em 2 fases (F1, F2). Totalizando 50 modelos digitais;
- Grupo 3 (G3) – 25 pacientes com fissura unilateral de lábio e palato, sendo que as moldagens foram realizadas em 3 fases (F1, F2, F3). Totalizando 75 modelos digitais;
- Grupo 4 (G4) – 25 pacientes com fissura bilateral de lábio e palato, sendo que as moldagens foram realizadas em 3 fases (F1, F2, F3). Totalizando 75 modelos digitais.

A análise das modificações dimensionais será realizada por meio de imagens 3D de modelos dentários do arco superior, obtidos nas seguintes fases: G1 e G2 - Fase 1 (F1): 3 meses e Fase 2 (F2): 1 ano.

No G3 e G4 além de F1 e F2 também será analisado Fase 3 (F3): 2 anos.

Os modelos de estudo serão selecionados a partir do arquivo de documentação existente no HRAC/USP.
Os modelos dentários em gesso serão digitalizados por meio de um sistema comercial de laser scanner (3Shape´s R700TM Scanner) acoplado a um computador.
As medidas serão realizadas por meio de um software do sistema de estereofotogrametria (Mirror imaging software, Canfield Scientific Inc., Fairfield, NJ, USA).

O estudo havia ficado com pendência devido às inadequações abaixo relacionadas:
- O desenho do estudo na plataforma Brasil precisa ser substituído por: "estudo observacional quantitativo longitudinal". Os autores acrescentaram as características metodológicas do estudo na descrição do desenho na Plataforma Brasil - PENDÊNCIA TOTALMENTE ATENDIDA.
- Não ficou claro na metodologia se os autores irão publicar/apresentar alguma imagem dos modelos de estudo digitalizados; se isso fizer parte do estudo, os autores deverão anexar o Termo de Permissão para uso de Registros para Fins Científicos. Esse termo deverá estar com a assinatura do paciente e/ou responsável na apresentação do relatório final do estudo. Os autores acrescentaram o termo de Permissão para uso de registros para fins científicos, caso no final do estudo desejarem publicar alguma imagem dos modelos avaliados.PENDÊNCIA TOTALMENTE ATENDIDA.

Considerações sobre os Termos de apresentação obrigatória:
Carta de encaminhamento;
Formulário HRAC;
Folha de Rosto da Plataforma Brasil;
Termo de Compromisso de Manuseio de Informações;
Termo de Permissão para uso de Registros para Fins Científicos;
Termo de Compromisso de Tornar Públicos os Resultados da Pesquisa e Destinação de Materiais ou Dados Coletados;
Termo de Compromisso do Pesquisador Responsável.

Recomendações:
Não se aplica.

Conclusões ou Pendências e Lista de Inadequações:
Como as pendências foram corrigidas, sugiro que o projeto seja aprovado.

Considerações Finais a critério do CEP:

O pesquisador deve atentar que o projeto de pesquisa aprovado por este CEP refere-se ao protocolo submetido para avaliação. Portanto, conforme a Resolução CNS 466/12, o pesquisador é responsável por "desenvolver o projeto conforme delineado", se caso houver alterações nesse projeto, este CEP deverá ser comunicado em emenda via Plataforma Brasil, para nova avaliação.

Cabe ao pesquisador notificar via Plataforma Brasil o relatório final para avaliação. Os Termos de Consentimento Livre e Esclarecidos e/ou outros Termos obrigatórios assinados pelos participantes da pesquisa deverão ser entregues ao CEP. Os relatórios semestrais devem ser notificados quando solicitados no parecer.

Este parecer foi elaborado baseado nos documentos abaixo relacionados:

Tipo Documento	Arquivo	Postagem	Autor	Situação
Outros	Term_Perm_Uso_Registro19012018.pdf	19/01/2018 10:25:14	Rafael Mattos de Deus	Aceito
Informações Básicas do Projeto	PB_INFORMAÇÕES_BÁSICAS_DO_PROJETO_1038219.pdf	18/01/2018 13:20:07		Aceito
Outros	Of_pendencia_hrac_.pdf	18/01/2018 13:19:13	Eloá Cristina Passucci Ambrosio	Aceito
Outros	eloa_carta_coparticipante.pdf	09/12/2017 07:53:36	Eloá Cristina Passucci Ambrosio	Aceito
Outros	aquiescencia_hrac_acervo_modelos.pdf	19/10/2017 18:22:48	Eloá Cristina Passucci Ambrosio	Aceito
Outros	oficio_respostas.pdf	19/10/2017 18:22:08	Eloá Cristina Passucci Ambrosio	Aceito
Outros	Questionario_tecnico.pdf	21/09/2017 18:26:41	Eloá Cristina Passucci Ambrosio	Aceito
Outros	Termo_de_compromisso_de_manuseio_de_informacoes_HRAC.pdf	21/09/2017 18:25:29	Eloá Cristina Passucci Ambrosio	Aceito
Outros	Termo_de_compromisso_de_tornar_publicos_os_resultados.pdf	21/09/2017 18:24:45	Eloá Cristina Passucci Ambrosio	Aceito
Outros	Declaracao_de_compromisso_do_pesq_com_os_resultados_FOB.pdf	21/09/2017 18:24:08	Eloá Cristina Passucci Ambrosio	Aceito
Outros	Termo_de_Aquiescencia_FOB.pdf	21/09/2017 18:22:44	Eloá Cristina Passucci Ambrosio	Aceito
Outros	Termo_de_Aquiescencia_hrac.pdf	21/09/2017 18:22:10	Eloá Cristina Passucci Ambrosio	Aceito
Projeto Detalhado / Brochura Investigador	Projeto_Pesquisa.docx	21/09/2017 18:14:18	Eloá Cristina Passucci Ambrosio	Aceito

USP - HOSPITAL DE REABILITAÇÃO DE ANOMALIAS CRANIOFACIAIS

Continuação do Parecer: 2.481.667

Situação do Parecer:
Aprovado

Necessita Apreciação da CONEP:
Não

BAURU, 01 de Fevereiro de 2018

Assinado por:
Renata Paciello Yamashita
(Coordenador)

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