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Non-pathological facial asymmetry in adult women: an approach to bite force, occlusal contact distribution and masticatory muscle thickness

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ABSTRACT

Facial asymmetries, often subtle, can indicate imbalances that go beyond aesthetic concerns. ***Aim:*** *This cross-sectional study analyzed molar bite force, occlusal contact distribution, and masseter and temporal muscle thickness in adult women with facial symmetry and slight non-pathological facial asymmetry, which generally goes unnoticed and is often considered a variation of normality.* ***Materials and Method:*** *Forty-two women aged 18 to 30 were evaluated for slight non-pathological facial asymmetry using the VECTRA M3. Two groups were established: facial symmetry (n=21) and slight non-pathological facial asymmetry (n=21). Molar bite force was measured with a dynamometer. T-Scan was used to evaluate occlusal contact distribution. Masseter and temporal muscles thickness was assessed using ultrasound. Analyses used a 5% significance level (Student's t-test).* ***Results:*** *No significant difference was found in maximum molar bite force between the groups, though the slight asymmetry group showed lower force in clinical observation. No significant difference was observed in masseter and temporal muscle thickness during rest and maximum voluntary contraction, but clinically, the masseter was thicker than the temporal in both groups, being thicker in the slight non-pathological facial asymmetry group than in the facial symmetry group. Occlusal contact distribution did not differ significantly between groups, but clinically, the slight non-pathological facial asymmetry group showed less distribution in the occlusal contacts of the first permanent molars and more pronounced distribution in the left hemiarch compared to facial symmetry group.* ***Conclusion:*** *Although no significant difference was observed between groups in this study, the numerical analysis of the results highlights the importance of evaluating the stomatognathic system in dental procedures, particularly with regard to non-pathological facial asymmetry.*

Keywords: *facial asymmetry - masticatory muscles - three dimensional imaging - bite force - occlusion - ultrasonography*

Assimetria facial não patológica de mulheres adultas: uma abordagem da força de mordida, distribuição de contatos oclusais e espessura dos músculos mastigatórios

RESUMO

Assimetrias faciais, muitas vezes discretas, podem indicar desequilíbrios que ultrapassam questões estéticas. ***Objetivo:*** *Este estudo transversal analisou força de mordida molar, distribuição do contato oclusal e espessura dos músculos masseter e temporal em mulheres adultas com simetria facial e assimetria facial leve não patológica, que geralmente passa despercebida e muitas vezes é considerada variação da normalidade.* ***Materiais e Método:*** *Quarenta e duas mulheres com idades entre 18 e 30 anos foram avaliadas quanto à assimetria facial leve não patológica usando o VECTRA M3. Foram estabelecidos dois grupos: simetria facial (n=21) e assimetria facial leve não patológica (n=21). Força de mordida molar foi medida com dinamômetro. T-Scan avaliou a distribuição do contato oclusal. A espessura dos músculos masseter e temporal foi avaliada por meio de ultrassonografia. As análises utilizaram nível de significância de 5% (teste t de Student).* ***Resultados:*** *Não foram encontradas diferenças significativas na força máxima de mordida molar entre os grupos, embora o grupo com leve assimetria tenha apresentado menor força na observação clínica. Não foram observadas diferenças significativas na espessura dos músculos masseter e temporal durante o repouso e contração voluntária máxima, mas clinicamente o masseter foi mais espesso que o temporal em ambos os grupos, sendo mais espesso no grupo com assimetria facial leve não patológica em comparação ao grupo com simetria facial. Distribuição dos contatos oclusais não apresentou diferenças significativas entre os grupos, mas clinicamente, o grupo com assimetria facial leve não patológica apresentou menor distribuição nos contatos oclusais dos primeiros molares permanentes e distribuição mais pronunciada na hemiarcada esquerda em comparação ao grupo com simetria facial.* ***Conclusão:*** *Embora não tenham sido observadas diferenças significativas entre os grupos neste estudo, a análise numérica dos resultados ressalta a importância da avaliação do sistema estomatognático em procedimentos odontológicos, principalmente no que se refere à assimetria facial não patológica.*

Palavras-Chave: *assimetria facial - músculos mastigatórios - imagem tridimensional - força de mordida - oclusão - ultrassonografia*

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INTRODUCTION

Symmetry is important for aesthetic sense and beauty standards, suggesting order, proportion and elegance in architecture and arts, and health, strength and favorable reproduction in animals. In humans, it affects relationships, quality of life, and aesthetic well-being[1]. The importance attributed to symmetry contrasts with the fact that human faces may exhibit slight asymmetry that is often unnoticed[2,3].

Although highly prevalent across the population, facial asymmetry is rarely addressed in dental literature. There is a lack of epidemiological information, studies, and histological and genetic research to determine the real etiology and factors associated with such disharmony, which affects patients' aesthetics and is significantly challenging to correct by means of clinical interventions[2].

Evaluation of facial asymmetry by dental and medical professionals can determine the intensity of asymmetries and be used to plan effective treatment. There are not usually any major structural impairments or functional problems associated with non-pathological facial asymmetry, but patients often seek treatment due to the impact on their facial attractiveness[4].

Dynamic modifications in facial structures can have implications on the complex stomatognathic system, which consists of interdependent dynamic and static structures, including the temporomandibular joint, bones, muscles, teeth, tongue, lips, cheeks, glands, blood vessels and nerves[5]. These structures work together, and any anatomical or functional alteration can result in functional imbalance, affecting proprioceptive information and thus, chewing, swallowing and speech[6-8].

It is essential to understand the origin and clinical aspects of facial asymmetry in order to comprehend the effects of the function of masticatory and facial muscles on the craniomandibular system, as well as the variations in development and how they relate to functional and aesthetic outcomes[9,10]. Evaluation methods can provide information about the cause and consequences of facial asymmetries, especially non-pathological ones, and such information is essential for planning corrective procedures and controlling functional imbalances[11].

The aim of this cross-sectional study was therefore to evaluate molar bite force, occlusal contact distribution, and the thickness of the masseter and temporal muscles in adult women with facial symmetry or slight non-pathological facial asymmetry. The null hypothesis assumes the absence of significant differences in molar bite force, occlusal contact distribution and masseter and temporal muscles thickness between the symmetric and slight non-pathological asymmetry groups.

MATERIALS AND METHOD

Sample

This cross-sectional study was approved by the ethics committee at the Ribeirão Preto School of Dentistry, University of São Paulo, Brazil (protocol # 59833522.0.0000.5419). All subjects were informed of the objectives and procedures, and signed an informed consent form.

The G* Power software (Franz Faul, Kiel University, Kiel, Germany) was used to calculate the sample size via a priori test, considering $\alpha = 0.05$, effect size of 1.31, and 95% power with the variable of left masseter muscle thickness in maximum voluntary contraction based on the pilot project with 5 subjects. The minimum sample size was determined as n=18 for each group.

Recruitment was conducted through an open invitation sent via email to the population. The invitation contained a link to information about the project and the informed consent form. Interested subjects consented to participate in the study through the Research Electronic Data Capture (REDCap) system[12]. The demographic questionnaires and baseline data, including personal information, anthropometrics, parafunctional habits, and history of pre-existing conditions were completed after the subjects had expressed their agreement to participate in the study.

The Diagnostic Criteria for Temporomandibular Disorders (DC/TMD) questionnaire, sent via email as an online survey, was used to assess the presence of temporomandibular dysfunction. Researchers received notifications upon completion of the responses. A total 77 subjects responded to the questionnaires provided in REDCap, of whom 6 did not fully complete the forms, and 2 did not attend the scheduled date for the initial examination. After completing the distributed questionnaires, the 69 subjects who met the online criteria received email invitations to attend the research laboratory for a clinical examination to confirm inclusion or exclusion criteria, resulting in the non-selection of 27 subjects for the study.

The eligibility criteria ensured sample homogeneity and the validity of the results. Inclusion criteria were having a Class I standard profile, natural dentition, all teeth present except third molars, body mass index between 18.5 and 24.9, and age 18 to 30 years. Exclusion criteria were symptoms of temporomandibular dysfunction, ulcerations, skin hypersensitivity, uncompensated neurological and systemic pathologies, periodontal disease, parafunctional habits, being on continuous use of muscle relaxants that could interfere with neuromuscular physiology or having undergone prior orofacial harmonization procedures.

After applying the inclusion and exclusion criteria, 42 adult women (mean age ± SD: 23.14 ± 4.14 years) were selected to compose two groups matched by age and body mass index: symmetric (n=21) and with slight non-pathological asymmetry (n=21) (Table 1). The variable in this study was slight non-pathological facial asymmetry, defined as absent or present. The measure was obtained by classifying the subjects based on the root mean square (RMS) values through stereophotogrammetry.

Table 1. Data on the characteristics of the group with facial symmetry (FSG) and the group with mild non-pathological facial asymmetry (FAG). Significant difference, Student's t-test (p < 0.05).

Groups	Age	Body Mass Index
FSG	22.3 ± 4.1	22.1 ± 2.4
FAG	23.1 ± 3.6	21.4 ± 2.1
p value	0.52	0.35

Facial asymmetry analysis

The classification method for subjects as symmetric or asymmetric was based on clinical examination criteria established. During the initial assessment, trained calibrated examiners evaluated facial symmetry using predefined parameters, considering anatomical landmarks, proportions, and any visible deviations. The classification was further supported by objective measurements derived from stereophotogrammetry methods, which generated RMS values to enhance consistency and reliability in distinguishing between symmetric and asymmetric subjects.

The 3D imaging system VECTRA M3 (Canfield Scientific, Inc., Parsippany, NJ, USA) was used for image acquisition[3,13,14]. The Vectra M3 software enabled the creation of a symmetry plane that aligned two surfaces in three-dimensional space through manual alignment using reference points, and subsequently automatically through the integrated closest-point algorithm.

During the examination, the subjects remained seated in an upright position, with the torso straight, shoulders relaxed, hands on the lap, and feet fully supported on the ground. The face was cleaned with hypoallergenic wet wipes to remove any oiliness and makeup residue. Instructions were given on positioning in front of the 3D camera according to the manufacturer's guidelines. Subjects were asked to keep their face at rest and expressionless while focusing on the front mirror during image capture.

Images were prepared for quantitative comparison between the original facial surface and the mirrored image according to the following protocol: the first point was marked at the Trichion, on the hairline, followed by points from left to right. Starting from the Frontotemporale, the image was rotated to expose the left side of the face, marking until the Cheilion, and then the image was rotated to expose the Gonion. The selection continued until the Menton, returning to the frontal view to complete the contour of the mandibular body. The image was rotated laterally to expose the right Gonion and moved up from the Gonion to the Trichion, bordering the muscle insertion. After marking the points, the excess area was delineated and removed. Subsequently, the facial area of interest was delimited, gridlines were applied, and positioning was adjusted along the y-axis . Then, the entire face was selected, and the option to find symmetry was applied. The image was viewed in both frontal and lateral views. The gridlines were removed, and the original face was mirrored, preparing it for comparative quantitative analysis.

The quantitative comparison between the original facial surface and its mirrored image calculated the distance between them, enabling quantification of non-pathological asymmetry. The root mean square (RMS) of the means of the distances between corresponding points in the overlaid images was calculated. To enhance visualization, the regions contributing most significantly to the asymmetry were analyzed using a color map generated by the software.

Criteria for classifying non-pathological facial asymmetry

The Receiver Operating Characteristic (ROC) curve analysis was used to compare the clinical

examination - considered the gold standard for facial asymmetry classification- to subjects' RMS scores. This analysis determined the point of greatest agreement between the two assessments, which was defined as the cutoff point for group classification.
The Jamovi software (The Jamovi Project, 2023, version 2.3.17) was used for this analysis. The cutoff point that optimized both sensitivity and specificity was 0.68, with a sensitivity of 94.44% and a specificity of 83.33%. Subjects with RMS of up to 0.68 were classified as symmetrical, while those with values above 0.68 were considered to have mild, non-pathological facial asymmetry.
The classification into symmetric and asymmetric was used exclusively for methodological purposes in this study, aiming to identify the potential impacts that visible asymmetry could have on morpho-functional balance. Non-pathological facial asymmetry was defined as a subtle asymmetry, likely resulting from self-compensatory mechanisms, with no readily observable effects on function, though subtle effects might still have been present.

Maximum molar bite force analysis
Maximum molar bite force was analyzed with a digital dynamometer (IDDK, Kratos - Equipamentos Industriais Ltda, Cotia, São Paulo, Brazil) with a capacity of 1000 N. The dynamometer was initially placed in the region of the first upper and lower permanent molars on the right side and then on the left side. Probe tips were protected with disposable latex finger cots (Waripaer, São Paulo, Brazil) as a biosafety measure. Three measurements were recorded at 2-minute intervals, alternating between sides[7,15,16].

Occlusal contact distribution analysis
The T-Scan® III occlusal analysis system (Tekscan Inc., Ann Arbor, MI, USA) evaluated occlusion in terms of the sequence of occlusal contact distribution on the first upper and lower permanent molars, as well as the right and left hemiarches. Subjects were instructed to occlude their teeth on the recording sensor several times, until a repetitive contact pattern was captured. Then, three closures were recorded, during which subjects were instructed to bite down as hard as possible, maintaining the pressure for 5 seconds. The equipment recorded the relative force as a percentage of the individual maximum occlusal force[17-19].

Masseter and temporal muscle thickness analysis
The Sonosite® Nano Maxx ultrasound (SonoSite, Inc., Bothell, Washington, USA) with a 13 MHz linear transducer was used to determine masseter and temporal muscle thickness in centimeters. The location of the muscle belly was confirmed by digital palpation and movement of the linear transducer[20]. For the masseter muscle, the linear transducer was positioned transversely to the muscle fibers, approximately 1.5 to 2.0 cm above the angle of the mandible towards the zygomatic arch. For the temporal muscle, the linear transducer was positioned transversely over the anterior belly of the muscle, located in the region of the temporal fossa, about 1.0 to 1.5 cm backward and upward from the lateral canthus of the eyelids, on both sides[7,21]. Ultrasound images were acquired during the mandibular rest task and during maximum voluntary clenching. Ultrasound images were acquired three times by one appropriately trained examiner.

Statistical analysis
The data were subjected to the Shapiro-Wilk test for normality, which showed normal distribution. All analyses were performed with a significance level of 5% (Student's t-test) using SPSS version 20.0 software (SPSS Inc., Chicago, IL, USA).

RESULTS
Table 2 shows the results of molar bite force, distribution of occlusal contacts, and masseter and temporal muscle thickness in adult women with facial symmetry and mild non-pathological facial asymmetry. There was no significant difference in maximum molar bite force between groups, although the group with mild non-pathological facial asymmetry showed lower force in clinical observation. The distribution of occlusal contacts did not differ significantly between the groups, but clinically, the group with mild non-pathological facial asymmetry showed less distribution in occlusal contacts of the first permanent molars and more pronounced distribution in the left hemiarch compared to the symmetrical group. In terms of masseter and temporal muscle thickness, there was no significant difference during rest and maximum voluntary contraction, but clinically, the masseter was thicker than the temporal in both groups, being thicker in the group with mild non-pathological facial asymmetry than in the symmetrical group.

Table 2. Mean ± standard error and p value of molar bite force, distribution of occlusal contacts and thickness of the masseter and temporal muscles of the group with facial symmetry (FSG) and the group with mild non-pathological facial asymmetry (FAG). Significant difference, Student's t-test (p < 0.05).

Variables	FSG	FAG	p value
Bite Force (N)			
Right	387.75 ± 38.73	382.45 ± 30.98	0.82
Left	400.01 ± 40.89	388.63 ± 30.01	0.96
Muscle thickness (cm)			
Rest			
Right masseter	0.64 ± 0.01	0.67 ± 0.01	0.20
Left masseter	0.65 ± 0.01	0.66 ± 0.01	0.54
Right temporal	0.28 ± 0.007	0.28 ± 0.007	0.95
Left temporal	0.27 ± 0.007	0.27 ± 0.007	0.84
Maximum voluntary contraction			
Right masseter	1.20 ± 0.03	1.22 ± 0.02	0.60
Left masseter	1.22 ± 0.04	1.25 ± 0.02	0.61
Right temporal	0.44 ± 0.01	0.42 ± 0.01	0.97
Left temporal	0.40 ± 0.01	0.39 ± 0.001	0.84
Distribution of occlusal contacts (%)			
Upper first molar	16.20 ± 1.15	15.25 ± 1.78	0.65
Upper second molar	15.67 ± 1.37	15.39 ± 1.57	0.89
Lower first molar	15.80 ± 2.11	15.55 ± 1.62	0.64
Lower second molar	15.00 ± 1.60	14.23 ± 1.59	0.73
Right hemiarch	49.00 ± 1.30	46.36 ± 1.72	0.15
Left hemiarch	50.95 ± 1.31	54.20 ± 1.83	0.73

DISCUSSION

The null hypothesis was accepted since there was no significant difference in molar bite force, distribution of occlusal contacts, and masseter and temporal muscle thickness between women in the symmetrical and mild non-pathological asymmetry groups. Notwithstanding, clinical analysis showed differences between groups, highlighting the importance of the clinical approach in observing subtle anatomical differences that may affect the functions of the stomatognathic system.

Although the results revealed no significant difference between the groups for maximum molar bite force, during clinical analysis, lower maximum molar bite force was observed in the group with mild non-pathological asymmetry. The muscles involved in facial kinetics function in synchrony, responding to contractile forces, which may result in morphological modifications in asymmetric subjects[22].

In response to asymmetry, the masticatory and facial muscles can be activated compensatorily on both sides, regardless of the degree of asymmetry promoting neuromuscular adaptations[23]. This occurs at motor level, and is an important aspect to consider in the analysis of the stomatognathic system, as it shows the nervous system's capacity to regulate muscle function and strength[24].

Facial asymmetry can induce adaptations in the pattern of muscle force, resulting in uneven distribution, and consequently, a decrease in the overall strength of the stomatognathic system. Even

mild facial discrepancies can affect the distribution of occlusal force, leading to a decrease, especially during attempts at functional compensation[25].

No significant difference was found in the distribution of occlusal contacts on the upper and lower first permanent molars or on the right and left hemiarches between the symmetrical and mild non-pathological asymmetry groups. However, clinical analysis revealed a less uniform distribution of occlusal contacts on the upper and lower first permanent molars in the group with mild non-pathological asymmetry. Specifically, the asymmetrical group showed more pronounced distribution on the left hemiarch.

Facial asymmetry, when not considered pathological, and often imperceptible visually, can also influence the functionality of dental occlusion and the distribution of occlusal contacts, resulting in potential occlusal misalignments[26]. One of the manifestations of occlusal misalignment is the presence of abnormal occlusal contact points, which can arise from poorly adjusted dental restorations or irregular tooth wear, thereby altering the craniomandibular cervical system[27].

These contact points can interfere with the normal distribution of occlusal loading force during the chewing process, promoting inadequate distribution of occlusal contacts on the posterior teeth[28]. It is relevant to highlight that, although abnormal occlusal contact points on the first permanent molars were not evaluated in this study, they are important in interpreting the results. These abnormal contact points on the teeth can affect the proper distribution of occlusal contacts, and should be considered when analyzing occlusion and masticatory function in subjects with facial asymmetry.

Differences in muscle strength between the left and right sides can also lead to an asymmetric distribution of load during the chewing process. Stronger or more active muscles on one side of the face may promote greater force and, consequently, a more pronounced distribution of occlusal contacts on that side[29]. A preference for chewing predominantly on one side of the mouth provides an asymmetric distribution of occlusal contacts[30], and asymmetries in the contraction patterns of the masticatory muscles, resulting in an uneven distribution of load in the dental hemiarch during chewing. These factors may account for the more pronounced distribution in the left hemiarch in the group with mild non-pathological facial asymmetry. However, this study did not identify the preferred chewing side.

This study investigated potential differences in masseter and temporal muscle thickness between groups with symmetry and mild non-pathological facial asymmetry, during resting and maximum voluntary dental clenching, finding no significant difference. However, in clinical analysis, it was observed that the masseter muscle was thicker than the temporal muscle in both groups, being even thicker in the group with mild non-pathological asymmetry. These findings are consistent with data from the literature, which report thicker masseter muscles than temporal muscles[16,31].

Thicker masseter muscles than temporal muscles, both at rest and during maximum voluntary dental clenching, can be explained by anatomy. Firstly, the masseter muscle plays a crucial role in chewing, elevating the mandible during mouth closure and applying the necessary force to crush food[32]. This predominant function in chewing naturally leads to greater development and thickness of the masseter than the temporal muscle, which has a secondary – though important – function: stabilizing and positioning the jaw during chewing and other mandibular movements[33].

In addition to the anatomical and morphological differences between the masseter and temporal muscles that contribute to this discrepancy in thickness, it is important to highlight their distinct functional characteristics. The masseter muscle, considered a thick muscle with synergistic action with the medial pterygoid, is inserted in the mandible, giving it a mechanical advantage in applying force during chewing. It also has a higher proportion of fast-twitch muscle fibers, enabling it to generate more substantial and sustained force during chewing than the temporal muscle, which has a fan-shaped structure originating from an extensive area of the lateral aspect of the skull and is designed more for movement than force[33,34].

Mild non-pathological facial asymmetry may lead to a greater thickness in the masseter muscle, suggesting a morphological compensation in the stomatognathic system, which could result in an imbalance in force distribution and muscular activity during chewing to maintain mandibular functional stability[35]. This demonstrates the importance of considering not only the external facial appearance but also the

internal adaptations of the stomatognathic system when analyzing subjects with facial asymmetries.

There are several limitations to this study. Firstly, only a few of the numerous available tests were used to assess masticatory function; future studies should incorporate a variety of tests and consider different age groups. Another limitation is the absence of comparisons with the underlying bone structure. Ethical constraints prevented the use of imaging examinations with ionizing radiation for this purpose. Moreover, preferred chewing side and abnormal occlusal contact points on the first permanent molars were not investigated.

The pursuit of balance transcends all areas of dentistry, from maintaining oral health to developing innovative techniques and continuous professional improvement. The findings of this study emphasize the relevance of clinical observation of non-pathological facial asymmetries, highlighting that even mild discrepancies can affect the functionality of the stomatognathic system without apparent significant difference. Therefore, when planning rehabilitation and aesthetic procedures, it is important to consider not only facial appearance but also the function of the anatomical structures involved in the masticatory process. This approach can contribute to more satisfactory, long-lasting results.

CONCLUSIONS

The authors of this study highlight that, although no significant difference was observed in maximum molar bite force, masseter and temporal muscle thickness, or distribution of occlusal contacts between the groups of women with facial symmetry and those with slight non-pathological facial asymmetry, clinical analysis revealed noteworthy subtleties. The group with slight non-pathological facial asymmetry had lower bite force, less uniform distribution of occlusal contacts – particularly in the left hemiarch – and greater masseter muscle thickness compared to the symmetrical group. The results emphasize the need to assess the stomatognathic system in dental procedures, especially concerning non-pathological facial asymmetry

CONFLICT INTERESTS

The authors declare no potential conflicts of interest regarding the research, authorship, and/or publication of this manuscript.

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