THE INFLUENCE OF MAXILLARY AND MANDIBULAR OSTEOPOROSIS ON MAXIMAL BITE FORCE AND THICKNESS OF MASTICATORY MUSCLES

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ABSTRACT

The aim of this study was to examine the bite force and masseter and temporal muscle thickness in individuals with maxillary and mandibular osteoporosis. 72 individuals were distributed into two equal groups: (1) facial osteoporosis and (2) healthy controls. Bite force on the right and left molar regions was recorded with a dynamometer and the highest value out of three measurements was recorded as the maximal bite force. Muscle thickness was measured with a SonoSite Titan ultrasound scanner. Ultrasound images were obtained of the bilateral masseter and temporal muscles at rest and at maximal voluntary contraction. The means of the measurements in each clinical condition were analyzed with multivariate statistical analysis (SPSS 19.0). Student's t test indicated no significant difference for muscle thickness, but indicated significantly lower bite force values in the osteoporosis group (p> 0.05). Lower bite force in individuals with facial bone loss demonstrates functional impact of osteoporosis on the complex physiological stomatognathic system.

Key words: *Osteoporosis; ultrasound; bite force; masticatory muscles.*

A INFLUÊNCIA DA OSTEOPOROSE MAXILAR E MANDIBULAR NA FORÇA DE MORDIDA E ESPESSURA DOS MÚSCULOS MASTIGATÓRIOS

RESUMO

Este estudo teve como objetivo analisar a força de mordida e a espessura dos músculos masseter e temporal em indivíduos com osteoporose maxilar e mandibular. 72 indivíduos distribuídos em dois grupos equivalentes: (1) osteoporose facial e (2) controles saudáveis. Força de mordida nas regiões de molar direita e esquerda foi gravada com o dinamômetro e o valor mais alto das três medidas foi registrado como a força de mordida máxima. A espessura muscular foi mensurada com ultrassom SonoSite Titan. As imagens de ultrassom foram obtidas dos músculos masseter e temporais bilateral em repouso e em contração voluntária máxima. As médias das medidas em cada condição clínica foram analisadas com a análise estatística multivariada (SPSS 19.0). Teste t de Student não revelou diferenças significativas para a espessura músculos, mas indicou valores significativamente mais baixos de força de mordida no grupo com osteoporose (p> 0,05). Força de mordida menor em indivíduos com perda óssea facial demonstra um impacto funcional da osteoporose na fisiologia complexa do sistema estomatognático.

Palavras-chave: *Osteoporose; ultrassom; força de mordida; músculos mastigatórios.*

INTRODUCTION

Increasing longevity of the world population has led to osteoporosis being considered the "epidemic of the twenty-first century" [1,2]. Osteoporosis is a serious public health problem for middle-aged and elderly women and increases after menopause [3]. By 2050, the worldwide incidence of hip fracture is projected to increase by 240% for women and 310% for men. The estimated number of osteoporosis hip fractures worldwide is expected to rise from 1.66 million in 1990 to 6.26 million in 2050, even if age-adjusted incidence rates remain stable [4]. The International Osteoporosis Foundation in 2013 reports that it is one of the most important diseases associated with aging.

Systemic osteoporosis affects femoral, radial, and spinal bones, in addition to affecting craniofacial bones and oral structures, directly influencing vari-

ous oral conditions and dental procedures [5,6]. Clinical and scientific dental interest in the effects of osteoporosis on facial structures has been growing. In a preliminary study, Siéssere et al. [7] evaluated the electromyographic activity of the masseter and temporal muscles of patients with maxillary and mandibular osteoporosis compared to a control group. They found that the decrease in the amount of maxillary and mandibular bone tissue that supports the muscle structure in individuals with osteoporosis does not cause a change in the level of electromyographic pattern activation.

Dental radiographs might be useful for screening for osteoporosis. Some studies indicate the use of the relationship between mandibular bone mineral density (BMD) and other skeletal sites commonly used for bone densitometry in the detection of osteoporosis [8]. The evaluation of dental radiographs may have a role in the detection of individuals with osteoporosis [9]. Other oral signs of osteoporosis could be alveolar ridge resorption, tooth loss and chronic destructive periodontal disease [10].

Mastication is one of the functions of the stomatognathic system, which comprises a functional and physiological entity integrating a set of organs and tissues whose biology and physiopathology are absolutely interdependent and therefore require complex evaluation. In addition to the electrical activity previously evaluated [7], structural evaluation of masticatory muscles and their ability is essential for complete understanding of the possible influences of osteoporosis on the masticatory process.

In this context, the aim of this study was to investigate the thickness of the masseter and temporal muscles and the bite force of patients with mandibular and maxillary osteoporosis. The data from these osteoporotic patients was compared to data obtained from healthy individuals.

MATERIALS AND METHODS

Volunteers

Seventy-two individuals of both genders, with an average age of 53.0±5 years, with no distinction of ethnicity or social class, took part in this study. They were divided into two groups of 36. Group 1 consisted of thirty-six individuals selected at random from the pool of users of the Radiology Clinic at the Ribeirão Preto Dental School, University of São Paulo, Brazil, with mandible and maxillary osteoporosis, who had been diagnosed by means of panoramic radiographs, obtained through the acquisition of digital image indirectly, with the chassis plans 15x30 or 18x24cm, using the panoramic X-ray machine and cephalometric brand - Siemens, model - Orthophos CD with kVp: 90 mA and: 16 and turnover time 14.1s. Lorente – Ramos et al. in 2011 reported that panoramic radiographs showed low bone mineral density (BMD), confirmed by BMD values of the lumbar spine (L_1–L_4) as measured by the exam Dual Energy X-ray Absorptiometry or DEXA, which has high diagnosis accuracy and a low dose of radiation compared to other methods. The DEXA exam was used to diagnose skeleton osteoporosis in each individual. The scanner takes a picture of the bones in the spine, hip, total body and wrist, and calculates their density. To take a DEXA bone density scan, the patient lies on a bed underneath the scanner, a curving plastic arm that emits X-rays. These low-dose X-rays form a fan beam that rotates around the patient. During the test, the scanner moves to capture images of the patient's spine, hip or entire body. The test takes about 20 minutes to perform and is painless. Group 2 (control) included thirty-six individuals, who were employees, and relatives of patients and students, paired subject-to-subject by gender and age (Table 1) with the subjects with osteoporosis.

The sample and inclusion/exclusion criteria were selected by means of anamneses and clinical examinations. The anamneses provided information on the participants' personal data, medical and dental history, any existing parafunctional habits, and possible temporomandibular dysfunction symptoms. All subjects were completely dentate or orally rehabilitated by means of partial fixed dentures or dental implants and had no periodontal problems. The following exclusion criteria were applied during the anamnesis: any systemic or local disorders other than osteoporosis, which could compromise craniofacial growth or the masticatory system, such as neurologi-

Table 1: Demographics of the two groups evaluated. Age, gender and standard deviation (±) in osteoporosis and control group.

Groups	N	Age	Gender
Osteoporosis	36	53.0 ± 5 years	33 female and 3 male
Control	36	51.0 ± 6 years	33 female and 3 male

cal disorders, cerebral palsy, and others; taking any medication that could interfere with muscle activity, such as antihistamines, sedatives, homeopathy, or central nervous system depressors; being under any kind of treatment that could, directly or indirectly, interfere in muscle activity during the period in which the study was performed, such as speech therapy and otorhinolaryngology treatment. Subjects were informed about the purposes and stages of the study and they all provided written consent, signing the form previously approved by the National Health Council (process number 2006.1.242.58.3). Thirty-six control patients were matched individual to individual with the osteoporosis sample. Each subject was assigned to one of two groups, named 1 and 2, and only one examiner knew which group the numbers referred to (control or osteoporosis). All examinations were performed without the researchers knowing which group the subjects belonged to, which made it a double-blind study.

Ultrasound analysis

Muscle thickness was analyzed with a SonoSite Titan ultrasound tool using a high-resolution real-time 56mm/ 10 MHz linear-array transducer placed transversally to the muscle fibers. The middle of masseter muscle was considered to be located between 1.5 and 2.0 cm above the jaw angle towards the upper eyelid, and the anterior portion of the temporal muscle between 1.0 and 1.5 cm to the back and above the external palpebral commissure. The muscle location was confirmed by palpation and transducer movement at the time of image acquisition. The ultrasound program enables measurements with a precision of 0.1 mm. Three acquisitions were made in each muscle condition (rest and dental clenching at maximal habitual optimized imaging). Ultrasound images were obtained from bilateral temporal and masseter muscles at rest and maximal voluntary contraction. During the examination, the participants remained seated, leaning on the backrest with the head unrestrained. Measurements were taken at intercuspidation, with an interval of 2 min between each acquisition for the participants to rest their muscles after dental clenching.

Bite Force analysis

Bite force measurements were collected with the volunteers sitting on a comfortable chair (office-like), with arms extended along the body and hands resting on their thighs. The records were taken with a digital dynamometer, model IDDK (Kratos, Cotia, São Paulo, Brazil), with a capacity of 1000 N, adapted to the mouth. The apparatus has a "set-zero" key, which allows the exact control of the values obtained and also "peak" registers that facilitate the record of the maximal force during measurements. It has two arms with plastic disks on each end, on which the force to be measured is applied. Its high precision charge cell and electronic circuit to indicate force supply precise measurements easily viewed on a digital display. The dynamometer was cleaned with alcohol, and disposable latex finger cots (Wariper, São Paulo, Brazil) were positioned on the biting arms as a biosafety measure. The participants were given detailed instructions and bite tests were performed before the actual recordings were made in order to ensure the reliability of the procedure. The volunteers were then asked to bite the dynamometer three times with maximal force, with a 2-min rest interval between records. Evaluations were performed at the first molars (left and right). Maximal bite force was measured in N through the "peak" force record indicated on the screen, for subsequent analysis. The highest value out of three records was considered as the individual's maximal bite force.

Method Error

The method error of muscle thickness measurements was performed on 18 individuals. Recordings were obtained at two different sessions with a 7-day interval. At each session, an average of three measurements was considered for each side and used later to assess the results. The method error (Se) was calculated using Dahlbergs's formula: $Se = \sqrt{\sum d^2 / 2n}$, where "d" is the difference between the two recordings of the individual and "n" the number of double recordings. Percentage errors were calculated using the formula % = (Se/mean) 100%, where "Se" is the result from Dahlberg's formula and mean corresponds to the mean value of the total of the initial and second measurements. A small difference was found between the first and second (1 week later) series (2.57 – 6.37 %).

The method error of bite force measurements was performed on five subjects. Recordings were obtained at two different sessions with a 7-day interval. At each session, the mean of three bites was considered for each side and used later to assess the results. Paired measurements were analyzed to identify systematic errors. No difference was found between the first and second (one week later) series.

Data analysis and statistics

The maximal molar bite force and muscle thickness measurements on both sides were analyzed using Student's T - test (SPSS 19.0 for Windows; Chicago, USA). A 5% ($p \leq 0.05$) level of significance was adopted.

RESULTS

There was no significant difference between the osteoporosis and control groups regarding masseter and anterior temporalis muscle thickness during rest or dental clenching (Table 2).

The bite force of the osteoporosis group was statistically significantly lower ($p<0.01$) than the bite force of the control group (Table 3).

DISCUSSION

Ultrasound scanning imaging (US) allows real-time evaluation of human masticatory muscle morphology. It is a considerable improvement over computed tomography and magnetic resonance imaging because it does not produce cumulative biological effects, and it has greater clinical availability and lower cost, making it suitable for large-scale studies [11,12].

The thickness of the masseter and temporal muscles, as measured by US, has been related to occlusion, temporomandibular dysfunction, and gender [13]. Thus, this measurement deserves special attention when studying mastication [14,15]. The generalized bone loss in the skeleton found in osteoporotic patients can cause disturbances in the masticatory system, such as modification of muscular position and masticatory muscle hyperactivity and thus, increases the chances of temporomandibular or muscular disorders [7].

It is therefore essential to examine the thickness and bite force of osteoporotic patients in order to analyze possible functional changes associated with this disease.

In the present study, both the osteoporosis and control groups presented higher masseter and temporalis thickness during contraction than at rest, which is in accordance with other studies [11,15-18].

Table 2: Mean, standard deviation (±) and statistical significance of US thickness (mm) of the right and left masseters (RM and LM) and anterior temporalis (RT and LT) muscles during rest and dental clenching, in osteoporosis and control group.

Clinical conditions and muscles	N	Osteoporosis	Control	Significance
Rest				
RM	36	0.89 ± 0.02	0.93± 0.03	ns
LM	36	0.91 ± 0.02	0.96 ± 0.03	ns
RT	36	0.59 ± 0.01	0.58 ± 0.02	ns
LT	36	0.60 ± 0.02	0.56 ± 0.01	ns
Dental clenching				
RM	36	1.38 ± 0.15	1.36 ± 0.08	ns
LM	36	1.31 ± 0.12	1.48 ± 0.14	ns
RT	36	1.07 ± 0.07	1.23 ± 0.09	ns
LT	36	1.04 ± 0.07	1.07 ± 0.05	ns

ns no significance

Table 3: Mean, standard deviation (±) and statistical significance of maximal bite force (N) in osteoporosis and control group.

Clinical conditions and muscles	N	Osteoporosis	Control	Significance
Right molar	36	14.01 ± 1.81	23.51 ± 2.60	**
Left molar	36	14.87 ± 1.71	28.87 ± 3.50	**

** statistical significance $p<0.01$

The absence of differences in muscular thickness between groups also indicates that facial osteoporosis does not interfere in masseter and temporalis morphology. According to Siéssere et al.[7], the masticatory efficiency of osteoporotic patients is similar to that of healthy individuals when evaluated by electromyography. The normal activity of masticatory muscles may explain the normal thickness of these muscles.

On the other hand, osteoporosis has a strong association with the progressive reduction in muscle mass, strength and function (sarcopenia) [19-22] that affects older people [23]. In age-related muscle atrophy, a decrease in both muscle fiber size and number has been reported [24].

The osteoporosis group had significantly lower bite force than the control group. Because of the reduction of bone mass, it is suspected that the patients with osteoporosis tend to have less masticatory muscle strength than healthy patients. If the musculature is not trained over several years, there is a reduction in bite force [25]. In one study, a Brazilian urbanized population was found to have lower bite force when compared to a Brazilian indigenous population, because the soft food consumed by the white population fostered non-trained masticatory musculature [26]. Thus, if osteoporotic patients do not exert masticatory muscles for a long period, this reduced function is expected to affect muscular thickness.

Osteoporosis is a disease that occurs principally in elderly people. Good nutrition is crucial to the reduced morbidity of osteoporotic patients. There is an effective participation of bite force in mastication. Thus, if bite force increases, masticatory efficiency increases as well [12,17]. Bone tissue is continuously remodeling in response to mechanical stress. The alveolar bone mass and the cross-sectional dimension of the alveolar bone increase with increasing functional loading [26,27].

A thicker masseter muscle is associated with a higher local bone density [26]. Thus, the maintenance of a higher muscular loading may contribute to bone loss control in osteoporotic patients. However, further studies are required to evaluate the possible positive effects of muscular stimulation therapy on the jaw muscles of osteoporotic patients.

This study verified lower bite force in patients with osteoporosis than in healthy controls. In addition, both the osteoporosis and control groups presented higher masseter and temporalis thickness during contraction than at rest. If bite force is positively correlated to masticatory efficiency, then it very important to plan for the treatment of patients with osteoporosis via the training of masticatory muscle force as a way to improve masticatory efficiency.

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