GABRIELA MAYRINK GONÇALVES

ANÁLISES CEFALOMÉTRICAS PARA CIRURGIA ORTOGNÁTICA UTILIZANDO O SOFTWARE DOLPHIN IMAGING

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ANÁLISES CEFALOMÉTRICAS PARA CIRURGIA ORTOGNÁTICA UTILIZANDO O SOFTWARE DOLPHIN IMAGING

Orientador: Prof Dr. Marcelo Marotta Araújo

TESE APRESENTADA À FACULDADE DE ODONTOLOGIA DE PIRACICABA, DA UNIVERSIDADE ESTADUAL DE CAMPINAS, PARA OBTENÇÃO DO TÍTULO DE DOUTORA EM CLÍNICA ODONTOLÓGICA, ÁREA DE CIRURGIA E TRAUMATOLOGIA BUCO-MAXILO-FACIAIS.

Este exemplar corresponde à versão final
da Tese defendida pela aluna,
e orientada pelo Prof.Dr.Marcelo Marotta Araújo

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RESUMO

Análises cefalométricas constituem um importante passo no planejamento pré-operatório de cirurgias ortognáticas. A partir da década de 80, traçados cefalométricos digitais foram incorporados e tornaram-se populares entre ortodontistas e cirurgiões. O Dolphin Imaging Software® (Chatsworth, California) é um dos programas computacionais mais comumente utilizados em todo o mundo para fins de planejamento e previsão do resultado pós-operatório. Para a análise cefalométrica, é necessária a digitalização de teleradiografias de perfil. Este trabalho, dividido em três capítulos, analisou no Dolphin Imaging Software: 1) se há diferença nas imagens digitalizadas por câmeras digitais ou *scanners* para uso neste programa 2) a inclinação ântero-posterior de incisivos centrais superiores e inferiores no pré-operatório imediato de pacientes Classe II de Angle submetidos à cirurgia de avanço mandibular e; 3) a recidiva de cirurgias de avanço maxilar em pacientes Classe III de Angle nos quais um cimento de fosfato de cálcio foi utilizado como material de enxertia. Para a realização do primeiro estudo foram utilizadas 10 teleradiografias de perfil escaneadas e fotografadas. Traçados cefalométricos foram realizados e medidas lineares e angulares foram analisadas. Os testes *t-Student e Wilcoxon* foram aplicados e concluiu-se que ambos os métodos podem ser utilizados para a digitalização das imagens, sem diferenças estatisticamente significantes entre os mesmos. O segundo estudo utilizou 30 teleradiografias de perfil de pacientes Classe II no pré-operatório imediato de cirurgias de avanço mandibular. Foram realizados os traçados digitais e a inclinação dos incisivos superiores e inferiores foi analisada por meio de medidas angulares e lineares. Após aplicados os testes estatísticos (*t Student)*, concluiu-se que os incisivos inferiores, em sua maioria, estavam compensados, ou seja, demonstravam uma inclinação mais vestibular, enquanto que os incisivos superiores estavam dentro das medidas consideradas ideais, tratando-se de descompensação dentária. Por fim, o último estudo avaliou a recidiva do

movimento de avanço de maxila em 8 pacientes Classe III em que um cimento de fosfato de cálcio foi utilizado como material de enxertia. Foram realizados os traçados cefalométricos das radiografias pré-operatórias e pós-operatórias imediatas e tardias e medidas lineares e angulares que ditam o posicionamento maxilar foram avaliadas. Após realizado o teste estatístico de Tukey (ANOVA), pode-se concluir que apenas em 1 medida foi observada recidiva do movimento, podendo esta técnica ser considerada estável.

PALAVRAS-CHAVE: Cirurgia ortognática, Cefalometria, Ortodontia

ABSTRACT

Cephalometric analyzes are an important step in preoperative planning of orthognathic surgery. From the 80's, digital cephalometric tracings were incorporated and became popular among orthodontists and surgeons. Dolphin Imaging Software (Chatsworth, California) is one of the computer programs most commonly used worldwide for planning purposes and forecasting the postoperative result. For cephalometric analysis is needed to digitize cephalometrics radiographs. This study was divided in three chapters, analyzed at Dolphin Imaging Software: 1) whether there are differences in the scanned images by digital cameras or scanners for use in this program, 2) the anteroposterior inclination of the upper and lower central incisors in the immediate preoperative patients with Angle Class II underwent mandibular advancement surgery and 3) relapse of maxillary advancement surgery in patients with Class III malocclusion in which a calcium phosphate cement was used as grafting material. For the first study were used 10 cephalometric radiographs scanned and photographed. Cephalometric tracings were performed, and linear and angular measurements were analyzed. The *Student t test and Wilcoxon* was applied and was concluded that both methods can be used for the digitization of images without statistically significant differences between them. The second study used 30 immediate preoperative cephalometric radiographs of Class II patients that were submitted to mandibular advancement surgery. Digital tracings were made and the inclination of the upper and lower incisors was analyzed by means of angular and linear measurements. After applied the statistical tests (*Student t test*), it was concluded that the lower incisors were mostly compensated, showing a labially inclination while the upper incisors were at the “ideal” position. Finally, the last study examined the relapse of maxillary advancement surgery of 8 Class III patients where calcium phosphate cement was used as a grafting material. We carried out the cephalometric analysis of radiographs of preoperative and postoperative early and late, and linear and

angular measurements that dictate the maxillary positioning were evaluated. After performing the *Tukey* statistical test (ANOVA), it was concluded that although in one measure relapse were observed this is an effective method to decrease relapse in maxillary orthognathic surgery.

KEY WORDS: Orthognathic surgery, Cephalometry, Orthodontics

LISTA DE ABREVIATURAS E SIGLAS

A- Ponto de maior concavidade na região anterior da maxila

B- Ponto de maior concavidade acima do mento

G- Glabela

N- Nasion

Gn- Gnation

Go- Gônio

Me- Menton

S- Sella

Pg- Pogônio

L1- Incisivo inferior

U1- Incisivo superior

L6- Cúspide mesial do 1º molar inferior

U6- Cúspide mesial do 1º molar superior

SNA- ângulo/ medida formado pelos pontos Sella, Nasion e A

SNB- ângulo/ medida formado pelos pontos Sella, Nasion e B

ANB- ângulo/ medida formado pelos pontos A, Nasion eB

SUMÁRIO

INTRODUÇÃO

A análise cefalométrica constitui um importante passo no planejamento da cirurgia ortognática. A partir da década de 80, traçados cefalométricos digitais foram incorporados ao planejamento, permitindo ao paciente uma melhor visualização dos resultados esperados (Talwar & Chemaly, 2008). O primeiro *software* desenvolvido para cirurgia ortognática foi o Quick Ceph (San Diego, California), amplamente utilizado por ortodontistas e cirurgiões bucomaxilofaciais (Talwar & Chemaly, 2008).

O *Software* Dolphin Imaging (Chatsworth, California), permite ao clínico utilizar análises pré-definidas ou personalizadas, dependendo do propósito do tratamento. Dessa forma, são disponibilizadas análises frontal e de perfil consagradas na literatura (como Ricketts, McNamara, Jarabak, Steiner) além da análise de Bolton. As radiografias devem, pelos operadores, ser digitalizadas (fotografadas e/ou escaneadas) com uma régua que permitirá a calibração da imagem. Após realizado o traçado diagnóstico, o traçado de previsão é realizado e pode ser sobreposto com uma fotografia de perfil do paciente, o que facilitará a visualização do perfil do mesmo após a realização da cirurgia. Este *software* disponibiliza amplas informações sobre o paciente como a eficácia do preparo ortodôntico pré-operatório e, em longo prazo, a eficácia do procedimento cirúrgico (quantidade de recidiva do procedimento, e se esta recidiva foi óssea ou dentária), além de visualização do espaço aéreo e simulação do resultado final da face. Com a versão em 3D (tridimensional), a simulação do resultado final torna-se ainda mais fidedigna.

Diante da ampla utilização deste aplicativo de computador, é necessário, primeiramente, avaliar se o método de digitalização das radiografias é fidedigno. As fotografias são mais amplamente utilizadas pelos cirurgiões, visto a maior rapidez e praticidade quando comparados ao uso do *scanner*. Entretanto, a fotografia mal executada pode levar a distorções, como o chamado “efeito barril” (no qual há distorção das bordas da imagem geradas pela lente), e essas

distorções podem levar a erros no diagnóstico, planejamento e previsão dos resultados da cirurgia ortognática. Dessa forma, o primeiro estudo deste trabalho consistiu em comparar radiografias cefalométricas de perfil fotografadas e escaneadas para sua utilização no Dolphin, e avaliar se houve diferença entre os dois métodos de digitalização.

O segundo estudo deste trabalho consistiu na avaliação pré-operatória de pacientes má oclusão Classe II de Angle (Angle, 1899) que foram submetidos à cirurgia de avanço mandibular. A descompensação dentária é um passo importante na ortodontia pré-operatória de pacientes que serão submetidos à cirurgia ortognática. Se não for realizada de maneira adequada, os resultados cirúrgicos podem ser comprometidos e os movimentos planejados podem ficar limitados, diminuindo as possíveis alterações estéticas que poderiam beneficiar o paciente. Dessa forma, o objetivo deste segundo trabalho foi avaliar, por meio de medidas angulares e lineares de traçados de diagnóstico realizados no Dolphin, a inclinação de incisivos superiores e inferiores de pacientes Classe II que foram submetidos a avanço mandibular, e foi analisado se o posicionamento dos incisivos estava dentro das normas cefalométricas.

Por fim, o terceiro estudo consistiu na avaliação da recidiva pós- operatória de pacientes submetidos a avanço maxilar associado ou não a cirurgia mandibular. Dentre os materiais aloplásticos, o cimento de fosfato de cálcio está disponível no mercado para preenchimentos de “gaps” ósseos, sejam eles criados cirurgicamente ou após um trauma (Clarkin *et. al.* ,2009). O presente estudo avaliou o uso do Hydroset ® (Stryker) em 8 casos de cirurgia de avanço de maxila como material de enxertia, e analisou sua eficácia em relação a estabilidade pós-operatória. Assim, medidas lineares e angulares da maxila foram avaliadas e comparadas no pré-operatório, no pós-operatório imediato e no pós-operatório de no mínimo 6 meses, identificando quantitativamente a recidiva do procedimento.

MATERIAL E MÉTODOS

Para estes 3 trabalhos, as diferentes amostras de radiografias foram fotografadas e, no primeiro estudo, também foram escaneadas. O mesmo padrão de fotografias foi realizado em todos os trabalhos.

Inicialmente, todas as radiografias foram marcadas, com uma caneta prata, nos seguintes pontos cefalométricos (Fig 1):

Sella (S) , Nasion (N), ponto A (A), ponto B (B), Condilion (Co), Gnathion (Gn), Ponta do incisive inferior (L1), Ponta do incisivo superior (U1), Cúspide do molar superior (U6) e cúspide do molar inferior (L6).

Fig 1: Teleradiografia de perfil com os pontos cefalométricos demarcados.

Para a realização das fotografias, após demarcados os pontos, as radiografias foram colocadas em um negatoscópio e a câmera fotográfica (Canon EOS Rebel XS, Lente Canon 0.25m/0.8ft- Canon, NY, EUA) foi fixada na estativa, a uma mesma distância (50 cm). A câmera foi programada para disparar automaticamente após 2 segundos que tivesse sido acionada. (Fig 2).

Fig 2: Estativa na qual a câmera foi fixada e negatoscópio no qual as radiografias foram posicionadas.

No primeiro trabalho, as radiografias também foram escaneadas, duas vezes, no intervalo de 1 semana, pelo mesmo operador (HP Scanjet G4050, 4800 dpi, 96 bits, Hewlett-Packward Development Company, EUA).

Após digitalizadas, as radiografias foram transferidas para o Dolphin Imaging Software® , onde foram realizados os traçados cefalométricos (Fig 3). Dessa forma, as diferentes análises cefalométricas, de acordo com os objetivos de cada estudo, puderam ser realizadas.

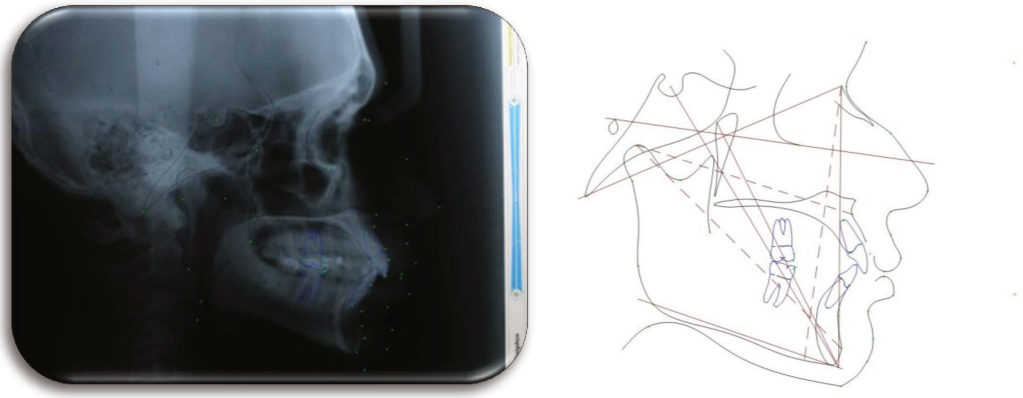


Figura 3: Imagem digitalizada no Software Dolphin Imaging® e traçado cefalométrico obtido.

Todas as radiografias foram traçadas duas vezes, pelo mesmo operador, em um intervalo de uma semana, para que as análises estatísticas pudessem ser realizadas.

CAPÍTULO 1

A COMPARISON OF SCANNED AND CORRESPONDING PHOTOGRAPHED CEPHALOGRAMS FOR USE IN DOLPHIN IMAGING SOFTWARE

ABSTRACT

Purpose: The purpose of this paper is to compare the accuracy of scanned cephalograms to photographed cephalograms for use in Dolphin Imaging Software

Materials and Methods: Ten lateral cephalograms were photographed and scanned to be used in Dolphin Imaging Software. Linear and angular measurements were traced and analyzed. Each tracing was repeated twice with 1-week interval by the same operator. The measures were tabulated at Microsoft Excell® and *Students-t* and *Wilcoxon* tests were used to compare each measurement. The intraclass correlator coefficient was used to test the intraexaminer reliability.

Results: The intraclass correlation coefficient was >0.92 and it featured a high reliability. No statistical difference was observed between the two groups in all of the linear and angular measurements.

Conclusion: For the use in the Dolphin Imaging Software both methods (photographs and scans) can be used.

KEY WORDS: Orthognathic surgery, Software validation, Cephalometry

INTRODUCTION

Until the 70´s the only way to do predictive tracings in orthognathic surgery was by manual cut-and-paste profile cephalometric tracings. In the 1980´s, the integration of computer technologies in orthognathic surgery planning allowed for digitization of cephalometric tracings and simulation of surgical outcomes, allowing the patient and the professional to preview the surgical treatment plan [1].

Dolphin Imaging Software® is one of the most used computer software for cephalometric tracing around the world. It allows standard and customized analyses for treatment planning purposes. The lateral analyses include Ricketts, McNamara, Steiner, Jarabak, Holdaway and many other combinations and variations. The clinician can visualize surgical outcomes by superimposing the photograph and the calibrated radiography. Nowadays, in the newer version software a CT can be used instead of radiographs and it´s possible to have 3-D images [1].

The clinician can take a photograph or use a scanner to digitize the cephalometric radiographs. The photo is an easy and quick way to do so. However, the lens of the photo camera can produce a distortion in the image (barrel distortion) and this effect can alter the radiographic image and the cephalometric tracing as well.

PURPOSE

The purpose of this study was to analyze if there is a difference in angular and linear measurements in photographed and scanned images to use in the Dolphin Imaging Software.

MATERIALS AND METHODS

This study was first submitted and approved by the Ethics Committee of Piracicaba Dental School (University of Campinas, Unicamp, Piracicaba, São Paulo, Brazil), protocol number 025/2012.

Ten lateral cephalograms were randomly selected of patients treated at Piracicaba Dental School. All of these radiographs were obtained in the same radiologic department of this university.

Each radiograph was marked with a silver color pen at the following cephalometric points: Sella (S) , Nasion (N), A-point (A), B-point (B), Condilion (Co), Gnathion (Gn), Lower incisor tip (L1), Upper incisor tip (U1), Upper Molar (U6) and Lower Molar (L6).

These radiographs were photographed (Canon EOS Rebel XS, Canon Lens 0.25m/0.8ft- Canon, NY, USA) at the same distance (50cm), 90 degrees, by the same operator. The radiograph was placed in a light box and the camera was fixed at a static display. Camera was programmed to automatically shoot after 2 seconds af the trigger was hit, ISO 100. All these radiographs were also scanned (HP Scanjet G4050, 4800 dpi, 96 bits, Hewlett-Packward Development Company, USA).

These images were converted to the JPEG format (Microsoft Office Picture Manager) and transferred to Dolphin Software Image to do the cephalometric tracings. Some linear and angular measures of McNamara and Steiner analyses were included in this study.

For linear measures, the following points were used:

U1- NA (mm) ,L1- NB (mm), Co- A (mm), Co-Gn (mm)

For angular measures, the following points were used:

SNA (°), SNB (°), ANB (°), U1-NA (°), L1-NB (°)

Each radiograph was traced twice by the same operator within a one week interval for the intraexaminer reliability analysis. The intraclass correlation coefficient was > 0.92 and it features a high reliability.

Data was statistically analyzed to compare each measurement with its corresponding normal value using *Student´s t* test and *Wilcoxon* statistical test. Probabilities of less than 0.05 were accepted as significant.

RESULTS

The quantifying test reliability using the intraclass correlation coefficient (ICC) was utilized to test the intraexaminer reliability. Values between 0.8 and 1.0 meant excellent reliability. In this study, all of measurements were >0.92 and this statistical test showed the quality of measurements made by the same operator. (Table 1)

Table 1: Intraclass correlation coefficient of the cephalometric measurements evaluated.

Measures	ICC
SNA (°)	0,98883
SNB (°)	0,99710
ANB (°)	0,92073
U1 – NA (°)	0,94437
L1 – NB (°)	0,99957
U1 – NA (mm)	0,95024
L1 – NB (mm)	0,93920
Co – A (mm)	0,99985
Co – Gn (mm)	0,97898

The descriptive analyses of paired Student´s t test and Wilcoxon test results are shown in Table 2 and 3. No statistically difference was observed between the two groups (scanned or photographed).

Table 2. Descriptive analyses of Student´s t and Wilcoxon tests for the tracings (measurements in degrees), p<0,05.

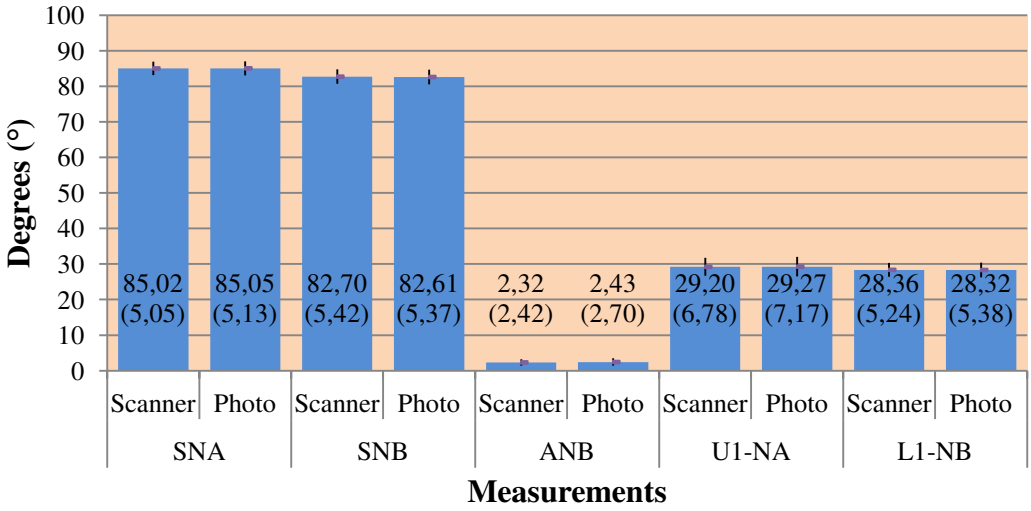
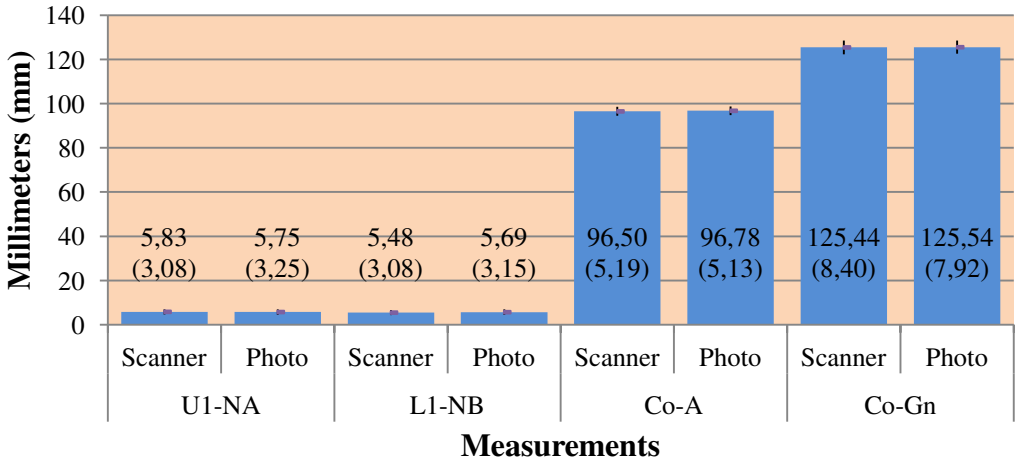


Table 3. Descriptive analyses of Student´s t and Wilcoxon tests for the tracings (measurements in millimeters), p<0,05.



DISCUSSION

Dolphin Imaging Software is a computer program that allows clinicians to perform cephalometric tracings in a short-time compared to manual tracing with the same reliability [2, 3]. According to Paixão et. al., 2010, Dolphin Imaging Software can be used as an aid in diagnosing, planning, monitoring and evaluating orthodontic treatment both in clinical and research settings [4]. However, the high cost can be pointed as a disadvantage.

Radiograph images can be digitized in the Dolphin Imaging Software by the aid of a photo or a scanner.

Radiographs can easily be scanned into a digital format by using a relatively inexpensive, consumer-grade flatbed scanner equipped with a transparence adapter [5]. The flatbed scanner produces an image with a minimal distortion and a great definition appropriate to visualize all points in cephalometric radiograph.

Taking photographs of a radiograph is a quick way to obtain digital images. However, the quality of pictures is related to proper technique for shooting. Wrong regulation may provide inadequate radiographs out of focus, lack of depth, excess or lack of brightness and out of frame. More than this, barrel effect (caused by the distortion of the light beam through lens curvature) and perspective error can lead to incorrect analysis [6] (Fig 1).

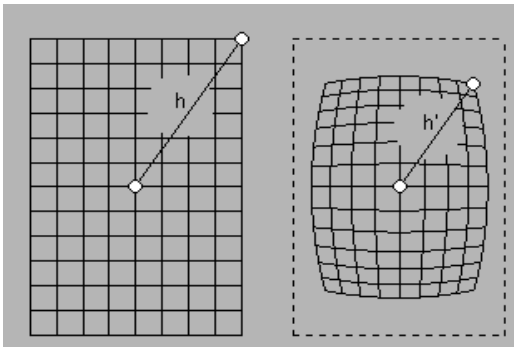


Fig 1:Barrel effect caused by the distortion of the light beam through lens curvature

The resolution of the digital camera can also affect the quality of the digital image. Radiographs images are captured by a digital camera on an image sensor that contains photosites. Photosites are light-sensitive diodes that convert light energy into electrical energy. The amount of detail or resolution of the digital camera is determined by the number of photosites present. In general, a pixel, a digital image term, is equivalent to a photosite in the digital camera. As the number of photosites and the number of pixels increase, the higher the resolution of each [7]. In this study, a semi professional camera was utilized because in non professional cameras there is a variety of standards, and this is not suitable for this use.

In the present study, all photos were taken with a high resolution (1809 X 1428 pixels) and all of them were converted to JPEG format. This conversion reduces the image quality but the storage space requirement is reduced. Resolutions higher than this requires a larger amount of storage space and is an uncommon practice for clinicians that use this software. According to Held et al., 2001, the loss of detail that occurs when an image is compressed into a JPEG format does not significantly affect the diagnostic quality of the image when standard compression settings are used [8].

The scanner used in this study was an HP Scanjet G4050 (4800 dpi, 96 bits, Hewlett-Packward Development Company, USA). Different from photographs, the scanner setting doesn´t affect significantly the image. Held et. al., 2001, studied how the variety of scanner settings can affect the interpretation of cephalograms. They concluded that the scanner settings used in the digitization of a cephalometric film did not significantly matter when standard settings were used.

In this study, there were no differences between linear and angular measurements obtained by scanner or photographs. It enables the use of cameras or flatbed scanner to digitize radiographs. Considering the much more time-consuming process of using a flatbed scanner, adequate photos can be a good technique to digitize cephalograms. There are few studies similar to this,

comparing measurement from scanned and photographed cephalograms. According to the study of Collins et. al., 2007, there is a statistical difference between linear measurements when photos were used and they attributed this to a distortion caused by camera [9].

CONCLUSION

It was been concluded that there is no difference between photographed (professional cameras) or scanned images to digitalize images for the use in Dolphin Imaging Software. The small differences between the two methods can be attributed to random operator failures and not associated to the method of obtaining the image.

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CAPÍTULO 2

CEPHALOMETRIC EVALUATION OF PREOPERATIVE INCISOR INCLINATION IN PATIENTS WITH CLASS II DENTOFACIAL DEFORMITIES TREATED WITH MANDIBULAR ADVANCEMENT

ABSTRACT

Purpose: To evaluate cephalometrically the preoperative incisor inclination of 30 patients with Class II malocclusion who were treated with mandibular advancement.

Materials and Methods: Thirty immediate preoperative lateral cephalograms were photographed to be used in Dolphin Imaging Software. Linear and angular measurements were traced and analyzed. Each tracing was repeated twice with 1-week interval by the same operator. The measures were tabulated at Microsoft Excel and submitted to *Students-t* test and mean measures were compared with the normal values. The intraclass correlator coefficient was used to test the intraexaminer reliability.

Results: The intraclass correlation coefficient was >0.9 and it featured a high reliability. Mean values of lower incisors differed from normal values, presenting labial inclination compared to normal values.

Conclusion: In this study, the results showed that Class II patients had dental compensations and the lower incisors are more proclined comparing to the standard values.

KEY WORDS: Orthognathic surgery, Orthodontics, Cephalometry

INTRODUCTION

Dentoalveolar compensations in Class II skeletal malocclusion (upright maxillary incisor and mandibular incisors proclined) are common and help to maintain function and mask the underlying skeletal discrepancy. These dental compensations are manifested in all three planes of space but are most apparent in the sagittal dimension [1, 2].

Surgical-orthodontic management of nongrowing Class II patients includes presurgical orthodontic treatment to dental decompensation malocclusion, followed by surgical correction of skeletal discrepancy and post-surgical orthodontic with maximal intercuspidation [2].

Incomplete decompensation may influence the quality of the postoperative results and magnitude of surgical moviments. Previous studies showed that incisor inclination had an important impact on the aesthetics in a profile view [3, 4].

PURPOSE

The purpose of this study was to analyze the immediate preoperative incisor inclination of Class II malocclusion patients that were treated with mandibular advancement.

MATERIALS AND METHODS

This study was first submitted and approved by Ethics Committee of Piracicaba Dental School (University of Campinas, Unicamp, Piracicaba, São Paulo, Brazil), protocol number 004/2012.

Thirty lateral cephalograms of Class II patients that had been treated with mandibular advancement were selected. Inclusion criteria were: totally dentate patients, with an immediately preoperative lateral cephalogram and treated only by mandibular advancement (without maxillary surgery associated).

Each radiograph was marked with a silver color pen at the following cephalometric points: Porion (Pr), Sella (S) , Nasion (N), Basion (B), A-point (A), B-point (B), Condilion (Co), Pogonion (Po), Gnathion (Gn), Menton (Me), Orbitale (Or), Gonion (Go), Anterior Nasal Spine (ANS), Lower incisor tip (L1), Upper incisor tip (U1), Upper Molar (U6) and Lower Molar (L6).

These radiographs were photographed (Canon EOS Rebel XS, Lens Canon 0.25m/0.8ft- Canon USA, NY) at the same distance (50cm), 90 degrees, by the same operator. The radiographs were placed in a light box and the camera was fixed at a static display. Camera was programmed to automatically trigger after 2 seconds of the shooting.

These images were converted to the JPEG format (Microsoft Office Picture Manager) and transferred to Dolphin Software Imaging® to undergo the cephalometric tracings. Some linear and angular measures of Steiner analyses [5] were included in this study.

For linear measures, were used:

U1- NA (mm) ,L1- NB (mm)

For angular measures, were used:

IMPA(°), U1-NA (°), L1-NB (°), INTERINCISAL (°)

Each radiograph was traced twice by the same operator, at a 1-week interval for the intraexaminer reliability analysis. The second tracing was used. The intraclass correlation coefficient was > 0.90 and it features a high reliability.

Data were statistically analyzed to compare each measurement with its corresponding normal value using *Student´s t* test. Probabilities of less than 0.05 were accepted as significant.

RESULTS

Thirty patients were included in this study comprising 23 women and 7 men. All of the mandibular advancements were performed by mandibular bilateral saggital split osteotomies and fixation with positional screws, or hybrid fixation were performed (plates + screw).

The quantifying test reliability using the intraclass correlation coefficient was used to test the intraexaminer reliability. Values between 0.8 and 1.0 mean excellent reliability. In this study, all measurements were >0.90 and this statistical test showed the quality of measurements made by the same operator.

Mean values were compared with normal values. Upper incisors showed measurements similar to ideal values. However, lower incisors showed means that demonstrate dental compensations, so lower incisors are labially and have increased inclinations. (Table 1)

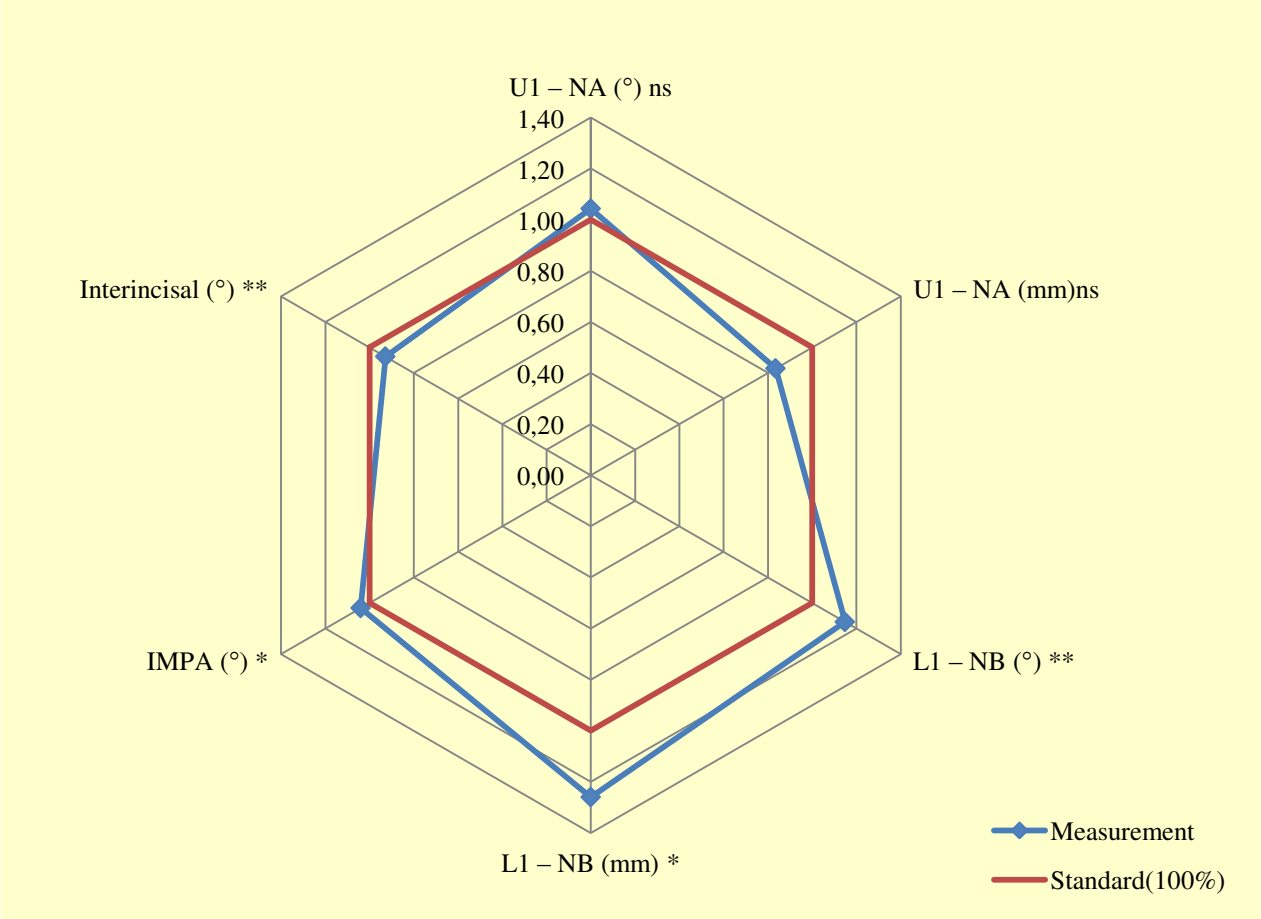
Table 1: Mean and standard deviation of measurements compared to standard values according to Steiner [7]

Measurement	Mean	Standard deviation
U1 – NA (°) Standard: 22º	22,94 ^{ns}	8,38
U1 – NA (mm) Standard: 4 mm	3,34 ^{ns}	4,41
L1 – NB (°) Standard: 25 º	28,71 **	6,85
L1 – NB (mm) Standard: 4 mm	5,04 *	2,29
IMPA (°) Standard: 93 º	96,69 *	9,13
Interincisal (°) Standard: 131º	121,59 **	12,15

ns: not significantly; * p <0.05; ** p < 0.01

For better understanding, values were converted to percentages. Figure 1 allows better visualization comparing normal values to obtained measures.

Fig 1: Comparison in percentage of normal to obtained values



ns: not significantly; * p <0.05; ** p < 0.01

DISCUSSION

Angle Class II malocclusion or mandibular retrognatism can be classified in Class II division1 and Class II division 2. In both cases, maxilla is forward in relation to mandible. However, there are differences in skeletal and dental characteristics.

According to Angle, in Class II division 2, upper incisors are more retroclined compared to division 1 [6]. Al-Katheeb et. al., 2009, analyzed the differences

between these two types of occlusion in cephalometric analysis and concluded that in Class II division 1, the lower incisors are proclined and the interincisal angle was reduced, while in Class II division 2 the lower incisors are at normal inclination and the interincisal angle are significantly increased [7].

In orthognathic patients, this natural camouflage of dental inclinations must be corrected. One of the presurgical objectives in orthognathic surgery includes positioning the incisors in axial relationships that are as “ideal” as possible [1]. It will often be necessary to “decompensate” the incisors with orthodontic mechanotherapy. Thus, when the surgery procedure is carried out, the jaws can be correctly positioned with minimal interferences from the occlusion [1].

According to Steiner (1954), the “ideal” position of the upper incisors should lie on the line NA in such a way that the most mesially placed point of its crown is 4 mm and its axial inclination is at 22 degrees to the line NA [5]. In this study, the mean of the crown position was 3,34mm and the mean of axial inclination was 22,94 degrees. These values suggest that should not be so difficult for the orthodontists to “decompensate” upper incisor and in Class II malocclusion the natural compensation of the lower incisors are more evident than in upper incisors.

The “ideal” position of the most mesial point of the crown of the lower central incisor to the line NB is 4mm and the axial inclination of the tooth is at 25 degrees. In our study, these values varied significantly, demonstrating the difficulty to decompensate lower incisors in Class II malocclusions. The periodontal condition (periodontal disease or thickness of the alveolar bone) can be a factor that difficult decompensations and premolar extraction or dental slices can be considered in the treatment to allow lingual torque if there is no space in arcade to do the orthodontic movement. Furthermore, the lack of professional training and the patient´s desire fastly conclude the treatment can lead the orthodontist together with the surgeon to minimize the period of the orthodontic mechanoterapy.

However, the standard Brazilian´s values are different from American´s standard. Martins et. al.,1998, analyzed cephalometric pattern of facial growth in Brazilian [8] (Table 2). Comparing values obtained in this study to the adults Brazilian values standard (Student t test), the results are somewhat different. Mean measurements of U1-NA (degrees) and L1-NB (in millimeters) do not differ from the standard values, while the other values are statistically significant. It may suggest that there are difficulties to decompensate superior and inferior incisors. Nevertheless, these measures are still underutilized for Brazilians orthodontists and the Steiner analyses, widely used around the world, is still considered standard for most of the orthodontists in Brazil.

Table 2: Measurements compared to Brazilian standard values according to Martins [8]

Measurement	p value
U1 – NA (°) Brazilian Standard: 22º	0,63 ^{ns}
U1 – NA (mm) Brazilian Standard: 4,3 mm	0,04 *
L1 – NB (°) Brazilian Standard: 23,4 º	0*
L1 – NB (mm) Brazilian Standard: 4,7 mm	0,7 ^{ns}
IMPA (°) Brazilian Standard: 89,9 º	0,007*
Interincisal (°) Brazilian Standard: 132º	0*

ns: not significantly; * p <0.05

Potts et.al, 2009, also evaluated the dental changes produced by orthodontic treatment in conjunction with orthognathic surgery [9]. They showed that the maxillary incisors, in average were overretracted presurgically and returned to a normal position postsurgically, whereas the mandibular incisors were proclined and protuded presurgically and remained so at posttreatment, showing that the incisors were not ideally decompensated in many patients. These results

corroborate with our study and the authors showed that the surgical advancement was limited by incisor position and amount of overjet so this limited the treatment outcome.

Pereira-Stabile et. al. (2011), studied the position of incisors in immediate presurgical treatment of Class III patients. They also showed differences at the "ideal" and the obtained position of the incisors, suggesting that incomplete decompensation seems to be a common finding in orthognathic surgery but the pattern of the incisors compensation in Class III patients is opposite than in Class II patients [3].

However, it is important to try to reach an ideal position. Ghaleb et.al (2010), evaluated the impact of maxillary incisor inclination on the aesthethics of the profile view of a smile and concluded that this position is perceptible to laypeople and dentists. More than this, a compensated occlusion limit the movement and the final result of orthognathic surgery [4].

Proffit et. al. (1992), compared results of orthodontic camouflage to surgical treatment and concluded that the surgical patients experienced greater esthetic improvement than the orthodontic patients [10]. The labially motion of the inferior incisors in camouflage is a great factor associated to treatment relapse. This may also explain the relapse of the surgical treatment in cases that incisors were not totally decompensated.

The profile and the amount of overjet desired in the pretreatment phase is very important to determine if dental compensations can be accepted.

CONCLUSION

In this study, most of Class II dentofacial malloclusions were not correctly decompensated to reach normal values. Lower incisors were frequently labially inclined but upper incisors were at ideal values.

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CAPÍTULO 3

ANALYSIS OF THE USE OF CALCIUM PHOSPHATE CEMENT AS A GRAFT IN MAXILLARY ADVANCEMENT

ABSTRACT

Purpose: The purpose of this paper is to evaluate the relapse in maxillary advancement for treatment of Class III malloclusion when calcium-phosphate cement was used as graft material.

Materials and Methods: Eight preoperative, immediate and late postoperative lateral cephalograms of patients that were submitted to a maxillary advancement and a calcium-phosphate cement was used as a graft material were photographed to be analyzed in Dolphin Imaging Software. Linear and angular measurements were traced and analyzed (SNA, Co-A, A-Nperp). Each tracing was repeated twice with 1-week interval, by the same operator. The measurements were tabulated at Microsoft Excel and ANOVA test was applied. The intraclass correlator coefficient was used to test the intraexaminer reliability.

Results: The intraclass correlation coefficient was >0,64 and it featured a great reliability. Mean values of the distances of SNA and Co-A showed no significant relapse, however, A-Nperp distance showed a statistically significant relapse.

Conclusion: In this study, calcium-phosphate cement proved to be an adequate grafting material to be used in orthognathic surgery reducing relapse movement.

KEY WORDS: Biocompatible materials, orthognathic surgery, cephalometry

INTRODUCTION

Maxillary advancement cause a step gap between the bone segments and may increase the chances of a bone relapse. Numerous studies have documented the stability of Le Fort I osteotomy in combination with bilateral sagittal split ramus osteotomy. Some reports have shown stability of the procedures using plates and screws alone with titanium plate or poly-L-lactic acid plates [1,2]. However, there was no report regarding the use of a calcium-phosphate cement (Hydroset® - Stryker International, Limerick, Ireland) as a graft to improve stability.

Calcium-phosphate cements are materials that consist essentially of only calcium phosphate compounds and are capable of self-setting to a hard mass [3]. Hydroset® is a calcium phosphate cement that converts to hydroxyapatite and was specifically formulated to set in a wet field environment and exhibits outstanding wetfield characteristics [3]. (Fig 1)

Fig 1: Hydroset ®, a calcium phosphate cement of Stryker International.

Many studies showed the use of calcium-phosphate cement as a material to fill bone gaps[1,3]. However, there aren´t studies that evaluates this material as a graft material in orthognathic surgery.

PURPOSE

The purpose of this study was to analyze the movement relapse of Class III patients submitted to a maxillary advancement where a calcium-phosphate cement as a graft material was used.

MATERIALS AND METHODS

This study was first submitted and approved by Ethics Committee of Piracicaba Dental School (University of Campinas, Unicamp, Piracicaba, São Paulo, Brazil), protocol number 139/2011.

Inclusion criteria were: patients who had anteroposterior maxillary deficiency treated with Le Fort I osteotomy, without segmentation; patients had been operated by the same senior surgeon, using the same technique; patients had undergone orthodontic and surgical treatment; the maxillary fixation was done using four titanium plates (two Lindorf plates on canine buttress and two L-shaped plates on maxillary-zygomatic buttress) and the gap between the bone segments was filled by a calcium-phosphate cement (Hydroset- Stryker®).

Eight Class III patients and their lateral cephalograms of preoperative, immediate postoperative and a minimal of 6 months postoperative phase were landmarked: Porion (Pr), Sella (S) , Nasion (N), Basion (B), A-point (A), B-point (B), Condilion (Co), Pogonion (Po), Gnathion (Gn), Menton (Me), Orbitale (Or), Gonion (Go), Anterior Nasal Spine (ANS), Lower incisor tip (L1), Upper incisor tip (U1), Upper Molar (U6) and Lower Molar (L6).

All of the 3 radiographs of the same patient were obtained at the same cephalometric radiograph machine.

This radiographs were photographed (Canon EOS Rebel XS, Lens Canon 0.25m/0.8ft- Canon USA, NY) at the same distance (50mm), near 90 degrees, by the same operator. The radiograph was placed in a light box and the camera was fixed at a static display. Camera was programmed to automatically trigger 2 seconds after shooting.

The images were converted to the JPEG format (Microsoft Office Picture Manager) and transferred to Dolphin Software Imaging® to do the cephalometric tracings. Some landmarks of McNamara (1984) [4] analyses were included in this study to observe the maxilla movement (Fig 1).

For linear measures, were used: A-Nperp (mm) ,Co-A (mm)

For angular measures, were used: SNA (°)

No dental measurement was used, because orthodontic movements should influence in the relapse analysis.

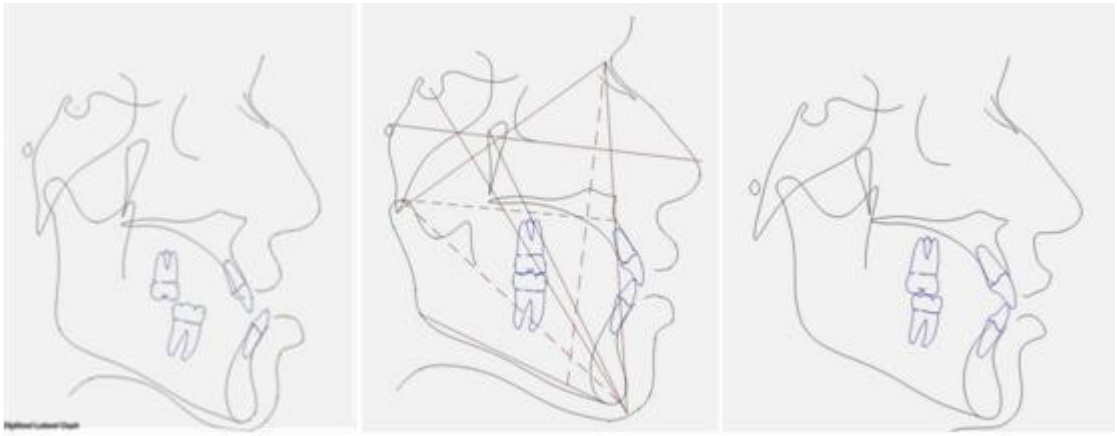


Fig 1) Cephalograms of preoperative, immediate and late postoperative treatment

Each radiograph was traced twice by the same operator at a one week interval for the intraexaminer reliability analysis. The intraclass correlation coefficient was > 0.64 and it features a high reliability.

Data were statistically analyzed by ANOVA test to compare mean values of each measurement with its corresponding anterior value. Probabilities of less than 0.05 were accepted as significant.

RESULTS

Eight patients were included comprising 3 women and 5 men. All of them were submitted to a maxillary advancement and 5 of them had mandibular movements associated. A mean maxillary advancement of 6,25mm (SD: 2,43) was found.

On the postoperative phase, there was no infection, inflammatory or foreign body reaction associated to the calcium-phosphate cement.

The quantifying test reliability using the intraclass correlation coefficient was used to test the intraexaminer reliability. Values between 0.6 and 0.8 mean a very good reliability. In this study, all of measurements were >0.64 and the statistical test showed the quality of measurements made by the same operator.

The ANOVA (Tukey test) was used to evaluate the relapse of the maxilla movement. The means values of preoperative, immediate postoperative and a minimal of 6 months postoperative phase were analyzed.

All of the 3 measurements demonstrate statistically significant differences between preoperative and immediate postoperative values. Analyzing the movement relapse, measures of Co-A and SNA showed a minimal relapse. (Fig 1 and 2). However, A-Nperp showed a significant relapse, the values were maintained superior of the preoperative phase. (Fig 3) This can suggest that a relapse occurred, but not sufficient to return to the preoperative values.

Fig 2: Mean values of Co-A. There was no difference between late and immediate postoperative values, but immediate and preoperative values were significant.

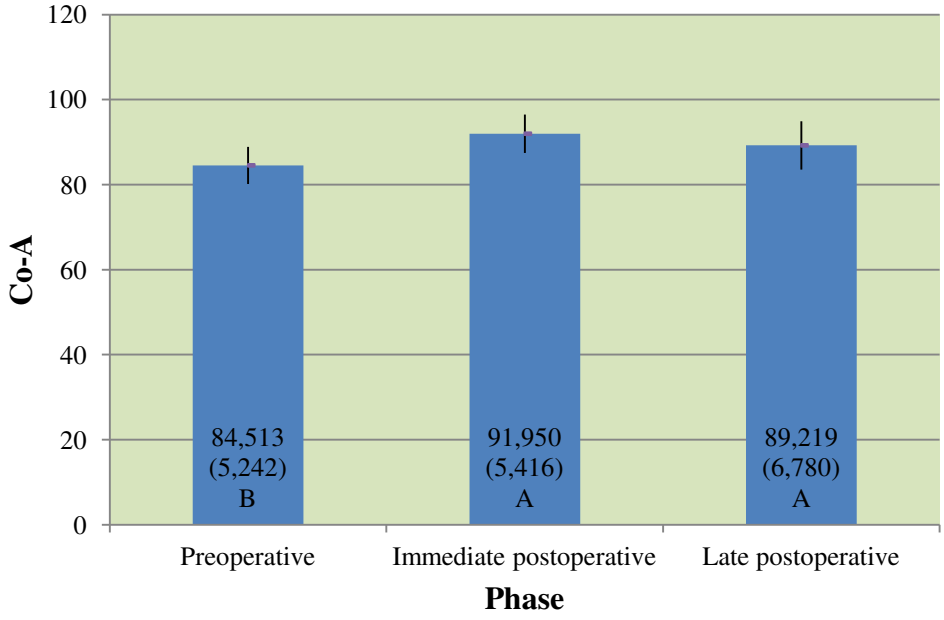


Fig 3: Mean values of SNA. There was no difference between late and immediate postoperative values, but immediate and preoperative values were significant.

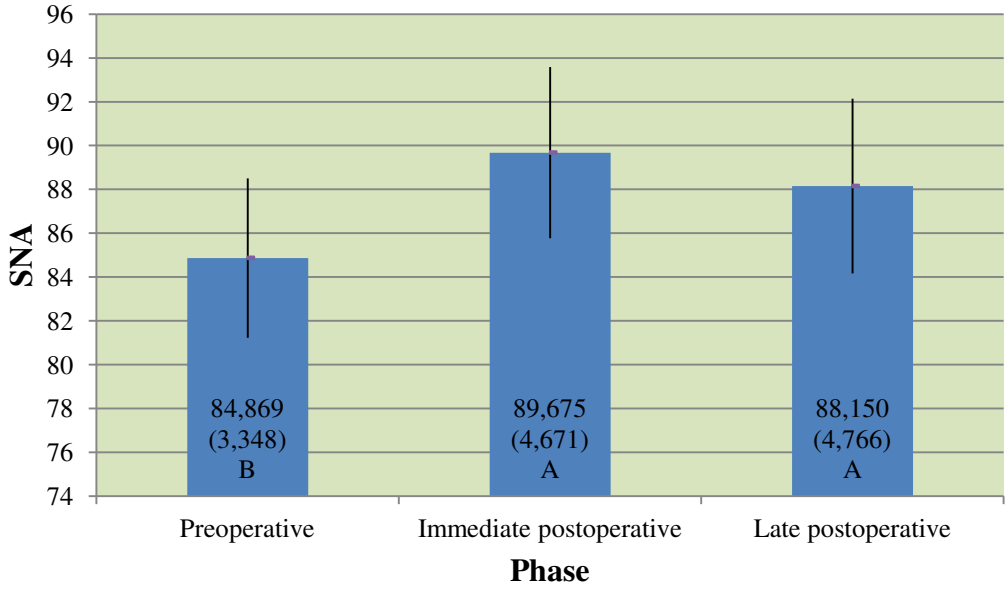
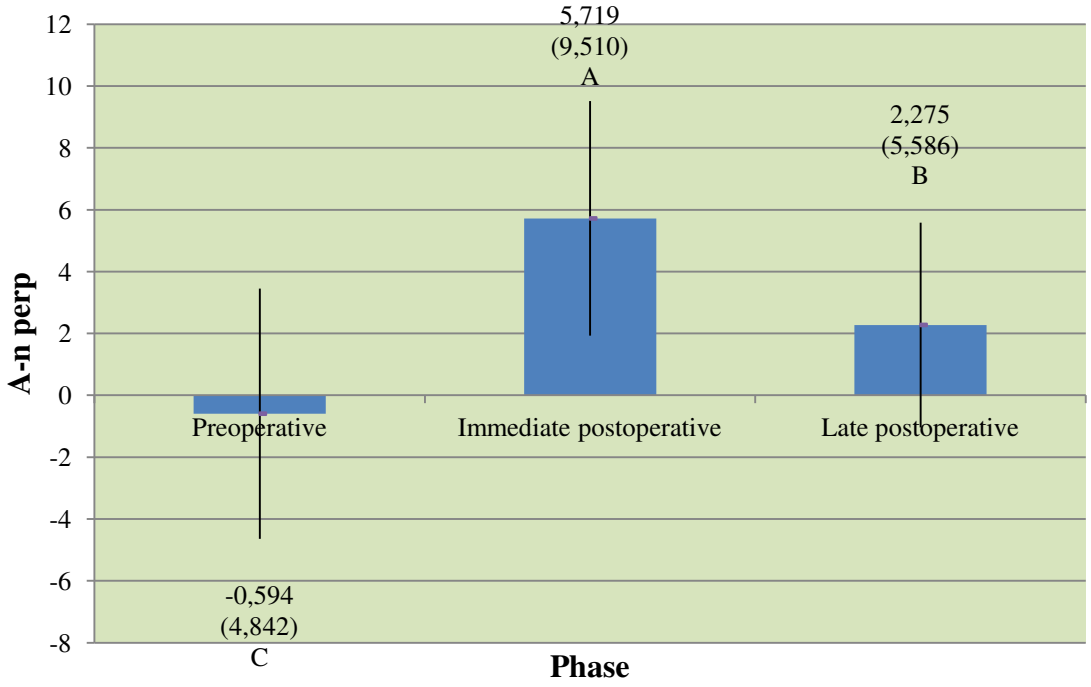


Fig 4: Mean values of SNA. There was a statistically significant difference between all of the 3 phases.



DISCUSSION

Relapse of maxillary movements and different graft materials to minimize it have been studied by many authors [1, 2, 5, 6].

The use of surgical cement to fill traumatic or surgically induced bone voids and gaps in the skeletal system is widespread, with three main material types dominating the literature on the subject: acrylics, composites and calcium-phosphates [7].

Calcium-phosphate cements have established clinical interest due to their potential to be resorbed and replaced with new bone as part of the natural bone remodeling cycle without provoking inflammatory response [6]. In our study, no patient had inflammatory response or foreign body response.

According to Chow & Takagi, 2001, the porosity of this material makes it an effective osteoconductive and osteointegrative material, with excellent biocompatibility and mechanical properties [4]. Added to this, Hydroset ® has a great working time (about 4 min 20 s) and is chemically formulated to be set in a wet field environment, similar characteristics of the surgical operative field [8].

Schimtz et. al., 1999, performed a critical review of reconstruction of bone using calcium phosphate bone cements in craniofacial surgery [9]. According to them, these materials are substantially different from the previously hydroxyapatite ceramic materials of the 1980´s. These materials 1) have x-ray diffraction spectra similar to the mineral phase of bone, 2) set endothermically at body temperature, 3) are capable of being injected into fractures or bone defects, 4) have compressive strengths equal to or greater than bone, 5) form chemical bonds to the host bone and 6) may exhibit osteoconductive properties.

The requirement for grafting in maxillary advancement is still controversial in literature (Table 1). Many studies in literature suggest the indication of grafting the gaps between bone segments in orthognathic surgery [1,5, 6,10, 12].

Araujo et. al., 1978, suggested that bone graft should be used when the advancement is greater than 6 mm and certainly for those in excess than 10 mm [5].

Wardrop & Wolford, 1989, evaluated stability in maxillary advancement and inferior repositioning of the maxilla, whereas hydroxyapatite blocs were used as a graft material [6]. Preoperative, immediate and late postoperative cephalograms were overlapped and less than 1 mm of relapse was observed. Microscopically bone incorporation was observed and there was no inflammatory response enabled the use of this material.

Waite et. al, 1996, compared the relapse of maxilla forward in patients that bone graft were utilized and in patients that had rigid fixation alone [10]. They concluded that stability was greater in a bone-grafted group (mean relapse of 7%)

than in a nongrafted group (mean of 18%) and indicated the use of grafts when maxilla was forwarded more than 4 mm.

Kerawala et. al., 2001, evaluated how iliac crest grafts are important in maxillary surgery in non-cleft patients. They analyzed 112 radiographs and suggested that bone grafts increase stability in Le Fort I surgeries[1].

Downling et. al., 2005, analyzed by cephalometrics the stability and risk factor for relapse in Le Fort I advancement [11]. They concluded that a 1-piece Le Fort I osteotomy is a relatively stable procedure, however suggested that there are factors that can augment the relapse possibilities (higher advancements and when inferior repositioning are associated).

Kuvat et.al., 2009, evaluated the use of osteogenetic materials in maxilla advancement surgery [12]. They concluded that these materials are adequate to reduce skeletal relapse and suggest the use of synthetic materials or bone grafts when maxilla advancement of 3 mm or more will be performed.

None of these studies used the calcium-phosphate cement as a grafting material.

While some studies related the amount of maxillary advancement to necessity of grafting [5, 10, 12], there are others studies that did not perform grafting and had a minimal skeletal relapse [11, 14, 15].

Hoffman & Brennan, 2004 [13], revealed that uncontrollable variables, including patients age, sex, together with the magnitude of advancement and the influence of simultaneous mandibular advancement had no effect on the post-operative skeletal stability in orthodontically prepared, rigid fixed one-piece Le Fort I osteotomy without bone grafting to advance the maxilla [13].

Hoffman & Brennan, 2004 [14], studied the skeletal relapse of 45 patients who had undergone a uniform one-piece maxillary advancement (15 with simultaneous

mandibular advancement) without using grafts in the bone gaps [14]. The mean surgical maxillary advancement was 7.42mm, and the maxilla was fixed with plate and screws and the relapse was not significant.

Proffit et. al., 2007, in a study that updated the hierarchy of stability in orthognathic surgery, evaluated cephalometric measurements of 45 patients after 1-year of forward movement of maxilla and rigid fixation. Relapse until 4 mm are considered moderate relapse and it was observed in 80% of the sample [15]. They concluded that this is a stable movement. However, when maxilla forward movement is associated with mandible setback, the stability decreases.

Van Sickels & Richardson (1996), suggested advancing the maxilla at least 2mm more than the ideal overjet to compensate for relapse when mandibular surgical movements are associated [16].

Table 1: Data in literature concerning maxillary stability after advancement with or without grafting with number of patients, type of fixation, association with mandibular surgery, mean of maxillary advancement and relapse. IRF- Internal Rigid Fixation; HA- hydroxyapatite, HDBM- Human Demineralised Bone Matrix, BB- Bovine Bone Collagen-Protein Extracts, CP- Calcium-phosphate cement; G – graft; NG –Nongraft; ns: not significantly.

First author	Year	Patients	Type of Fixation	Mandible (number)	Graft	Maxillary Advancement (mean, mm)	Relapse
Wardrop	1989	14	IRF	5	Yes (HA)	> 5	U1 - FHP: < 1 mm
Waite	1996	22	IRF	22	Yes (Bone)	9.7 (mean - G) 10 (mean - NG)	A: 0.7 mm (G); 1.7 mm (NG)
Kerawala	2001	112	IRF	76	Yes (Bone)	3.8 (mean)	A: 3.1 mm
Hoffman	2004	45	IRF	15	No	7.43 (mean)	Ba-Na: 0.7 mm
Downling	2005	43	IRF	No	No	4.9 (mean)	A: 0.9 mm
Proffit	2007	43	IRF	0	No	> 2	2-4 mm
Kuvat	2009	10	IRF	10	Yes (HDBM and BB)	5.7 (mean)	ns
This study	2012	8	IRF	5	Yes (CP)	6.5 (mean)	Co-A: ns; SNA: ns; A-Nperp: 4m

This study consisted in a mean of 6.5 mm of maxillary advancement and 5 of them had mandible setback associated. Analyzing SNA and Co-A measurements, there is no significantly relapse. However, A-Nperp measure demonstrated a mean of 4 mm of movement relapse (moderate relapse). This difference at the same sample but in different landmarks should be explained because Nperp is influenced by another landmark, the Frankfurt Horizontal Plane. It can increase the number of variables and should lead to a different result from other. Calcium-phosphate cement can be used safely as graft material but the high cost until limits its use.

CONCLUSION

In this study, calcium-phosphate cement proved to be an adequate graft material to be used in orthognathic surgery. Associated with titanium plates, improve a minimal skeletal relapse of the movement.

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CONCLUSÕES

Por meio destes três trabalhos, pode-se concluir:

- O Software Dolphin Imaging pode ser utilizado com radiografias escaneadas ou fotografadas, sem prejuízo em relação a fidedignidade das imagens;

- Nesta amostra, os traçados cefalométricos no Dolphin Imaging Software em pacientes Classe II que foram submetidos a cirurgia ortognática de avanço mandibular mostraram que os incisivos superiores estão dentro dos valores "ideais" enquanto os incisivos inferiores permaneceram compensados, em sua maioria;

- O cimento de cálcio fosfato é um material de enxertia que pode ser aplicado com segurança em cirurgia ortognática. Juntamente com o uso de placas e parafusos de titânio, reduziu a recidiva do movimento quando analisadas a distância Co-A e o ângulo SNA. Entretanto, quando leva-se em consideração a distância A-Nperp, a recidiva foi moderada.

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* De acordo com a norma da UNICAMP/FOP, baseadas na norma do International Committee of Medicals Journal Editors- Grupo Vancouver. Abreviatura dos periódicos em conformidade com o Medline.

ANEXO 1

COMITÊ DE ÉTICA EM PESQUISA
FACULDADE DE ODONTOLOGIA DE PIRACICABA
UNIVERSIDADE ESTADUAL DE CAMPINAS

CERTIFICADO

O Comitê de Ética em Pesquisa da FOP-UNICAMP certifica que o projeto de pesquisa **"Estudo comparativo entre dois métodos de obtenção de radiografias para traçado cefalométrico digital: Uso do escaner e uso da fotografia"**, protocolo nº 025/2012, dos pesquisadores Gabriela Mayrink Gonçalves, satisfaz as exigências do Conselho Nacional de Saúde - Ministério da Saúde para as pesquisas em seres humanos e foi aprovado por este comitê em 21/06/2012.

The Ethics Committee in Research of the School of Dentistry of Piracicaba - State University of Campinas, certify that the project **"Comparative study of two methods of measurements from photographed lateral cephalograms and scanned cephalograms"**, register number 025/2012, of Gabriela Mayrink Gonçalves, comply with the recommendations of the National Health Council - Ministry of Health of Brazil for research in human subjects and therefore was approved by this committee at 06/21/2012.

Profa. Dra. Lívia Maria Andaló Tenuta
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COMITÊ DE ÉTICA EM PESQUISA
FACULDADE DE ODONTOLOGIA DE PIRACICABA
UNIVERSIDADE ESTADUAL DE CAMPINAS

CERTIFICADO

O Comitê de Ética em Pesquisa da FOP-UNICAMP certifica que o projeto de pesquisa **"Análise da inclinação de incisivos pré-operatória em pacientes com deformidade Classe II submetidos a cirurgias de avanço mandibular"**, protocolo nº 004/2012, dos pesquisadores Gabriela Mayrink Gonçalves, satisfaz as exigências do Conselho Nacional de Saúde - Ministério da Saúde para as pesquisas em seres humanos e foi aprovado por este comitê em 23/03/2012.

The Ethics Committee in Research of the School of Dentistry of Piracicaba - State University of Campinas, certify that the project **"Preoperative incisor inclination in patients with Class II dentofacial deformities treated with orthognathic surgery"**, register number 004/2012, of Gabriela Mayrink Gonçalves, comply with the recommendations of the National Health Council - Ministry of Health of Brazil for research in human subjects and therefore was approved by this committee at 03/23/2012.

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COMITÊ DE ÉTICA EM PESQUISA
FACULDADE DE ODONTOLOGIA DE PIRACICABA
UNIVERSIDADE ESTADUAL DE CAMPINAS

CERTIFICADO

O Comitê de Ética em Pesquisa da FOP-UNICAMP certifica que o projeto de pesquisa **"Avaliação da estabilidade em cirurgia ortognática utilizando um cimento de cálcio-fosfato"**, protocolo nº 139/2011, dos pesquisadores Gabriela Mayrink Gonçalves, satisfaz as exigências do Conselho Nacional de Saúde - Ministério da Saúde para as pesquisas em seres humanos e foi aprovado por este comitê em 23/01/2012.

The Ethics Committee in Research of the School of Dentistry of Piracicaba - State University of Campinas, certify that the project **"Stability in orthognatic surgery using a calcium-phosphate cement"**, register number 139/2011, of Gabriela Mayrink Gonçalves, comply with the recommendations of the National Health Council - Ministry of Health of Brazil for research in human subjects and therefore was approved by this committee at 01/23/2012.

Lívia M. A. Tenuta

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