SIMONE GUIMARÃES FARIAS GOMES

INFLUÊNCIA DO PADRÃO FACIAL VERTICAL SOBRE A MASTIGAÇÃO E SEUS PARÂMETROS

Tese apresentada à Faculdade de Odontologia de Piracicaba da Universidade Estadual de Campinas para obtenção do título de Doutor em Clínica Odontológica – Área de concentração Prótese Dental.

Orientadora: Profa. Dra. Renata Cunha Matheus Rodrigues Garcia

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RESUMO

Acredita-se que a morfologia craniofacial vertical influencia a disposição dos músculos mastigatórios, podendo afetar algumas funções do sistema estomatognático. Diante disto, os objetivos deste estudo foram comparar, entre indivíduos com diferentes padrões faciais verticais, a qualidade da mastigação e os seguintes parâmetros: área de contato oclusal, atividade muscular, esforço muscular, movimentos mandibulares, assimetrias laterais e lado de preferência da mastigação. Para isto, setenta e oito indivíduos saudáveis e dentados foram selecionados e divididos em três grupos de acordo com o padrão facial vertical determinado pelo índice VERT: (1) mesofacial, (2) braquifacial e (3) dolicofacial. A qualidade da mastigação foi obtida por meio dos índices de eficiência e performance mastigatórias, utilizando-se um material teste artificial à base de silicone e um sistema contendo dez peneiras. A eficiência mastigatória foi calculada pelo percentual de material triturado menor que 2 mm, e a performance, pelo valor de X50, obtido com a aplicação da fórmula de Rosin-Rammler. A área de contato oclusal foi avaliada bilateralmente por meio de moldagem das superfícies oclusais com silicone e análise da imagem reproduzida com software apropriado. A atividade eletromiográfica foi realizada nos músculos masseteres e temporais anteriores em repouso, durante contração vertical máxima e mastigação. O esforço que os músculos mastigatórios desempenharam durante a mastigação foi determinado pela porcentagem da atividade durante a função em relação à atividade individual máxima. Os movimentos mandibulares e o lado de preferência mastigatório foram avaliados utilizando-se um cinesiógrafo. A determinação das assimetrias laterais, força máxima de mordida e área de contato oclusal foram avaliadas unilateralmente por meio de sensores posicionados na região de primeiro molar e com molde de silicone, respectivamente. Os dados foram analisados por meio de métodos estatísticos cuidadosamente selecionados e com nível de significância de 5%. Para os dados de eficiência, performance, área de contato oclusal bilateral, atividade muscular em repouso e durante contração vertical máxima, indivíduos dolicofacias apresentaram menores valores, sendo seguidos por indivíduos mesofaciais e braquifacias. Dolicofaciais apresentaram também assimetria de força máxima de mordida, assim como desempenharam maior esforço muscular e maior movimentação posterior da mandíbula, ambos durante a mastigação. Não foram encontradas diferenças significantes entre os três grupos para atividade muscular durante a mastigação e lado de preferência. Todos os grupos apresentaram contatos oclusais assimétricos, com maior área do lado esquerdo. Nos termos em que este estudo foi realizado, pode-se concluir que a morfologia craniofacial influencia a função mastigatória e seus parâmetros.

Palavras-chave: Músculos mastigatórios, movimento, mandíbula.

ABSTRACT

Craniofacial vertical morphology may influence the disposition of masticatory muscles, affecting some functions of stomatognathic system. Thus, the aims of this study were to evaluate, in subjects with different facial vertical pattern, the quality of mastication and the following masticatory parameters: occlusal contact area, muscles activities, muscle effort, mandibular movement, lateral asymmetries and chewing side preference. Seventy-eight healthy and dentate individuals were selected according to facial vertical pattern, which was determined using VERT index: (1) mesofacial, (2) brachyfacial, (3) dolichofacial. Quality of mastication was determined by masticatory efficiency and masticatory performance indexes, using a silicon based test material and a system composed by 10 sieves. Masticatory efficiency was calculated by the percentage of comminuted material up to 2 mm, and masticatory performance was given by the X50 value, which was obtained by the Rosin-Rammler equation. Occlusal contact area was evaluated bilaterally using silicon casting of occlusal surfaces and analysis of scanned image with appropriate software. Electromyographic activity of masseter and anterior temporal muscles was carried out at rest, during maximal vertical clenching and during mastication. Muscles effort of masticatory muscles was determined by the percentage of activity used for mastication in relation to the maximal muscle activity. Mandibular movements and chewing side preference were evaluated using a jaw-tracking device. For determination of lateral asymmetries, maximal bite force and occlusal contact area were analysed unilaterally by means of sensors positioned in first molar region and silicon cast, respectively. Data were analyzed using carefully selected statistics methods at a 5% significant level. Dolichofacial subjects presented lower values of masticatory efficiency, masticatory performance, bilateral occlusal contact area, muscle activity at rest and during maximal vertical clenching followed by mesofacial and brachyfacial subjects. Dolichofacials also presented maximal bite force asymmetry, as well as accomplished larger muscle effort and mandibular posterior movement, both during chewing. No significant difference was found among groups for muscle activity during mastication and chewing side preference. All groups presented occlusal contact area asymmetry, with larger area at left side. In the terms in which this study was performed, it can be concluded that craniofacial morphology influences masticatory function and its parameters.

Key Words: Masticatory muscles, movement, mandible.

SUMÁRIO

INTRODUÇÃO

O crescimento do crânio, durante a vida intra-uterina, sobrepõe-se ao crescimento da face, priorizando o desenvolvimento cerebral. Ao nascimento, as alturas superior e inferior da face apresentam aproximadamente 40% das dimensões que poderão atingir na fase adulta. Nos primeiros anos de vida, o crescimento facial atinge um ritmo acelerado e, apesar do desenvolvimento tridimensional, o crescimento vertical é dominante (Ranly, 2000). Grande parte das variações faciais horizontais e verticais, 68% e 55%, respectivamente, são atribuídas ao genótipo de cada indivíduo (Jelenkovic *et al.*, 2008). No entanto, o desenvolvimento é determinado pela interação entre fatores genéticos e ambientais, os quais podem desencadear alterações morfológicas e funcionais dos músculos e influenciar o desenvolvimento da região dentofacial (Gedrange & Harzer, 2004).

A mandíbula funciona como uma alavanca capaz de transferir força muscular para os dentes (Weijs, 1989) e pode ser dividida em várias unidades de desenvolvimento: corpo, responsável por proteção nervosa e como base para os outros elementos; processo alveolar, que depende da presença dos dentes; processo condilar, que influencia o formato da mandíbula e sua direção de crescimento; processo coronóide e ângulo da mandíbula, que são influenciados de maneira significante pela atividade e inserção dos músculos (Ranly, 2000).

Em estudos realizados com animais, foi observado que aqueles alimentados com uma dieta de pouca consistência durante o crescimento apresentaram dimensões transversais reduzidas da maxila e da mandíbula. Além disso, ângulos mandibulares menos convexos, côndilos menores e rotação da mandíbula também foram encontrados nestes animais (Kiliaridis *et al.*, 1999; Katsaros *et al.*, 2002; Abed *et al.*, 2007), sugerindo-se que a função mastigatória desempenha papel determinante no padrão de crescimento facial (Abed *et al.*, 2007). Apesar dos achados, ainda não se sabe se a força dos músculos mastigatórios determina a morfologia facial ou se esta, por sua vez, dita a força da musculatura mastigatória (Pepicelli *et al.*, 2005).

Variações da dimensão facial vertical constituem três tipos básicos: braquifacial, indivíduos com tendência de crescimento no sentido horizontal; mesofacial, indivíduos com padrão de crescimento equilibrado; e dolicofacial, indivíduos com tendência de crescimento no sentido vertical (Ricketts, 1960) (Figura 1). O padrão facial é determinado por meio de análise cefalométrica, em que algumas variáveis podem ser utilizadas, como ângulo do plano mandibular em relação ao Plano de Frankfurt (Farella *et al.*, 2003) e ao plano SN (Ueda *et al.*, 2000), além de conjuntos de ângulos (Vianna-Lara *et al.*, 2009) e medidas lineares (Charalampidou *et al.*, 2008). O índice VERT preconizado por Ricketts (1982) utiliza cinco medidas: ângulo do eixo facial (Ba-Na e Pt-Gn), ângulo da profundidade facial (F e N-Pog), ângulo do plano mandibular (F e Go-Me), altura facial inferior (Xi-ENA e Xi-Pm), e arco mandibular (DC-Xi e Xi-Pm), sendo capaz de promover uma mensuração mais global e interativa da morfologia facial (Shinkai *et al.*, 2007).

Um modelo matemático de função mastigatória foi utilizado para demonstrar que a performance do sistema mastigatório está relacionada com as proporções e configurações dos músculos mastigatórios, e com a morfologia mandibular em diferentes espécies de peixe, baseado em sua anatomia e especificidade nutricional (Maie *et al.*, 2009). Em humanos, indivíduos dolicofaciais apresentam face com altura posterior curta, plano mandibular acentuadamente inclinado, ângulo mandibular oblíquo e comumente com a porção superficial do músculo masseter anteriormente inclinada em relação ao plano oclusal (Takada *et al.*, 1984). Isto gera uma desvantagem mecânica nos indivíduos de face longa em relação a indivíduos braquifaciais, por resultar em uma relação desfavorável entre braço de resistência exercido pelo músculo masseter e braço de potência gerado pela força de mordida (Throckmorton *et al.*, 1980; Charalampidou *et al.*, 2008), sugerindo que indivíduos de face longa podem apresentar menor capacidade da função mastigatória.

A mastigação é uma atividade sensório-motora, a qual prepara o alimento para deglutição e processamento, e é determinada por vários fatores, tais como força de mordida, área de contato oclusal, movimentos mandibulares, atividade muscular (Van der Bilt *et al.*, 2006) e área da secção transversal dos músculos (Hatch *et al.*, 2001). Há relato na literatura de associação entre padrão facial vertical e função mastigatória (Hirose & Ito, 1988), assim como da associação da morfologia facial com determinantes da mastigação. Raadsheer *et al.* (1999) e Sondang *et al.* (2003) relataram maior força máxima de mordida em indivíduos com características morfológicas associadas a face curta. É certo que num período de 24 horas, normalmente, a força máxima de mordida é exercida por um período muito curto, por isso, a carga gerada pelos músculos durante as atividades funcionais deveriam ser consideradas mais fortemente quando o intuito é associar fatores funcionais e morfológicos (Boom *et al.*, 2008). Esta relação foi relatada por Ingervall & Thilander (1974) e Proffit *et al.* (1983), que demonstraram que indivíduos com face longa obtiveram menor força de mordida tanto durante o apertamento como durante a mastigação.

A magnitude da força depende do tamanho do músculo, da sua arquitetura e da sua posição em relação à articulação (Boom *et al.*, 2008). Por isso, a vantagem mecânica é fator importante, no entanto, o tamanho dos músculos mastigatórios é um fator mais significante para a determinação da eficiência muscular (Throckmorton & Dean, 1994). Indivíduos dolicofaciais apresentam secção transversal dos músculos masseter, pterigóideo medial e temporal anterior, respectivamente, 15-30% (Van Spronsen *et al.*, 1992; Farella *et al.*, 2003), 22% e 15% menor quando comparados a indivíduos mesofaciais (Van Spronsen *et al.*, 1992). Volume dos músculos mastigatórios também apresenta correlação positiva com altura posterior da face (Boom *et al.*, 2008).

A atividade dos músculos mastigatórios já foi comparada entre indivíduos com diferentes tipos faciais; contudo, os resultados encontrados apresentam-se conflitantes ora mostrando padrão eletromiográfico diferente entre os tipos faciais verticais (Ueda *et al.*, 2000; Tecco *et al.*, 2007; Li *et al.* 2008) ora não detectando nenhuma influência da morfologia na atividade muscular (Farella *et al.*, 2005; Vianna-Lara *et al.*, 2009). Outros parâmetros, tais como contatos oclusais e movimentos mandibulares jamais foram descritos para populações com diferentes morfologias craniofaciais.

Considerando-se que o padrão facial vertical pode desempenhar papel significante nas funções orofaciais, faz-se importante conhecer como esta influência é exercida. Desta forma, tratamentos dentários, protéticos e das disfunções temporomandibulares poderiam ser individualizados e otimizados, tendo o padrão craniofacial como mais uma informação durante a tomada de decisões que envolve diagnóstico e tratamento odontológico. Por isso, este estudo teve como objetivos avaliar a influência do padrão facial sobre:

- Função mastigatória, por meio de eficiência e performance mastigatórias;
- Área de contato oclusal;
- Atividade dos músculos masseter e temporal anterior durante o repouso, contração voluntária máxima e mastigação;
- Esforço dos músculos masseter e temporal anterior durante a mastigação;
- Movimentos mandibulares durante a mastigação;
- Assimetrias laterais de área de contato oclusal e força máxima de mordida;
- Preferência de lado de mastigação.

CAPÍTULO 1: Mastication, EMG activity and occlusal contact area in subjects with different facial types.

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Abstract

Dentofacial morphology may affect orofacial functions, therefore the aims of this study were to evaluate the influence of craniofacial morphology on masticatory function, occlusal contact area (OCA) and masticatory muscles activity. Seventy-eight subjects were divided into 3 groups according to vertical facial pattern: (1) mesofacial; (2) brachyfacial; (3) dolichofacial. Artificial material and sieving method were used to access masticatory efficiency (ME). OCA was determined by registration of posterior teeth. Electromyographic (EMG) activity of masseter and anterior temporal (AT) muscles were accessed bilaterally at rest and maximal vertical clenching (MVC). ME (%) was significantly higher in brachyfacial and lower in dolichofacial subjects. Brachyfacials presented the highest OCA (mm^2) followed by meso and dolichofacials subjects. For EMG of masseter and AT in both conditions, dolichofacials presented the lowest activity values, while brachyfacials significantly higher measurements. Craniofacial morphology affected masticatory function, OCA and EMG activity of masticatory muscles.

Key words: Masticatory muscles, electromyography, dental occlusion.

Introduction

Masticatory function, which is objectively defined as masticatory performance and masticatory efficiency,[1] is highly correlated with dentofacial morphology.[2] Masticatory function is affected by several factors such as loss of postcanine teeth, severity of malocclusion, body size, age, gender, food texture and taste, sensory feedback, occlusal contact area and bite force,[1,3] being many of the mentioned masticatory predictors linked to vertical facial pattern. However, occlusal factors and bite force seem to be the key determinants,[3] controlling 48%[4] and 36%[5] of masticatory performance, respectively.

Craniofacial vertical pattern and bite force have been related, showing that individuals with strong bite force present a more uniform facial morphology, reduced anterior face high,[6] larger posterior face high, less inclination of the mandibular plane[7,8] and higher mandibular ramus.[9] These reports indicate that short face individuals (brachyfacials) present greater bite force when compared to long (dolichofacials) and medium face (mesofacials) individuals,[9] suggesting an indirect association of craniofacial morphology and masticatory function. A predictor of bite force and masticatory function is the masticatory muscles electromyographic (EMG) activity, once chewing requires muscle activity to make the movements of the jaw and to exert forces in order to cut or grind the food.[1] It is suggested that significant differences exist in muscles EMG activity according to vertical facial skeletal types,[10-12] however, controversial findings were reported in previous EMG studies conducted to determine this relationship.[13,14]

The association between masticatory function and occlusion is clear.[15] Tooth shape, chewing preferred side, number of teeth and occlusal contact area have been referred as occlusal factors, being the number of occlusal contacts the most significant occlusal variable.[15] On the other hand, the relation of occlusal contacts and facial vertical pattern has not been elucidated. It has been reported that morphology and orientation of jaw-closing muscles may have a complex correlation to the weaker and unbalanced occlusal force, as well as to a lower occlusal contact area in patients with skeletal mandibular asymmetry.[16]

A better understanding of the real and direct role of the craniofacial morphology on oral function is needed once many actions can be executed to prevent, facilitate and better indicate prosthetics and orthodontics therapy. To report what have not been analyzed yet or to elucidate some controversies, the aims of this study were to evaluate masticatory efficiency and two of its predictors: masticatory muscle activity and occlusal contact area, of individuals with different craniofacial vertical pattern.

Materials and Methods

Seventy-eight individuals (39 males and 39 females) with mean age of 23.5 years participated in this study. Subjects with good general and oral health, without facial deformities, presenting a complete dentition (except for missing third molars) and no malocclusion were selected. Subjects with history of maxillofacial surgery or jaw injuries, orthodontic treatment concluded in the last 2 years, temporomandibular disorders and parafunctional habits were excluded from the study. All subjects were selected among students and staff of Piracicaba Dental School, as well as among patients who had sought dental treatment in the same institution. The research protocol (number 059/2004) was approved by the Ethics Committee of Piracicaba Dental School, University of Campinas and all participants signed a written informed consent.

The selected subjects who accepted to participate in this study had their weight (in kilograms - kg) and height (in meters - m) measured with their body in the erect position and with nude feet (Mechanical anthropometric scale R110, Welmy, Santa Bárbara D'Oeste). The subjects were also submitted to lateral cephalograms image exam using the standard protocols and the same radiographic unit (Elipsopantomograph Funk X-15, Macrotec Indústria e comércio de equipamentos Ltda., São Paulo). The cephalograms were processed with an automatic processor (Macrotec MX-2, Macrotec Indústria e comércio de equipamentos Ltda, São Paulo) and analyzed by a digital cephalometric analisis (Radiocef v.4.0, Radio Memory Ltda, Belo Horizonte). The VERT Index was used to determine the facial vertical pattern of the participants, who were divided into 3 groups (n=26) according to the facial type: (1) mesofacial (VERT Index between -0.49 and + 0.49), (2) brachyfacial (VERT Index > 0.5) and (3) dolichofacial (VERT Index < - 0.5).[17] The cephalometric analysis and the classification of the subjects by facial pattern were accomplished after all the tests had been executed, i.e. the two operators were blind for facial pattern during the tests.

Masticatory efficiency

Masticatory efficiency was evaluated using an artificial test material for chewing and a sieve method of analysis. The artificial material was made of a silicon based rubber (Optosil, Heraeus Kulzer, Hanau), which was manipulated according to the instructions of the manufacturer and inserted in a metal mould to create cubes with 5.6 mm of edge. After setting, the silicon cubes were removed from the mould and individually weighted for standardization. The silicon cubes were transported to an electric stove for 16 hours at 60°C to ensure complete reticulation.[18] After, the silicon cubes cooled down at environment temperature, they were disinfected with 2% glutaraldehyde solution during 30 minutes, washed, dried with absorbent paper and weighted once again. Portions of 17 silicon cubes (approximately 3 cm^3 or 3.4 g) were separated and stored in plastic containers until the test. One portion of silicon cubes was given to each participant, who was oriented to chew it in the habitual way. The operator counted 20 chewing strokes and asked the subjects to expectorate the chewed particles into a paper filter sitting on a glass container. Two hundred milliliters of water were used for mouth rinses aiming the complete cleansing of the oral cavity and expectorated into the same filter. The mouths of the subjects were then examined for retained pieces of the fragmented artificial test material. After the total water drain, the paper filter was stored in an electric stove during 25 minutes at 80°C[4] and finally taken to the sieving system, which was composed by 10 sieves with gradually decreasing apertures from 5.6 to 0.5 mm, a bottom plate and a sieving machine (Bertel Indústria Metalúrgica Ltda., Caieiras) for 20 minutes. The fragmented test material present in each sieve and in the bottom plate was weighted in a 0.0001 g analytical balance (Mark, 2060, Bel Engineering s.r., Monza). Masticatory efficiency was calculated by the weight percentage of the fragmented material which passed the 10-mesh sieve (2 mm aperture),[19] i.e. the particles ≤ 2 mm.

Electromyographic activity

Activities of masseter and anterior temporal muscles were measured during rest and maximal clenching, using a BioEMG electromyographic amplifier (Bioresearch Inc., Milwaukee) and the BioPAK program (Microsoft Corporation, Redmond). BioEMG is an 8 channel electromyographic unit with a 30 to 600 Hz band-pass filter. Silver/ silver chloride bipolar passive surface electrodes (Bio-Research, Milwakee) were placed bilaterally in the direction of the muscles fibers, on the most prominent point of the masseter[14] and anterior temporal muscles during contraction. Before placement of the electrodes, the skin of the subjects was cleaned with alcohol to reduce the impedance between skin and electrodes.[12]

Subjects were sited on a dental chair and instructed to maintain the head with the Frankfort Plane parallel to the ground and asked to avoid head and body movements during the test. The EMG activity of masseter and anterior temporal muscles was studied bilaterally with the mandible at the rest position and during maximal voluntary clenching (MVC). For the MVC recording, the subjects were instructed to close their jaws in occlusion as forcefully as possible[12] during 7 seconds with a 2 minute interval between contractions measurements. The EMG activity during rest and MVC of masseter and anterior temporal muscles were conducted for three times and data was obtained by the arithmetic means of the three repetitions. The average electromyographic activities of the contralateral muscles were summed[11] and expressed as mean and s.d. In addition, EMG was normalized to the activity obtained during maximal voluntary contractions (MVC).

Method error (Se) was calculated using Dahlberg's formula. The measurement error was small, not exceeding for the recording of EMG activity 0,69 μV (0,2%) in the masseter muscle, while in the temporal muscle it was found to be larger, up to 1,36 μV (2,9%).

Occlusal contact area

Silicone-based occlusal registrations of the posterior teeth (molars and premolars) were obtained bilaterally[20] with the subjects in maximum intercuspation. Addition silicone (RE'CORD, Bosworth Company, Skokie) was applied to plastic frames (Big Bite Tray, Bosworth Company, Skokie) with the gauze mesh removed, and placed into the mouth of the subjects on the mandibular posterior teeth. The subjects were asked to close their teeth into the maximum intercuspal position and instructed to keep that position until complete setting of the silicone was recognized.[21] The record was carefully removed from their mouth and for each record, preparation for the image analysis was performed.[21]

Each occlusal registration was digitalized using a desktop scanner (2400, Hewlett Packard Development Company, Barueri). Registrations were placed on the scanner bed with the mandibular occlusal surface facing downward.[20] The software Adobe Photoshop CS3 (Adobe Systems Inc., San Jose) was used to discolor, invert and adjust the images of the occlusal registrations. The software program Image Tool (University of Texas Health Science Center, San Antonio) was used to manually trace the occlusal contact areas of the posterior teeth of the 3 times magnified image. The traced occlusal contact areas were automatically calculated by the software by the frequency distributions of pixels corresponding to each of 256 gray scales.[20] Pieces of addition silicone of known thickness, measured with a digital caliper (Digimess Instrumentos de Precisão Ltda., São Paulo) was analyzed by the Image Tool program and used to establish the relationship between each of the 256 gray scales and the thickness of the occlusal registration on the basis of the pixels density per unit area.[20]

Data were evaluated according Gurdsapsri *et al.*,[21] who considered that occlusal contact areas present less than 50 μm thickness of the impression material and near contact area, from 50-350 μm thickness.[20]

Statistical Analysis

Anthropometric characteristics may influence some masticatory parameters, therefore, ANOVA one-way was used to analyze homogeneity of the sample, concerning weigh and high of meso, brachy and dolichofacial subjects. Same attention was reserved for age, which was analysed using ANOVA on Ranks.

Comparison between masticatory efficiency, masticatory muscles activity and occlusal contact area of subjects with different facial morphology was accessed. Normality or equal variance test failed for all variables studied, therefore, ANOVA on Ranks and Student Newman-Keuls were used for all data. Statistics were performed at a 5% significance level using the SigmaStat software (Version 3.5, Systat Software, Inc. Chicago).

Results

Anthropometric and sample characteristics are shown in Table 1. A homogeneous distribution among groups can be observed ($p>.05$).

Differences in facial morphology affected the reduction of the artificial material test ($p<.0001$). Long face subjects (dolichofacials) presented lower masticatory efficiency, while short face (brachyfacials) subjects pulverized the silicone cubes better, presenting higher percentage of fragmented material < 2 mm (Table 2).

Occlusal contact area differed between the three facial morphologies ($p<.0001$), being larger in brachyfacial subjects, followed by mesofacial and dolichofacial participants (Table 2).

Table 1. Characteristics of the subjects (Means ± sd).

	Mesofacial	Brachyfacial	Dolichofacial	Total
Male (number)	13	13	13	39
Age (years)	23.5 ± 2.9	23.9 ± 4.5	22.9 ± 3.8	23.5 ± 3.7
BMI	25.8 ± 2.9	23.9 ± 2.6	24.9 ± 3.3	24.9 ± 1.0
Female (number)	13	13	13	39
Age	25.2 ± 5.7	23.2 ± 4.6	22.1 ± 2.2	23.6 ± 4.4
BMI	22.3 ± 4.7	22.3 ± 2.5	21.7 ± 1.9	22.1 ± 0.3
Total (number)	26	26	26	78
Age	24.4 ± 4.5	23.7 ± 4.3	22.5 ± 3.1	23.5 ± 4.0
BMI	24.1 ± 4.3	21.6 ± 5.2	23.3 ± 3.1	23.3 ± 1.3

BMI = body mass index, which is calculated by the formula: weight / $heigh^2$.

Table 2. Masticatory efficiency (%) and occlusal contact area (mm^2) of subjects with different facial morphology (Means ± sd).

	Masticatory efficiency	Occlusal contact area
Mesofacial	8.8 ± 5.0 a	122.4 ± 13.9 a
Brachyfacial	14.0 ± 6.8 b	144.1 ± 27.8 b
Dolichofacial	4.4 ± 3.8 c	97.5 ± 23.9 c

Different letters show statistical differences among groups ($p \leq .05$).

Significant differences among groups were observed in masseter muscles at rest ($p<.001$) and during MVC ($p<.001$), as well for anterior temporal muscles in both contraction conditions ($p<.001$), being the higher values observed in the brachyfacial group, followed by mesofacial and dolichofacial groups respectively (Table 3).

Table 3. Masticatory muscles activity of masseter and anterior temporal muscles at rest and MVC (Means ± sd).

	Mesofacial	Brachyfacial	Dolichofacial
Rest			
Masseter	3.33 ± 0.27 a	3.60 ± 0.29 b	3.15 ± 0.31 c
Temporal	3.45 ± 0.36 a	3.63 ± 0.17 b	3.37 ± 0.17 c
MVC			
Masseter	238.49 ± 17.90 a	258.25 ± 23.91 b	223.09 ± 10.78 c
Temporal	236.02 ± 26.38 a	245.72 ± 12.12 b	230.31 ± 9.95 c

For each muscle and state of contraction, different letters show statistical differences among groups ($p \leq .05$).

Discussion

In the present study, masticatory efficiency measurements were significantly different between the three groups studied, demonstrating that the shorter the face the better the masticatory function, once short face subjects present greater mechanical advantage of elevator muscle,[9] as well as greater bite force,[8,22] which is one of the key determinants of masticatory function.[3] No other study was found in the literature associating craniofacial vertical pattern and masticatory efficiency. These findings are important and could be used during prosthetic planning to evaluate the need to compensate the functional disadvantages of some patients, for example, when determining the number of teeth to be replaced in removable conventional dentures.

Subjects with lower masticatory efficiency, i.e. dolichofacials, presented significantly smaller occlusal contact area, while brachyfacials, who presented higher masticatory efficiency, showed significantly larger occlusal contact area.[5]

However, it was found that during adulthood, decreases in oclusal contact area influence the amount of sternocleidomastoid and trapezius, auxiliary masticatory muscles activity.[23]

There is much controversy regarding the patterns of elevator muscles electromyographic activity in relation to craniofacial morphology. Farella *et al.*,[14] reported no influence of facial morphology on daily masseter muscle activity, while Ueda *et al.*,[10] indicated the opposite about the duration of daytime muscle activity, being longer in subjects with low angle mandibular plane. In the present study subjects with different facial vertical pattern showed significantly different EMG activity of masseter and anterior temporal muscles during rest and MVC, being lower in dolichofacials and higher in brachyfacilals subjects. These results are in accordance with other studies, which showed considerably larger temporal muscles activity belonged to brachyfacial skeletal pattern during maximal voluntary clenching[24] and at rest position.[12] However, these findings are in disagreement to Cha *et al.*,[11] who observed an increased resting temporal muscle activity in subjects with hyperdivergent faces. This could be due to differences in subject's characteristics, once long face individuals recruited by Cha *et al.*[11] also presented Angle's Class III malocclusion, which may cause a higher stimulation of the muscle, leading to a higher resting activity. Furthermore, other factors may also explain the divergent EMG results found in the literature. It has been reported that muscle size and muscular fiber type seem to be associated to facial vertical morphology, once jaw muscles of long face subjects are up to 30% smaller than those of normal face individuals, which may be attributed to a different muscle fiber type composition.[25]

Conclusion

According to the terms this study was developed, it can be concluded that facial vertical pattern affects masticatory efficiency, occlusal contact area and EMG activity of masseter and temporal muscles during rest and MVC in adults. For all variables studied, dolichofacials presented the lowest measurements, being increasingly followed by mesofacials and brachyfacials subjects.

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CAPÍTULO 2: Masticatory features, EMG activity and muscle effort of subjects with different facial patterns.

Running title: Effect of facial type on masticatory parameters

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Abstract

It has been suggested that craniofacial morphology plays an important role in masticatory function, however, there are controversies and unsolved questions that still require elucidation. The aims of this study were to evaluate masticatory performance, mandibular movement, electromyographic activity and muscle effort of masseter and anterior temporal muscles during mastication. Seventy-eight dentate subjects were selected and divided into three groups according to vertical facial pattern: brachyfacial, mesofacial and dolichofacial. Silicon-based material was used for chewing tests. Masticatory performance was determined by a 10-sieve-method and masticatory movements during mastication were assessed using a 3D mandibular tracking device. Electromyographic activities of masseter and anterior temporal muscles were evaluated during mastication, and muscle effort was calculated by the percentage of activity required for mastication based on maximum muscle effort. Data were analyzed using ANOVA and ANOVA on-Ranks tests. Dolichofacial subjects presented significantly poorer masticatory performance (6.64±2.04; 4.33±0.70 and 3.67±0.63), slower rate of chewing (1.34±0.27, 1.18±0.22 and 1.21±0.20 cycles per second) and larger posterior displacement during mastication (6.22±2.18; 5.18±1.87 and 5.13±1.89) than meso- and brachyfacial individuals, respectively. No statistical difference was detected among groups for the other masticatory movement parameters. There was no difference in absolute EMG amplitudes of masseter and anterior temporal muscles during mastication among groups, but the relative effort of both muscles was higher in dolichofacial, followed by meso- and brachyfacial subjects (masseter: 39.34±2.25; 36.87±4.05 and 33.33±4.15; anterior temporal: 38.12±1.61; 38.20 ± 8.01 and 35.75±2.48). It was concluded that the vertical facial pattern influences masticatory performance, mandibular movement during mastication and the effort masticatory muscles require for chewing.

Key words: Masticatory performance, mandibular movement, electromyographic activity, muscle effort, chewing.

Introduction

It has been assumed that vertical facial morphology is an important mechanical factor influencing the masticatory muscles (1, 2). Greater hyperdivergence is related to poorer mechanical characteristics (2), indicating that subjects with reduced posterior facial height for a given anterior facial height (characteristics commonly found in dolichofacial subjects) present weaker masseter muscles (3). It is reported that subjects with a long-face pattern show lower bite force (2, 4, 5), as well as lower electromyographic activity of masticatory muscles (6, 7, 8). Morphologic features of the stomatognathic system have also been related to craniofacial vertical dimension, since the larger the masseter thickness and volume, the shorter the face (3, 9, 10). As the bite force, EMG activity, cross-sectional area and volume of masticatory muscles are significant chewing predictors, it would be reasonable to hypothesize that dento-facial morphology would also be associated with masticatory function.

The movements performed by the mandible during chewing are important for mastication (11) and are influenced by the inclination of the occlusal plane (12). In the sagittal plane, the masticatory closing path and occlusal plane maintain a perpendicular relationship with each other regardless of the inclination of the latter (12), suggesting that low-angle (angle between Frankfort Plane and Mandibular Plane) subjects exhibit a wider and more vertical path of mandibular movements than high-angle individuals (13).

The electromyographic activity of masticatory muscles in subjects with different vertical patterns has mostly been studied during rest and clenching (7) or even during the daytime (6). Moreover, bilateral isotonic contraction has been evaluated using rhythmic alternating maximum voluntary contractions and relaxations on Parafilm M, showing no difference in EMG values between vertical craniofacial patterns (14). Paphangkorakit *et al.* (15) reported that individuals who present high masticatory performance also present greater EMG activity of masticatory muscles during maximum voluntary clenching (MVC), however, they seemed to use more muscle work during chewing, which characterizes high muscle effort and poor muscle efficiency. There have been no reports on the comparison of individuals with different vertical facial patterns by means of EMG evaluation during chewing or for calculating muscle effort.

As observed, the relationship between facial morphology and oral functions is well accepted in the literature, however, there is lack of information, as well as a need to confirm and establish some functional parameters. Therefore, the aim of this study was to investigate whether vertical facial morphology influences masticatory performance, the mandibular path and masticatory muscle effort during mastication.

Materials and Methods

Seventy-eight subjects with a mean age of 23.5 years were selected among students, staff and individuals who sought dental treatment at the Piracicaba Dental School, State University of Campinas. The inclusion criteria were to present good general and oral health, complete dentition (except for third molars), no malocclusion, no history of temporomandibular disorders or parafunctional habits, no facial deformities and no history of maxillofacial surgery or jaw injury. Moreover, subjects who were undergoing, or who had concluded orthodontic treatment in the last 2 years were excluded from the study. All subjects invited to participate in this study signed a consent form, which was approved by the local Ethics Committee.

Weight (Kg) and height (m) measurements were taken (Mechanical anthropometric scale R110, Welmy, Santa Bárbara D'Oeste, SP, Brazil) of all subjects participating in the study, standing barefooted, in the erect position. Lateral cephalometric image exams (Elipsopantomograph Funk X-15, Macrotec Indústria e Comércio de Equipamentos Ltda, São Paulo, SP, Brazil) were taken using the standard protocols, and were processed with an automatic processor (Macrotec MX-2, Macrotec Indústria e Comércio de Equipamentos Ltda, São Paulo, SP, Brazil).

In order to determine vertical facial morphology, the VERT Index suggested by Ricketts (15) was used to obtain a more comprehensive analysis of overall facial morphology, since five different measurements are involved: facial axis (Ba-Na and Pt-Gn), facial depth (F and N-Pog), mandibular plane (F and Go-Me), lower anterior facial height (Xi-ENA and Xi-Pm), mandibular arch (DC-Xi and Xi-Pm) (16). The VERT Index was used after analysis of the images (Radiocef v.4.0, Radio Memory Ltda, Belo Horizonte, MG, Brazil) to define 3 groups (n=26) according to the facial pattern: (1) brachyfacial (VERT Index > 0.5), (2) mesofacial (VERT Index between -0.49 and + 0.49), and (3) dolichofacial (VERT Index < - 0.5) (17).

Masticatory performance

An artificial silicon-based material (Optosil; Heraeus Kulzer, Hanau, Hessen, Germany) was used for the chewing test. The silicone was proportioned and manipulated according to the manufacturer's recommendations and inserted into a metal matrix to prepare cubes with an edge size of 5.6 mm. After the material had set, the silicone cubes were removed from the matrix, weighed for standardization and stored in an electric oven for 16 hours at a temperature of 60°C to ensure total reticulation. After the silicone-based chewing material had been cooled, disinfected, rinsed and dried, portions of 17 silicon cubes were pooled together (18) and taken to an analytical balance to standardize the weight to approximately 3.4 g.

All subjects were instructed to chew a portion of silicone-based cubes, during 20 masticatory strokes. After this, the subjects expectorated the comminuted particles into a paper filter and then performed several mouth rinses with 200 mL of water to ensure oral cleansing. The triturated particles were dried in an electric oven at 80°C for 25 min (19) and sized using a 10-sieve-method, with an aperture range from 5.6 to 0.5 mm, and a sieving machine (Bertel Indústria Metalúrgica Ltda., Caieiras, SP, Brazil). The amount of particles in each sieve was weighed on a 0.0001 g analytical balance (Mark, 2060, Bel Engineering s.r., Monza, Monza & Brianza, Italy) and masticatory performance was calculated using the Rosin-Rammler formula, $Q_w(X) = 100[1 – 2^{-(X/X50)b}]$, in which the median particle size (x_{50}) is the theoretical sieve aperture through which 50% of the weight of the fragmented particles can pass (18).

Mandibular path during mastication

The trajectory of the mandible during mastication was recorded with a kinesiograph (K6-1, Evaluation System, Myotronics-Noromed, Inc., Kent, WA, USA). The equipment creates an electromagnetic field around the subject's face and captures the signal of a magnet (Coe Pak, GC America Inc., Alsip, IL, USA) temporarily bonded to the buccal face of the mandibular incisors. The test was carried out with the subject seated on a dental chair with the Frankfort Plane parallel to the ground, while the operator adequately positioned the equipment on the subject's face.

Mandibular movements were evaluated with a kinesiograph during mastication of a 17-cube-portion of a rubber based artificial material for 15 seconds, as described in the method of masticatory performance.

The following mandibular movement parameters were analyzed using the Image Tool Software (University of Texas Health Science Center, San Antonio, TX, USA): maximum vertical excursion, maximum posterior excursion, maximum lateral amplitudes, total duration, maximum opening velocity and maximum closing velocity. Additionally, chewing cycles were divided into three phases, opening, occlusal and closing, for measuring the duration of each phase. Maximum vertical and posterior excursions during mastication were defined as the distance between maximum intercuspal position and the maximum vertical and posterior excursions (mm), respectively; maximum lateral displacement was analyzed as maximum right and left movement amplitudes, separately. The phases of the chewing cycles were established based on a slice level defined as 0.7 mm below maximum intercuspal position. The occlusal phase was positioned above the slice level, while opening and closing phases were positioned below it, as shown in Figure 1. The total duration of a chewing cycle was defined as the sum of its three phases (20).

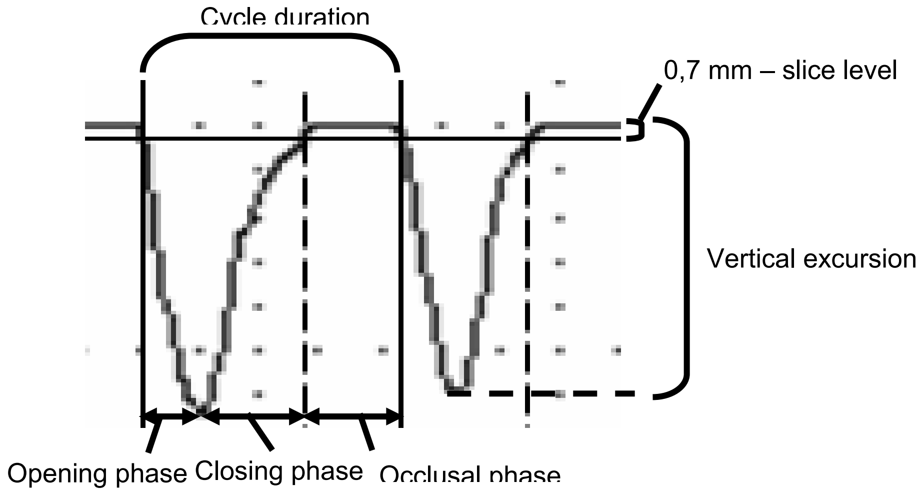

Figure 1: Schematic representation of slice level and cycle phases (Adapted from Yoshida *et al.*, 2007).

As the number of chewing strokes could vary between subjects in a given time, the first fifteen strokes were selected for standardization and the rate of chewing, i.e. the number of chewing cycles per second was calculated. Additionally, as it usually shows a different pattern, the first chewing stroke was excluded and the analysis of mandibular movement parameters, including rate of chewing, were assessed from the second to the fifteenth stroke. The result was given as a mean of the 14 strokes analyzed.

Electromyographic activity during mastication

Activities of the masseter and anterior temporal muscles were measured during mastication, using an eight channel electromyographic device (Bioresearch Inc., Milwaukee, WJ, USA) with a 30 to 600 Hz band-pass filter and the BioPAK software (Bioresearch Inc., Milwaukee, WJ, EUA). Before the electrodes were put into place, the subject's skin was cleaned with alcohol to reduce the impedance between the skin and electrodes (7). Ag/AgCl surface electrodes (Bio-Research, Milwaukee, WJ, USA) were placed bilaterally in the direction of the muscle fibers, on the most prominent point of the masseter (13) and anterior temporal muscles during contraction. The test was carried out with the subject seated on a dental chair with the Frankfort Plane parallel to the ground, and the subject was asked to avoid head and body movements during the test. A portion of an artificial material (as mentioned in the masticatory performance methods) was placed in the subject's mouth, and chewing began with the subject in the maximal intercuspal position (7). EMG activity of masseter and anterior temporal muscles was evaluated by the sum of the contralateral muscles (17) during 4 chewing cycles repeated three times. The data obtained for the 3 measurements were averaged and normalized as a function of the mean maximum voluntary contraction values.

Muscle effort

Muscle effort was defined by the percentage of muscle activity during mastication considering the muscle activity during maximum voluntary clenching (MVC) as 100% (17). With regard to the definition, EMG activity during MVC was measured in the same terms as those used for mastication, except for the chewing material and the instructions given to the subjects, who were asked to clench their teeth together as hard as possible for 7 seconds. Three measurements with a 2-minute interval between them were performed. The result was given as the mean of the three repetitions.

Statistical Analysis

Data were analyzed using SigmaPlot software (Version 11.0, Systat Software, Inc. Chicago, IL, USA). Normality and equal variance tests were performed and statistics were assessed as follows: one-way ANOVA and Student-Newman-Keuls as post-hoc for anthropometric characteristics, maximum opening velocity, maximum closing velocity, total cycle duration, closing duration, occlusal duration, maximum lateral amplitudes, rate of chewing and maximum posterior excursion. ANOVA on-Ranks which was performed for data which did not show normal distribution, was used to analyze masticatory performance, EMG activity of the masseter and anterior temporal muscles during mastication, opening duration, maximum vertical excursion and muscle effort of masseter and anterior temporal muscles. Analysis was performed at a 5% level of significance.

Results

Anthropometric and sample characteristics are shown in Table 1. A homogeneous distribution among groups was observed (P>.05).

Table 1: Sample characteristics (Means ± sd).

	Brachyfacial	Mesofacial	Dolichofacial	Total
Male (number)	13	13	13	39
Age (years)	23.9 ± 4.5	23.5 ± 2.9	22.9 ± 3.8	23.5 ± 3.7
BMI	23.9 ± 2.6	25.8 ± 2.9	24.9 ± 3.3	24.9 ± 1.0
Female (number)	13	13	13	39
Age	23.2 ± 4.6	25.2 ± 5.7	22.1 ± 2.2	23.6 ± 4.4
BMI	22.3 ± 2.5	22.3 ± 4.7	21.7 ± 1.9	22.1 ± 0.3
Total (number)	26	26	26	78
Age	23.7 ± 4.3	24.4 ± 4.5	22.5 ± 3.1	23.5 ± 4.0
BMI	21.6 ± 5.2	24.1 ± 4.3	23.3 ± 3.1	23.3 ± 1.3

Brachyfacial subjects comminuted the rubber based artificial material into smaller particles, i.e. presented higher masticatory performance, followed by meso- and dolichofacial subjects, respectively (Table 2).

EMG activity of the masseter and anterior temporal muscles during mastication, however, when comparing the effort of masseter and anterior temporal muscles in relation to their activity at MVC, dolichofacial subjects presented the worst efficiency for both muscles (Table 2).

Table 2: Masticatory performance (mm), EMG (μV) during mastication and effort (%) of masseter and anterior temporal muscles of subjects with different vertical patterns (Means ± s.d.).

	Brachyfacial	Mesofacial	Dolichofacial
Masticatory performance	3.67 ± 0.63 a	4.33 ± 0.70 b	6.64 ± 2.04 c
Masseter EMG	85.22 ± 5.29 a	87.27 ± 2.68 a	87.55 ± 2.16 a
Masseter effort	33.33 ± 4.15 a	36.87 ± 4.05 b	39.34 ± 2.25 c
Anterior temporal EMG	87.58 ± 2.55 a	88.25 ± 4.19 a	87.64 ± 1.03 a
Anterior temporal effort	35.75 ± 2.48 a	38.20 ± 8.01 a	38.12 ± 1.61 b

Different letters show statistical differences among groups ($P \leq .001$).

In the analysis of mandibular movements, it was observed that the number of chewing cycles performed during the given period of 15 seconds varied among subjects, consequently the rate of chewing differed significantly among the groups ($P<.05$), being higher in dolichofacial subjects (1.34±0.27) than in meso- and brachyfacial individuals (1.18±0.22 and 1.21±0.20, respectively).

The data of opening and closing velocities, number and total duration of chewing cycle, duration of opening, closing and occlusal phases, vertical and posterior excursions, as well as right and left deviations during mastication are shown in Table 3. Dolichofacial subjects presented a more posterior path in the sagittal plane than brachyfacial individuals (Table 3).

Table 3: Parameters of mandibular path during mastication of subjects with different vertical patterns (Means ± s.d.).

	Brachyfacial	Mesofacial	Dolichofacial
Opening velocity (mm/s)	124.64 ± 37.27	114.87± 24.40	122.66 ± 33.24
Closing velocity (mm/s)	106.39 ± 19.26	109.89 ± 29.18	107.99 ± 24.70
Total cycle duration (s)	0.79 ± 0.11	0.83 ± 0.15	0.75 ± 0.18
Opening duration (s)	0.24 ± 0.04	0.25 ± 0.07	0.23 ± 0.07
Closing duration (s)	0.37 ± 0.11	0.39 ± 0.14	0.33 ± 0.07
Occlusal duration (s)	0.19 ± 0.09	0.18 ± 0.08	0.17 ± 0.09
Vertical excursion (mm)	16.87 ± 2.77	16.9 ± 3.29	16.76 ± 2.23
Posterior excursion (mm)	5.13 ± 1.89 a	5.18 ± 1.87 ab	6.22 ± 2.18 b
Right displacement (mm)	2.36 ± 1.13	2.49 ± 1.12	2.55 ± 1.26
Left displacement (mm)	3.46 ± 1.62	3.29 ± 1.71	3.75 ± 1.48

*Different letters show statistical differences between groups (P < .05).

Discussion

The relationship between craniofacial vertical dimension and oral functions is not well established in the literature. The present study emphasizes the importance of this association in order to understand the oral function itself and its implications during the rehabilitation of patients.

As the association between masticatory predictors and vertical facial morphology (2-9) has been reported, one would expect to find significant differences among the groups of the present study, which showed that mastication was more efficient in brachyfacial and less efficient in dolichofacial individuals. This result is also in agreement with other studies, which showed that determinants of masticatory function, such as mechanical characteristics, bite force (4, 5) and muscle size (8-10), have been found to be more favorable in brachyfacial subjects.

Some studies have shown that the EMG activity of masticatory muscles in subjects with different vertical patterns at rest and during the daytime were higher and longer in brachyfacial individuals (6, 7). One study reported no difference in EMG values of the masseter and anterior temporal muscles during bilateral chewing when comparing meso-, brachy- and dolichofacial subjects (14), which corroborate the findings of the present study. However, the evaluation was performed during non-functional bilateral isotonic contraction (14), i.e., there was still a lack of data concerning EMG recording during free mastication in this population, which was performed in the present study.

When comparing the muscle effort used to chew the artificial material, it was found that dolichofacial subjects used a greater percentage of maximum muscular effort. However, the lower muscle efficiency is probably due to lower bite force (2, 4, 5) and lower EMG activity during MVC (7, 8) in dolichofacial subjects when compared with meso- and brachyfacial subjects, rather than to differences in muscle activity during mastication (14). These findings suggest that dolichofacial subjects have less efficient jaw muscles and a higher tendency to fatigue and disorder of the masticatory muscles in dolichofacial individuals, as proposed by Sonnesen *et al.* (21) and Cuccia *et al.* (22).

The mandibular movement path is closely correlated with the inclination of the occlusal plane (23). For example, mandibular closing path maintains a perpendicular (12) and constant relationship with the occlusal plane regardless of its inclination (12). It has been reported that low-angle subjects exhibit a more vertical path of mandibular movements than high-angle individuals during maximum jaw opening and chewing gum mastication (13). This data is in agreement with the present study, which demonstrated a greater posterior excursion of the jaw during mastication in dolichofacial subjects. This is probably due to a greater anterior inclination of the occlusal plane in long-face individuals and a tendency towards mandibular closing movement from a posterior position, as suggested by Ogawa *et al.* (12).

Dolichofacial subjects also chewed more times in a given period of time in comparison with meso- and brachyfacial individuals. Ow *et al.* (24) reported the existence of correlation between masticatory performance and duration of chewing cycle and its occlusal phase; moreover, when the chewing strokes appear to be inadequate for attaining a certain level of masticatory performance, the subject may increase the number of masticatory cycles in order to achieve better mastication within a given time. In the present study, although dolichofacial subjects presented no statistical differences in mandibular path characteristics in comparison with the other two groups, a trend towards a reduction in the total duration of the chewing cycle and the duration of its opening, closing and occlusal phases can be seen, which may be important features to explain the larger number of chewing strokes per second to compensate for the poorer masticatory performance.

It is suggested that during rehabilitation treatment planning, the vertical facial pattern should be taken into consideration. Because of the poorer masticatory function and higher muscle effort required, it is possible that dolichofacial subjects are more likely to present increased functional concerns in certain situations, such as when left with short dental arches or treated with conventional distal extension removable dentures.

The aim of this study was to gain better understanding of how the masticatory system functions, and its relationship with craniofacial dimensions, which still remains unclear and may be solved in future clinical researches. Taking the vertical facial pattern into consideration during rehabilitation treatment planning would be of great importance, and would be a way to personalize the prosthetic restoration according to the functional features of each facial type.

Under the terms in which this study was performed, it is possible to conclude that the vertical facial pattern influenced masticatory performance, the number of chewing cycles, posterior displacement and muscle effort during mastication.

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CAPÍTULO 3: Preferred chewing side, bite force and occlusal contact area of subjects with different craniofacial vertical dimensions.

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Abstract

Craniofacial dimensions may influence oral functions, however, it is not known whether there is an association with function asymmetry. The aims of this study were to evaluate chewing side preference, and lateral asymmetry of occlusal contact area and bite force of individuals with different craniofacial patterns. Seventy-eight dentate subjects were divided into 3 groups according to the VERT index as follows: (1) mesofacial, (2) brachyfacial and (3) dolichofacial. Chewing side preference was evaluated using a kinesiograph. Occlusal contact area was measured by silicon registration of posterior teeth and bite force was carried out unilaterally on molar regions using 2.25 mm-width sensors. Statistics was assessed using ANOVA on-Ranks, Student t-test and Mann-Whitney methods whenever indicated at a 5% significance level. Meso, brachy and dolichofacial subjects presented more occlusal contact area at left side. For bite force, only dolichofacial subjects showed lateral asymmetry, presenting higher force at left side. No statistical difference of chewing side preference was found between groups. In the terms in which this study was carried out, it can be concluded that craniofacial dimensions played a role in asymmetry of bite force.

Key-words: Mastication, bite force, dental occlusion, face, morphology.

Introduction

Basic jaw opening and closing movements during mastication are probably centrally determined and adjusted to a given situation by receptors found in periodontium, temporomandibular joints, tongue, mucosa, tendons and muscle spindles of elevator muscles, that may play an important role on chewing [1]. Differences in the jaw rotation between short and long-face subjects could lead to alterations of muscular force axis and to a different stimulation of muscle spindles of elevator muscles [2].

It has been reported that masticatory muscles of dolichofacial subjects are less efficient in generating bite force at a particular point on the lever arm, due to the poorer mechanical advantage when compared to brachyfacial subjects [3, 4]. Once bite force is considered to be a key determinant of masticatory function [5], it would be expected that mastication may also be affected by craniofacial morphology [6].

Lower masticatory function was also related to smaller occlusal contact area [7]. During growth, the musculature of the neck attached to the mandible must lengthen in synchrony, otherwise, there will be a tendency for a rotational growth pattern and a possible drift of posterior mandibular teeth for compensation [8], as found in dolichofacial subjects. In adults, it has been reported that cervical muscles may play a role in the exertion of bite force, and lower activity of those muscles was associated to smaller occlusal contact area [9], suggesting an indirect association between craniofacial dimension and occlusal contact area.

In order to achieve good food manipulation and transport, tongue and other tissues movements must be facilitated during mandibular movements for repositioning of mandibular teeth during sequential chewing strokes [10], being suggested that wide, bilateral chewing cycles are related to better masticatory performance [11]. Unilateral chewing is found to be present in 45 to 97% [12-14] of the population, being associated to centrally controlled factors [12], unilateral signs of temporomandibular disorders, asymmetrical loss of antagonist contact and presence of removable partial denture [13]. In a dentate population, chewing side preference was present in almost half of the subjects and was associated to lateral asymmetry on bite force and occlusal contact area [14].

It has been reported that dolichofacial subjects presented more masticatory and cervical muscles tenderness, which may be due to a functional overloading of weak masticatory muscles [15]. However, no study concerning neither occlusal nor functional asymmetry in individuals with different facial highs was found in the literature. Considering the importance that different craniofacial vertical dimension could represent during rehabilitation treatment planning, it is of great interest to understand the particularities of each facial pattern. The purpose of this study was to verify whether subjects with different craniofacial morphologies present chewing side preference of mastication and lateral asymmetries of bite force and occlusal contact area.

Material and methods

Students and staff of Piracicaba Dental School, and individuals seeking for dental treatment at the same institution were evaluated. Seventy-eight healthy dentate subjects (39 males and 39 females) with mean age of 23.5 years were selected to participate in this study according to the following inclusion criteria: present no facial deformities, no malocclusion, no history of signs and symptoms of temporomandibular disorder, no history of parafunctions, no history of maxillofacial surgery or jaw injuries and no orthodontic treatment concluded in the last 2 years. The research protocol (number 059/2004) was approved by the Ethics Committee of Piracicaba Dental School, University of Campinas and all participants signed a written informed consent.

The selected subjects who accepted to participate in this study had their weight (kg) and height (m) measured (Mechanical anthropometric scale R110, Welmy, Santa Bárbara D'Oeste) to control anthropometric data. Cephalometric exams were obtained for all participants using the standard protocols and the same radiographic unit (Elipsopantomograph Funk X-15, Macrotec Indústria e comércio de equipamentos Ltda., São Paulo). The cephalograms were processed (Macrotec

MX-2, Macrotec Indústria e comércio de equipamentos Ltda, São Paulo) and analyzed by a digital cephalometric analysis (Radiocef v.4.0, Radio Memory Ltda, Belo Horizonte). The VERT Index was used to determine the facial vertical pattern of the subjects, who were divided into 3 groups (n=26) according to the facial type: (1) mesofacial (VERT Index between -0.49 and + 0.49), (2) brachyfacial (VERT Index > 0.5) and (3) dolichofacial (VERT Index < - 0.5) [16]. Cephalometric analysis and classification of the subjects by facial pattern were accomplished after all the tests had been executed, i.e. the operators were blind for facial pattern during the tests.

Bite force

A transducer composed by two sensors (Spider 8, HBM do Brasil) was used and the signs were registered, amplified and analyzed by the software Catman Easy (HBM, Brasil). The sensors presented 12 mm of diameter and 0.25 mm of width (FSR Nº 151, Interlink Eletronics Inc.) and were protected in both sides with a metal device of 1 mm width, constituting a system with 2.25 mm of width. The sensors were positioned unilaterally on first molar region by the operator and subjects were instructed to occlude the teeth and bite as hard as they could during a 7-second period. After a 2-minute interval for release, the procedure was repeated for the other side. The order of side in which the test was first carried out was randomized.

Occlusal contact area

Addition silicone (RE’CORD, Bosworth Company, Skokie) occlusal registrations of the posterior teeth (molars and premolars) were obtained bilaterally [17] using plastic frames (Big Bite Tray, Bosworth Company, Skokie). Subjects were asked to close their teeth into the maximum intercuspal position and instructed to keep that position until complete setting of the silicone was recognized [18]. The record was carefully removed from their mouth and for each record, preparation for the image analysis was performed [18].

Each occlusal registration was digitalized using a desktop scanner (2400, Hewlett Packard Development Company, Barueri), where registrations were placed with the mandibular occlusal surface facing downward [17]. The software Adobe Photoshop CS3 (Adobe Systems Inc., San Jose) was used to discolor, invert and adjust the images. Pieces of the same addition silicone of known thickness, measured with a digital caliper (Digimess Instrumentos de Precisão Ltda., São Paulo) were analyzed by the Image Tool software (University of Texas Health Science Center, San Antonio) and used to establish the relationship between silicon thickness and each of the 256 gray scales. The same software was used to manually trace the occlusal contact areas of posterior teeth of 3x magnified images. Traced occlusal contact areas were automatically calculated by the software by the frequency distributions of pixels corresponding to each of 256 gray scales [17]. Areas of silicone thickness up to 350 μm were calculated [18], considering that occlusal contact areas present less than 50 μm thickness of the impression material and near contact area, from 50-350 μm thickness [17].

Preferred chewing side

To determine whether the subjects present bilateral or unilateral (right or left) mastication, a 3D jaw-tracking device (K6-1, Evaluation System, Myotronics-Noromed, Inc., Kent, WA, USA) was used with the participant sat in dental chair with the Frankfort Plane parallel to the ground. Mandibular movements were recorded during mastication of 3.4 g of a rubber based artificial test material (Optosil, Heraeus Kulzer, Hanau, Hessen, Germany) for 15 chewing cycles. Each chewing stroke was first evaluated vertically, being broken into three phases: open, close and occlusal. A slice level was determined as vertical displacement of 0.7 mm below maximum intercuspation position. Tracing above the slice level and below maximum intercuspation was determined as occlusal phase. Each chewing cycle was identified from the starting time of an opening phase (the end of a previous occlusal phase) until the end of the next occlusal phase [19]. After the identification, chewing strokes were analyzed laterally and each cycle was determined as right, left or bilateral according to the lateral position during the occlusal phase of the given stroke. To present a unilateral mastication or a chewing preferred side, the participant should perform 80% of the strokes coinciding on one side [20], i.e. twelve out of fifteen chewing strokes. Subjects were then divided into two groups: unilateral and bilateral mastication.

Statistical analysis

Analysis was performed using the SigmaPlot software (Version 11.0, Systat Software, Inc. Chicago, USA). Normal and equal variance tests were performed and statistical analysis was assessed as follows: to analyze homogeneity of the sample, concerning weight, high and age of meso, brachy and dolichofacial subjects, ANOVA one-way and ANOVA on Ranks methods were used.

To analyze the type of chewing, whether uni or bilateral, among meso, brachy and dolichofacial subjects ANOVA on Ranks was performed. Analysis of asymmetry of occlusal contact area and bite force was performed between right and left sides for each facial pattern using Student t-test. Data of mesofacial subjects for bite force, and data of meso and dolichofacial subjects for occlusal contact area were submitted to transformation using log10 before parametric test. All analysis were assessed at a 5% significance level.

Results

A homogeneous distribution between meso, brachy and dolichofacial subjects could be observed regarding weight, height and age ($P>.05$).

Concerning chewing side preference, no statistical difference was found among groups ($P>.05$), although, a higher number of dolichofacial subjects presenting unilateral chewing was found (Table 1).

Concerning craniofacial morphology, meso, brachy and dolichofacial subjects presented different values of occlusal contact area for each chewing side, with larger measurements on the left side. For bite force, only dolichofacial individuals demonstrated higher force at left side (Table 2).

Table 1. Distribution of chewing type in subjects with different facial vertical pattern. Absolute and relative (%) values.

Type of chewing	Mesofacial	Brachyfacial	Dolichofacial
Bilateral	18 (69.2%)	18 (69.2%)	13 (50%)
Unilateral	8 (30.8%)	8 (30.8%)	13 (50%)
Right	4 (50%)	4 (50%)	8 (61.5%)
Left	4 (50%)	4 (50%)	5 (38.5%)

Table 2. Lateral asymmetry of OCA (mm^2) and bite force (Kgf) between subjects with different facial vertical pattern.

	OCA		Bite force	
	Right	Left	Right	Left
Mesofacial	46.8±5.8	75.7±8.6*	23.4±13.0	26.5±13.0
Brachyfacial	53.7±10.4	90.4±17.8*	31.0±10.4	36.6±10.2
Dolichofacial	37.5±8.9	60.0±15.2*	16.1±8.4	21.1±10.2*

*Difference between right and left sides for each group and variable. P<.05.

Discussion

Bite force [4], occlusal contacts, type of chewing and craniofacial dimensions are reported as important factors that can influence oral functions [6, 11], however, their relationship have never been studied.

Masticatory function is predicted by a number of parameters, including bite force [5] and occlusal contact area [7], showing that the higher the bite force and the larger the occlusal contact area, the better the mastication. Additionally, it has been reported that dentate subjects with no malocclusion and unilateral mastication present different values of bite force and occlusal contacts area between right and left sides, suggesting that these peripheral factors are enrolled in the mechanism of chewing side preference instead of central factor, once type of chewing was not associated to handedness [14]. Since balanced bilateral mastication has been suggested to be associated to better mastication [11], it is possible that lateral asymmetric forces and contacts may promote unbalanced oral functions.

No study relating type of mastication and craniofacial vertical morphology has been found in the literature. The present study evaluated this association directly and indirectly, by means of asymmetry of bite force and occlusal contact area. Meso, brachy and dolichofacial individuals presented asymmetry in occlusal contact area, showing larger values in the left side. Otherwise, asymmetry of bite force was found only in dolichofacial subjects, with higher bite force exerted at the left side. Despite of this finding, analysis of type of mastication in subjects with different facial vertical pattern found no difference between groups, however a tendency for the relation between long-face subjects and unilateral chewing may be suggested, once 50% of dolichofacial group present chewing side preference, fighting back to meso and brachyfacial groups, which presented 30.8% of unilateral chewers. This may be explained by the weaker masticatory muscles found in long-face individuals [15], suggesting that weaker muscles could also present a tendency for unbalanced functions.

Although there was no difference between type of mastication and distinct craniofacial morphologies, it should be focused that dolichofacial subjects presented more chewing preference to the right side. As already pointed, all subjects, regardless the facial pattern, had larger occlusal contact area at the left side. Similar asymmetry occurred in long-face individuals for bite force. It could had been expected that individuals with these asymmetries would have a side preference to the left side during mastication, as stated by Martinez-Gomis *et al.* [14], who used the same artificial material for chewing as the present study. However, the referred authors conducted the evaluation of chewing side preference by observation of mandibular movements. The present study used kinesiographic analysis, which seems to be the most reliable technique, once it is able to detect unidentified cycles and very small lateral movements that may not be detected by visual methods [21]. Additionally, what at first, seemed to be a contradiction, may express that central factors may play a major role in the determination of chewing side preference, as it has already been reported [12]. However, central factors, such as handedness and footedness were not evaluated in the present study.

Mastication is the most studied oral function, however, there are still many questions without answers about its predictors and mechanisms. It is of great value to understand the needs of the patients during a rehabilitation treatment, as all kind of information will be precious at the time a decision should be made. For this reason, specific functional characteristics of people with different facial morphology and chewing side preference are important and need further clinical investigations.

Acknowledgements

We would like to thank subjects who participated in this study; and Dr. Francisco Haiter Neto, Dr. Jaime Aparecido Cury, Dr. Maria Beatriz Duarte Gavião and Thaís Marques Simek Vega Gonçalves for their assistance. This research was supported by National Council for Scientific and Technological Development - CNPq (Grant numbers 476385/2004-0 and 140204/2009-1).

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CONSIDERAÇÕES GERAIS

Este estudo avaliou diversos parâmetros funcionais de indivíduos com padrões faciais verticais diferentes e demonstrou que, de modo geral, indivíduos de face curta apresentaram funções mais favoráveis, enquanto indivíduos de face longa, menos favoráveis.

Quando o crescimento condilar acontece em sentido vertical e anterior, e sobrepõe-se ao crescimento vertical na região de molar, a mandíbula cresce com o centro de rotação na região de incisivo e desempenha rotação anterior, resultando num ângulo da mandíbula agudo (Schudy, 1965; Ranly, 2000) e dando origem a um maior crescimento horizontal com menor altura anterior da face (Schudy, 1965). Neste tipo de padrão, há um maior crescimento facial posterior e uma disposição mais horizontal do plano oclusal (Ranly, 2000), o que caracteriza tendência para face curta. Em contrapartida, quando os côndilos crescem em sentido posterior e este crescimento faz-se menor do que aquele na região de molar, a mandíbula é pressionada para frente, haverá tendência de rotação posterior e o ângulo da mandíbula permanecerá obtuso, resultando em menor crescimento horizontal e maior altura anterior da face (Schudy, 1965; Ranly, 2000) Estas características são encontradas em indivíduos de face longa.

As diferenças morfológicas entre tipos faciais verticais podem caracterizar diferenças marcantes no desempenho mecânico do sistema mastigatório (Weijs, 1989). Isto foi demonstrado no presente estudo, uma vez que indivíduos braquifaciais apresentaram qualidade de mastigação, atividade muscular em repouso e máxima contração vertical e área de contato oclusal significantemente maiores quando comparados aos outros tipos faciais, enquanto os indivíduos dolicofaciais apresentaram os menores resultados paras as mesmas variáveis. Estudos comparativos existem apenas em relação à atividade muscular (Ingervall & Thilander, 1974; Ueda *et al.*, 2000; Farella *et al.*, 2005; Cha *et al.*, 2007; Tecco et al, 2007; Li *et al.*, 2008; Vianna-Lara *et al.*, 2009), contudo, há diferenças significativas na metodologia e na população estudada. Compatibilidade de metodologia em relação ao presente estudo foi encontrada para aqueles realizados por Tecco *et al.*, (2007) e Li *et al.*, (2008), os quais apresentaram resultados opostos entre si, sendo Tecco *et al.*, (2007) semelhante ao presente estudo para atividade em repouso, e Li *et al.* (2008), para máxima contração vertical. Durante a mastigação, não houve diferença de atividade muscular entre os grupos do presente estudo, confirmando os achados de Vianna-Lara *et al.* (2009). No entanto, no estudo mencionado (Vianna-Lara *et al.*, 2009), os indivíduos foram orientados a alternar estados de contração máxima e repouso sucessivamente contra Parafilm M, enquanto o presente estudo utilizou mastigação habitual de material à base de silicone.

Indivíduos com ângulo do plano mandibular alto e ramo mandibular curto, que são característicos de face longa, podem apresentar musculatura inadequada (Ricketts, 1981). Este dado pode elucidar o motivo pelo qual indivíduos dolicofaciais exerceram maior esforço muscular durante a mastigação quando comparados com indivíduos meso e braquifaciais, impondo sobrecargas constantes sobre os músculos mastigatórios, como sugerido por Sonnesen *et al.* (2001). Os resultados do presente estudo podem explicar os achados destes autores (Sonnesen *et al.*, 2001), os quais relataram associação entre dolorimento muscular e características morfológicas encontradas em indivíduos dolicofaciais.

É relatado na literatura que a qualidade da mastigação está relacionada a aspectos da movimentação mandibular, como amplitude vertical, duração e ângulo de fechamento da mandíbula (Yoshida *et al.*, 2007), assim como de uma trajetória de abertura linear ou côncava em direção ao lado de trabalho e uma trajetória de fechamento convexa (Kobayashi *et al.*, 2009). No presente estudo, apesar de indivíduos dolicofaciais apresentarem mastigação de pior qualidade, parâmetros como amplitude vertical e duração de fechamento não foram diferentes entre os três grupos estudados. Em estudos comparando os movimentos durante a mastigação e o plano mandibular, foi relatado que indivíduos com característica de face longa apresentaram trajetória de fechamento mais inclinada (Ogawa *et al.*, 1997; Farella *et al.*, 2005; Sato *et al.*, 2007). No presente estudo, o único parâmetro de movimento mandibular que diferiu de maneira significante entre indivíduos braqui e dolicofaciais foi o deslocamento posterior. Sugere-se que isto tenha ocorrido pela diferença de inclinação do plano oclusal, tendo indivíduos de face longa uma maior inclinação dos planos mandibular e oclusal (Sato *et al.*, 2007).

Como já mencionado, acredita-se que indivíduos de face longa apresentam uma musculatura facial deficiente (Ricketts, 1981), com maior tendência à disfunção (Sonnesen *et al.*, 2001) e possível desequilíbrio funcional. O presente estudo confirmou estes achados no momento em que foi observado que indivíduos com padrões faciais diferentes apresentaram assimetria de contatos oclusais, no entanto, apenas sujeitos com face longa obtiveram assimetria lateral de força máxima de mordida, exercendo maior força no lado esquerdo.

Segundo Wilding & Lewin (1994), a função mastigatória está relacionada a ciclos mastigatórios bilaterais, no entanto, apesar da correlação entre estes dois fatores não ter sido realizada neste estudo, não houve diferença de tipo de mastigação entre os três padrões faciais verticais, apresentando indivíduos meso, braqui e dolicofaciais ausência de preferência de lado, ou seja, mastigação bilateral. Contudo, um número maior de sujeitos de face longa quando comparados àqueles com padrão equilibrado e àqueles de face curta, apresentou mastigação unilateral. Sugere-se que esta tendência de preferência de lado durante a mastigação em indivíduos com menor qualidade mastigatória pode ter acontecido devido a um desequilíbrio funcional com conseqüente assimetria lateral de força de mordida.

Diante do exposto, faz-se importante ao profissional da área odontológica manter-se atento quanto ao padrão facial vertical, no intuito de adequar um determinado tratamento de acordo com as características morfológicas de cada indivíduo. Podem-se direcionar melhor os tratamentos para pacientes com disfunção temporomandibular de origem muscular em sujeitos de face longa, sabendo-se que estes podem apresentar um déficit funcional e sofrer sobrecarga na musculatura mastigatória. Podem-se selecionar tratamentos reabilitadores com características diferentes, visando proteger as reabilitações de pacientes com grande força de mordida, como os braquifaciais, ou visando melhorar a função mastigatória de indivíduos que apresentam mastigação de menor qualidade, como os dolicofaciais. Estes são alguns exemplos de como o conhecimento acerca da morfologia craniofacial pode ser empregado na clínica diária. Naturalmente, outros estudos são necessários, a fim de confirmar os dados obtidos neste estudo, no entanto, pode-se afirmar com segurança que o padrão facial vertical pode influenciar a função mastigatória e alguns de seus parâmetros.

CONCLUSÕES

Nas condições em que este estudo foi realizado, faz-se possível afirmar que o padrão facial vertical exerceu influência sobre as seguintes varáveis estudadas:

- Mastigação;
- Atividade dos músculos mastigatórios em repouso e durante contração vertical máxima;
- Esforço muscular necessário para realizar a função mastigatória;
- Área de contato oclusal;
- Movimentos mandibulares durante a mastigação e
- Assimetria lateral da força máxima de mordida.

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* De acordo com as normas da UNICAMP/FOP, baseadas nas normas do International Commitee of Medical Journal Editors – Grupo de Vancouver. Abreviatura dos periódicos em conformidade com o Medline.

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ANEXO 1: Figuras

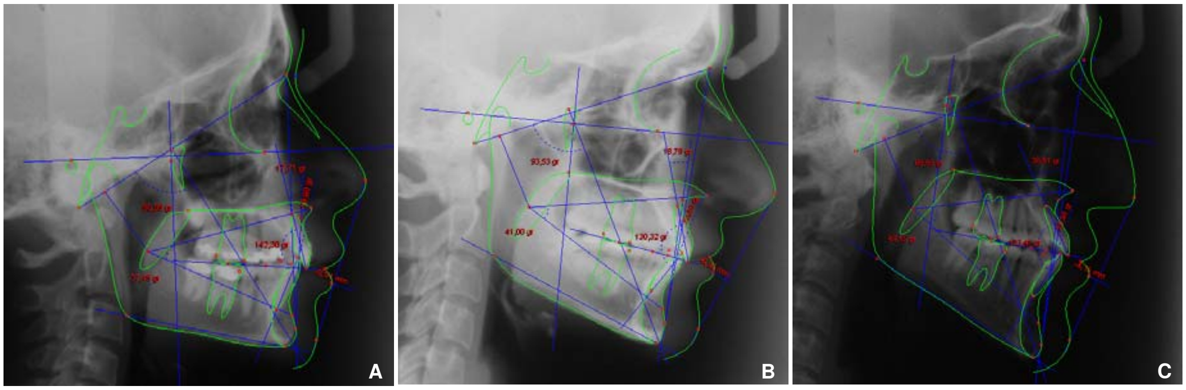

Figura 1 - Radiografia em norma lateral com análises cefalométricas mostrando os três tipos faciais. A, braquifacial; B, mesofacial; C, dolicofacial.

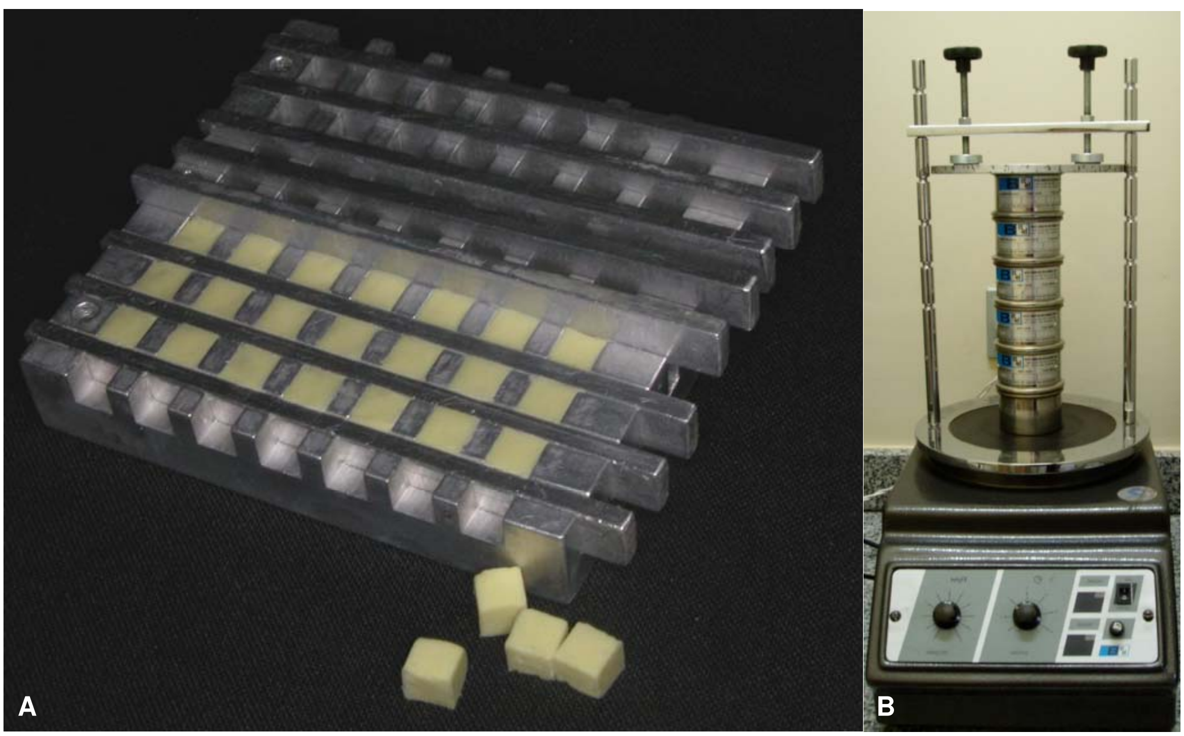

Figura 2 - A: Confecção de cubos de Optosil® com 5,6mm de aresta, utilizando-se matriz metálica; **B:** Sistema de peneiras acopladas ao agitador (Bertel Indústria Metalúrgica Ltda., São Paulo, Brasil).

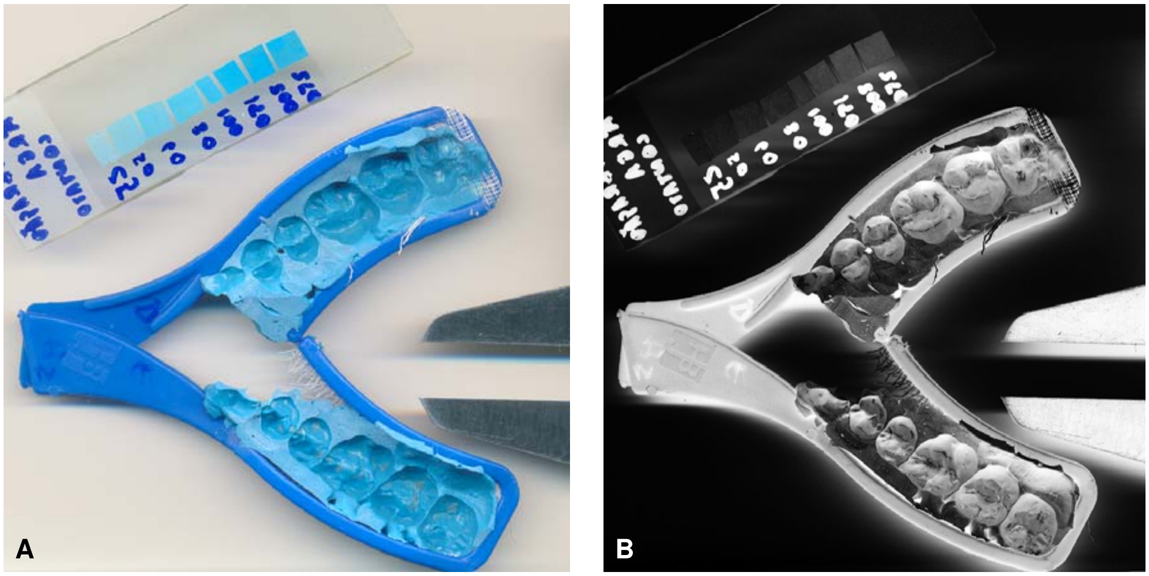

Figura 3 - Área de contato oclusal antes (A) e após (B) a inversão de cores da imagem.

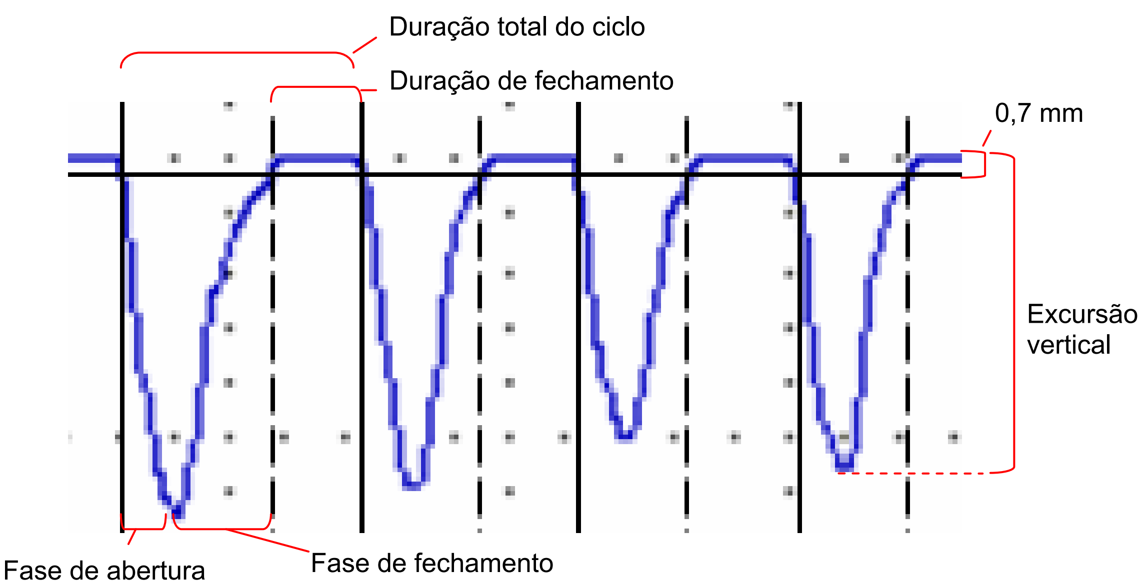

Figura 4 - Traçado do movimento vertical durante a mastigação, mostrando os limites e as divisões dos ciclos mastigatórios.

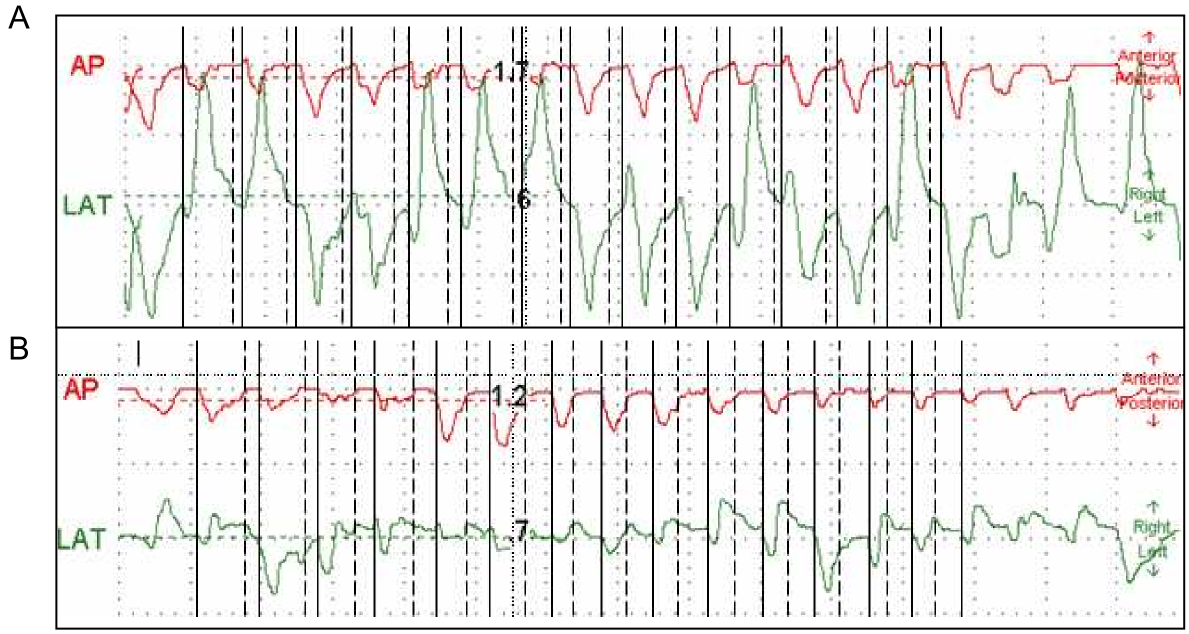

Figura 5 - Traçados dos movimentos ântero-posteriores e laterais durante a mastigação. A: Mastigação bilateral; B: Mastigação unilateral com preferência pelo lado direito.

Figura 6 - Sensor para mensuração da força máxima de mordida unilateral posicionado em região de primeiro molar.

ANEXO 2: Certificado de aprovação do Comitê de Ética em Pesquisa.

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

CERTIFICADO-2ª VIA

O Comitê de Ética em Pesquisa da FOP-UNICAMP certifica que o projeto de pesquisa "**Influência do padrão facial na força máxima de mordida, na deflexão mandibular medial e nos movimentos mandibulares**", protocolo nº **059/2004**, dos pesquisadores **ALTAIR ANTONINHA DEL BEL CURY, EVILIN SANCHES MORAIS, JULIANA SILVA MOURA, RENATA CUNHA MATHEUS RODRIGUES GARCIA, SIMONE GUIMARÃES FARIAS GOMES e WILLIAM CUSTODIO**, satisfaz as exigências do Conselho Nacional de Saúde – Ministério da Saúde para as pesquisas em seres humanos e foi aprovado por este comitê em 06/07/2004.

The Ethics Committee in Research of the School of Dentistry of Piracicaba - State University of Campinas, certify that the project "**Influence of facial type on maximum bite force, medial mandibular deflexion and mandibular movements**", register number **059/2004**, of **ALTAIR ANTONINHA DEL BEL CURY, EVILIN SANCHES MORAIS, JULIANA SILVA MOURA, RENATA CUNHA MATHEUS RODRIGUES GARCIA, SIMONE GUIMARÃES FARIAS GOMES and WILLIAM CUSTODIO**, 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 06/07/2004.

Prof. Pablo Agustin Vargas
Secretário
CEP/FOP/UNICAMP

Prof. Jacks Jorge Júnior
Coordenador
CEP/FOP/UNICAMP

Nota: O título do protocolo aparece como fornecido pelos pesquisadores, sem qualquer edição.
Notice: The title of the project appears as provided by the authors, without editing.

ANEXO 3: Certificado de aprovação do artigo referente ao capítulo 1.

From: Karen Kimbell
To: regarcia@fop.unicamp.br
Sent: Monday, October 19, 2009 1:48 PM
Subject: CRANIO status of manuscript #1629

October 19, 2009

Dear Dr. Garcia:

We are pleased to inform you that your manuscript, "**Mastication, EMG activity and occlusal contact area in subjects with different facial types.**" **(#1629)** is accepted for publication in CRANIO. Please find enclosed, a copyright form for you and your coauthors to sign and return to us (you may fax the copyright form to us if you wish at 423-490-0791). If you have not already done so, please send a brief bio for each author along with degree designations, as they should be published. Once your manuscript has been scheduled for an issue and is in production, you will receive a set of galley proofs on which to make any necessary changes.
If you have any questions or if we can be of any assistance to you, please don't hesitate to contact our office.

Sincerely,

Riley H. Lunn, D.D.S.
Editor
CRANIO: The Journal of Craniomandibular Practice

ANEXO 4: Certificado de aprovação do artigo referente ao capítulo 2

From: <psvensson@odont.au.dk>
To: <regarcia@fop.unicamp.br>
Cc: <jor@odont.au.dk>
Sent: Saturday, January 30, 2010 9:40 AM
Subject: Acceptance of JOR-09-0446.R2 - Journal of Oral Rehabilitation

30-Jan-2010

Dear Dr. Renata Rodrigues Garcia,

I am very happy to inform you that your manuscript entitled: "**Masticatory features, EMG activity and muscle effort of subjects with different facial patterns.**" has now been accepted for publication in the Journal of Oral Rehabilitation. Thank you for submitting your work to the journal.

You can track the progress of your manuscript by logging in with your ID and password to www.blackwellpublishing.com/bauthor.

Best wishes from JOR!

Peter Svensson
Editor in Chief
Journal of Oral Rehabilitation
http://mc.manuscriptcentral.com/jor

ANEXO 5: Certificado de submissão do artigo referente ao capítulo 3

From: Darlen.Basillaje@springer.com
To: regarcia@fop.unicamp.br
Date: Wed, 3 Feb 2010 12:19:01 -0500
Subject: CLOI: Submission Confirmation for Preferred chewing side, bite force and occlusal contact area of subjects with different craniofacial vertical dimensions.

Dear Dr. Rodrigues Garcia,

Your submission entitled **"Preferred chewing side, bite force and occlusal contact area of subjects with different craniofacial vertical dimensions."** has been received by Clinical Oral Investigations

You will be able to check on the progress of your paper by logging on to Editorial Manager as an author. The URL is http://cloi.edmgr.com/.

Your manuscript will be given a reference number once an Editor has been assigned.