



Botulinum toxin for modulating the muscle strength of patients rehabilitated with zygomatic implants

Toxina botulínica para modulação da força muscular de pacientes reabilitados por implantes zigomáticos

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ABSTRACT

Objective: To measure the intensity of muscle strength and electrical activity of masseter and anterior temporal muscles based on BTX-A therapy in patients rehabilitated with total prostheses on zygomatic implants. **Material and Methods:** The object of the study was a sample of 20 individuals subjected to zygomatic implant surgery and rehabilitated with implant-supported prostheses, in order to obtain electromyographic data using an eight-channel module (EMG System do Brasil). The data were collected for three consecutive months: prior to the application (single dose) of BTX-A (30 U/masseter muscle; 10 U/temporal muscle) and after 30 and 90 days of therapeutic treatment. **Result:** All muscle groups studied showed reduction of muscle electrical activity during voluntary contraction after 30 days of treatment (around 47%) ($p < 0.001$), which progressively reverted after 90 days of treatment. The anterior temporal muscles presented similar motor behavior, with activity reduction of 39% ($p < 0.05$). There was a reduction of 17.68% ($p < 0.05$) in mandibular force and an increase of 14.22% ($p < 0.05$) in mouth opening after 30 days of BTX-A administration. **Conclusions:** The results suggest that BTX-A significantly reduces muscle activity, in either the recruitment of motor units or muscle tone, in the first three months of therapeutic treatment. This therapy may also be useful as a preventive method for the failure of zygomatic implant-supported prostheses.

KEYWORDS

Electromyography; Dental implants; Prostheses on implants; Botulinum toxin.

RESUMO

Objetivo: Medir a intensidade da força muscular e atividade elétrica dos músculos temporal anterior e masseteres em função da terapia com BTX-A em pacientes reabilitados por próteses totais sobre implantes zigomáticos. **Material e Métodos:** Uma amostra composta por 20 indivíduos submetidos à cirurgia de implantes zigomáticos e reabilitados com próteses implantossuportadas foi objeto de estudo para obtenção de dados eletromiográficos utilizando um módulo de oito canais (EMG System do Brasil). Os dados foram coletados por três meses consecutivos: antes da aplicação (dose única) de BTX-A (30U / masseter muscular; 10U / temporal), após 30 e 90 dias do tratamento terapêutico. **Resultados:** Todos os grupos musculares estudados apresentaram redução da atividade elétrica muscular durante a contração voluntária, após 30 dias de tratamento (em torno de 47%) ($p < 0,001$), e revertidos progressivamente após 90 dias de tratamento. Os temporais anteriores apresentaram comportamento motor semelhante, apresentando redução de atividade de 39% ($p < 0,05$). Foi observada uma redução de 17,68% ($p < 0,05$) na força mandibular, assim como um aumento na abertura bucal de 14,22% ($p < 0,05$) após 30 dias da administração da BTX-A. **Conclusões:** Os resultados sugerem que a BTX-A reduz significativamente a atividade muscular, seja no recrutamento de unidades motoras ou no tônus muscular, nos primeiros três meses de tratamento terapêutico e pode ser útil como método preventivo de falha de prótese suportada por implantes zigomáticos.

PALAVRAS-CHAVE

Eletromiografia; Implantes dentários; Próteses sobre implantes; Toxina Botulínica.

INTRODUCTION

Implantology has emerged as a solution for rehabilitating fully edentulous patients with osseointegrated implants, as a support for total prostheses [1]. Although this specialty was developed to restore the aesthetics of single elements, complete rehabilitation is still a challenge when the patient does not present optimal bone availability for a prosthetic treatment on implants.

Bone graft techniques allow rehabilitating the lost bone structure, but they present limitations such as high cost, more surgical interventions, and high risk for elderly patients [2]. For the treatment of patients affected by severe pathological or physiological bone resorptions, implants were developed with anchorage made outside the alveolar bone. However, such implants seek support on the zygomatic bone, so they receive the same name. Zygomatic implants have length characteristics ranging from 30 to 55 mm and indication for patients without bone support to receive conventional implants [3].

The clinical success rate of zygomatic implants is 95.21% in a 12-month period, even in immediate loading conditions, and the most frequent complication in this type of rehabilitation is sinus involvement [3]. A 5-year follow-up of a rehabilitation treatment with zygomatic implants reported no implant or prosthesis failure, but half of the cases presented complications in both surgical and prosthetic phases [4]. Patients rehabilitated with prostheses on zygomatic implants are satisfied with the results of the treatment regarding hygiene, esthetics, phonetics, and chewing comfort [5].

Patients with total prosthesis on implants show greater bite force after rehabilitation when compared to patients with removable prosthesis [6], requiring greater care in prostheses maintenance so the excursive movements do not produce a mechanical overload on the prosthesis. Occlusal adjustment is required for the installation

and maintenance of prostheses, preventing implant overload and increasing the survival of the rehabilitation treatment.

Tooth loss causes atrophy of the masticatory muscles due to reduced function, but the rehabilitation of edentulous patients promotes muscle strength and activity recovery, restoring the masticatory capacity to patients [7]. However, the absence of proprioception in dental implants allows a patient with complete prostheses on implants to exert masticatory force on the implants, with an overload that may cause either bone loss around the implants or the fracture of prostheses, prosthetic components, retention screws, and implant bodies [8].

In contrast, botulinum toxin (Botox) is currently a therapeutic solution for modulating the muscle activity of patients affected by stress, hormones, medication reactions, trauma, neuromuscular disorders, and bruxism, which increase muscle tone and induce painful symptomatology.

Botulinum toxin type A (BTX-A) is one of the seven subtypes produced by *Clostridium botulinum*, which is a neurotoxin that causes muscle weakness or paralysis in the skeletal muscle, depending on the dose. Its action mechanism involves blocking the release of acetylcholine, mediated by calcium, from the motor nerve endings. The primary effect is the inhibition of alpha-motoneuron (α MN), which composes the motor units of the skeletal muscle. However, it may also affect gamma-motoneuron (δ MN), which involves the modulation of muscle tone through the action on neuromuscular spindles. The action of the toxin is reversed mainly by neuronal budding with muscle reinnervation. Muscle function is restored within two to four months [9].

Due to the risk of failure of the osseointegration process on a zygomatic implant or the risk of fracture of the element, considering such implants are three to four times longer than conventional ones and their insertion requires skill and surgical precision,

the presence of temporomandibular disorder is also indicated. Such disorder is characterized by a substantial increase in masticatory force and it may compromise the bone repair process, especially in the condition of immediate loading. The use of supporting or therapeutic methods that minimize the failure potential of the prosthetic treatment, such as the modulation of muscle activity during the tissue repair process, avoids delays, repetition of surgical procedures, and changes in the treatment plan.

Considering the need to protect the prosthesis on zygomatic implants against excessive muscle force, in addition to the occlusal adjustment in the maintenance of prosthesis on implants, the present study proposes to evaluate the modulation of muscle strength and activity of patients rehabilitated with prostheses on zygomatic implants by means of the therapeutic use of botulinum toxin.

The hypothesis is that botulinum toxin is useful as a muscle strength modulator, protecting implants and prostheses on implants.

MATERIAL AND METHODS

This study was performed after the approval by the local ethics committee (84013618.9.0000.0077) with a sample of 20 individuals who underwent zygomatic implant placement surgeries and rehabilitation with total implant-supported prostheses. During the evaluation, all subjects were examined for general and oral health prior to any application of botulinum toxin and they signed the informed consent form. For participation in the study, the individuals were subjected to the following inclusion criteria: minimum of 35 years old, no gender distinction, and presenting exclusive rehabilitation with zygomatic implants on total implant-supported prostheses. Exclusion criteria consisted of the presence of physical or mental disability, chemotherapeutic or radiotherapeutic

treatment, neurodegenerative diseases, temporomandibular disorder, injuries, lesions or irritations at the time of botulinum toxin application, and the use of poorly adapted prostheses.

The participants were instructed about oral health, especially on the peri-implant tissue, hygiene care and techniques, and prosthesis maintenance.

The electromyographic (EMG) evaluation followed the guidelines by Seniam and Isek [10-12], as described by Giannasi et al [13].

The EMG signals were captured using an eight-channel module (EMG System of Brazil, Sao Bernardo do Campo, São Paulo, Brazil) consisting of a conditioner with a bandpass filter and cut-off frequencies at 20 to 500 Hz, an amplifier gain of 1000 times, and a common mode rejection ratio >120 DB. All data were acquired and processed using a 16-bit analog-to-digital converter with a sampling frequency of 2 kHz. Active bipolar electrodes with a pre-amplification gain of 20 times were used.

The EMG of the right and left masseter and temporal muscles was performed prior to the BTX-A application and after 30 and 90 days of therapy. During the sessions, the volunteer was instructed to remain seated in a chair, with feet apart, shoulders relaxed and hands resting on thighs, in a well-lit and silent recording room, in a comfortable position, with eyes open, and no head support. Pregelled, self-adhesive, bipolar, silver-silver chloride electrodes were positioned over the right masseter (RM), left masseter (LM), right temporal (RT) and left temporal (LT) muscles, with an inter-electrode distance of 20 mm. The sites for electrode placement were shaved and cleaned with a cotton ball soaked in 70% alcohol to diminish impedance. A rectangular metallic electrode measuring 3 x 2 cm, coated with Lectron II conductive gel (Pharmaceutical Innovations), to increase the conduction capacity and avoid interference from external noise, was attached to the left

wrist of the volunteer for reference. Readings were performed with the mandible in the rest position, with an open mouth, and with maximum clenching effort (MCE). Three readings were performed in open mouth position with a five-minute interval between readings, using a goniometer to measure the mouth opening amplitude. After three minutes, three readings were performed during MCE, with a five-minute interval between readings, using a force transducer to measure the mandibular strength (bite force) (Model PLA 100 kg, Líder Balanças coupled with ID-M LCD with RS 323/Parallel, Filizola, no. 2805). Each signal was recorded for 10 seconds under each condition.

The EMG signals were processed using specific routines carried out in the Matlab program, version 7.1 (The MathWorks Inc., Natick, Massachusetts, USA). For MCE, a 3-second period was selected through a visual inspection of the raw data. A moving window was used to select the EMG signals of the RT, RM, LT, and LM muscles based on the greatest amplitude and regularity in the four muscles simultaneously. For the rest position, the entire 10-second period of the EMG signal was used in the analysis. The signals were analyzed using time domain (amplitude). The amplitude of the raw EMG signal was defined as the root mean square calculated with a 200-ms moving window. The mean amplitudes during the 3 - and 10 - second trials recorded during MCE and in the rest position, respectively, were used for analysis.

All patients presented good general health and had not had any previous antibiotic or anti-inflammatory treatment at the time of application. The first asepsis of the skin was performed with 70% alcohol solution at the application sites. A line was traced from the tragus of the ear to the commissure of the mouth to define a higher safety limit of the applicable area in the masseter muscle. Another line was drawn over a bony edge of the jaw to define the lower limit. The patient was seated at either 45 or 90 degrees to facilitate muscle evaluation and tagging.

The mandibular angle was used as reference for the first point of application in the masseter muscle. During palpation, the patient was asked to perform maximum teeth clenching and alternate it with relaxation, indicating the most hypertrophic points of the masseter muscle.

The anterior and posterior limits of the applicable area of the masseter muscle were traced according to muscle palpation, always requesting the patient to clench the teeth and relax, so the muscle showed its shape.

The width of the masseter muscle usually matches the width of two fingers with inclination of the mandibular angle forward and up. By means of palpation during maximum clenching alternated with relaxation, three main points of application of botulinum toxin and a diffusion halo of 1.5 cm were defined. Usually, three application sites are sufficient and safe for botulinum toxin diffusion. Using a fourth or even a fifth point of application may cause the risk of diffusion to the other muscles or to the parotid duct.

After the anesthetic effect of ointment and ice, a second asepsis with gauze soaked in chlorhexidine was performed only at the point of application, without losing the circled mark. The needle was inserted by keeping the syringe plunger free until it reached the center of the masseter muscle bundle. For the BTX solution (BOTOX™ (onabotulinumtoxinA) - ALLERGAN PRODUTOS FARMACÊUTICOS LTDA), a 100 U single-use vial was reconstituted with 2 ml of sterile, non-preserved, and normal saline (0.9% sodium chloride injection), and the resulting concentration was 5 Units per 0.1 ml. The 5-U dose of BTX was administered for each application site, so the diffusion was adequate and there was no excessive total effect on the masseter muscle.

Only after the final placement of the syringe, the toxin was injected with slight pressure of the thumb on the plunger.

Small bleedings were controlled by gently wiping with sterile gauze and an ice

pack aided the vasoconstrictor and anesthetic effect at low temperature.

Fifteen units were administered for each masseter muscle, divided into three application sites (3 x 5 Units per 0.1 ml). The above recommended dose for each muscle had the objective of not compromising masticatory function.

Patients received doses of 5 Units in the anterior and middle bundle of each temporal muscle at a single application site so not to cover other muscle bundles undesirable to the study.

The EMG data collected were submitted to analysis of variance (ANOVA) and Tukey's test (GraphPad Prisma version 5.0 for Windows XP, GraphPad Software, San Diego, California, USA). The level of significance was set at $p < 0.05$.

RESULTS

Table I shows the means of electrical activities of the muscle groups studied during the evaluations performed at the three collection times. There was an approximate activity reduction of 45% after 30 days of BTX-A application ($p < 0.001$) in both masseter and temporal muscles, bilaterally, at maximum voluntary contraction (MVC) in relation to the previous phase of toxin administration. This inhibition was reversed progressively with time, and it was around 11% in 90 days when compared to the absence of the toxin. In the mandibular (basal) rest condition, the reduction was up to 39% in 30 days and 17% in 90 days, respectively, when compared to the absence of the toxin. This followed a pattern similar to that observed in MVC, but only reached a level of significance in the anterior temporal muscle (bilaterally) (Figures 1 and 2).

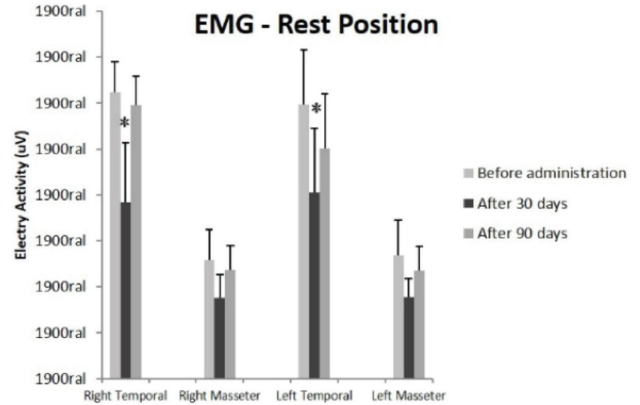


Figure 1 - Surface electromyography of the anterior temporal and superficial masseter muscles (both sides) after use of BTX-A in rest position; * $p < 0.001$.

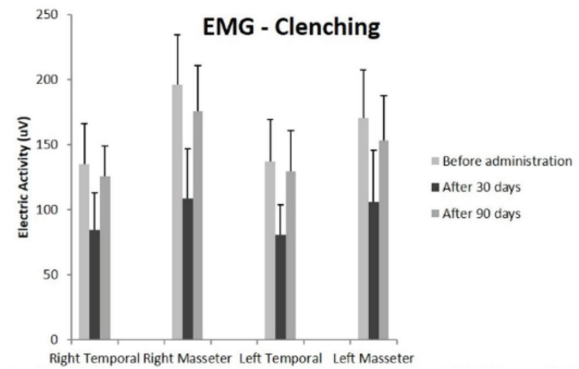


Figure 2 - Surface electromyography of the anterior temporal and superficial masseter muscles (both sides) after use of BTX-A in occlusal Clenching; * $p < 0.001$.

Table 1 - Mechanical properties of the materials used in the numerical simulations

	Right Temporal Muscle (20)	Right Masseter Muscle (20)	Left Temporal Muscle (20)	Left Masseter Muscle (20)
Rest position				
Before	124.80±13.12	51.78±13.09	119.29±23.77	53.69±15.40
After 30 days	76.75±25.76*	35.17±10.06	81.04±27.90*	35.49±8.13
After 90 days	119.19±12.58	47.48±10.29	100.12±23.87	47.17±10.45
Occlusal clenching				
Before	134.73±31.37	196.17±38.35	137.40±32.25	170.67±37.12
After 30 days	84.45±28.70*	108.89±37.76*	80.63±23.14*	106.01±39.58*
After 90 days	125.92±22.97	175.96±34.66	129.59±31.42	153.27±34.49

(N)= number of muscles; * $p < 0.001$.

In order to verify the functional consequence of reduced neuronal activity in the masticatory muscles, the total mandibular force of the patients was measured during the three experimental phases (Figure 3). Such force intensity values represent directly the level of recruitment of motor units activated voluntarily by the upper motor centers of patients, through α MN fibers. There was a reduction of 17.68% ($p < 0.05$) and 14.61% in mandibular force after 30 and 90 days of BTX-A application, respectively.

However, to evaluate the action of the toxin in muscle tone modulation, which involves the activity of gamma-motorneurons, the degree of mouth opening was measured (Figure 4) with a mandibular goniometer coupled to the system. There was an increase in the degree of openness ($p < 0.05$) after 30 days of toxin administration, suggesting that BTX-A acts on both the recruitment of new units (α MN) and the condition of muscle contraction (γ MN).

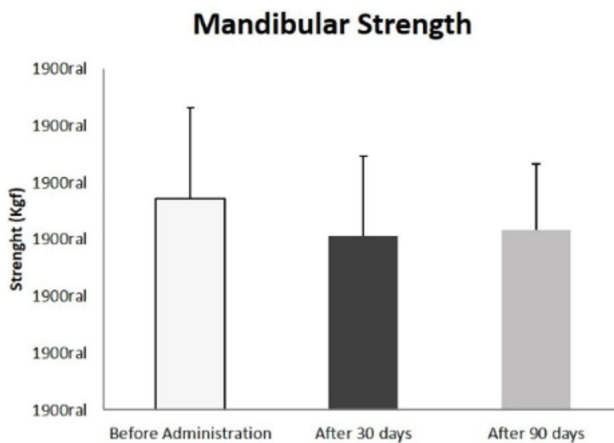


Figure 3 - Mean values and standard deviation of the Mandibular Strength after use of BTX-A; * $p < 0.05$.

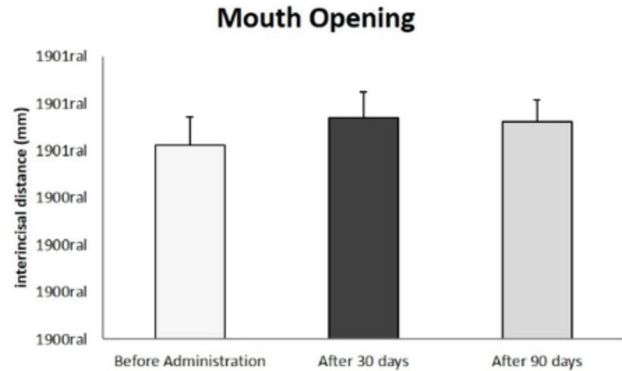


Figure 4 - Mean values and standard deviation of the interincisal distance after use of BTX-A; * $p < 0.05$.

DISCUSSION

The use of a zygomatic implant as an option in the rehabilitation of patients subjected to maxillectomy, with tumors in the oral and maxillofacial complex, was introduced by Bränemark in 1988 [14]. In 1990, this technique was also recommended for patients with severe maxillary resorption [15,16]. The major advantages of the zygomatic implant are to eliminate the maxillary sinus lift and bone grafts and potentially use prostheses after immediate loading [17]. The anchorage obtained in the zygomatic region contrasts with the bone quality of the posterior maxillary region, predominantly type IV. The zygomatic bone is used as an anchorage for placing implants for facial prostheses. For all these reasons, the zygomatic bone should be considered a constant anchorage for the rehabilitation of jaws with severe bone resorption [18].

The implantation on this anatomical area requires great technical development and professional skill due to the structures surrounding the surgical procedure, as well as the presence of temporomandibular disorder (TMD), which is characterized by a substantial increase in masticatory force and may compromise the bone repair process, especially for immediate loading [4].

Botulinum toxin, initially applied for aesthetic purposes, has been used for a wide range of motor dysfunctions such as TMD, trigeminal pain, migraine, and control of bruxism [19,20]. Its action mechanism, while not fully understood, is well established and its application has already been recognized and approved by several institutions related to pharmacological agents.

Botulinum toxin may be an alternative for the treatment of bruxism. This technique is considered safe and effective in the treatment of various forms of neurological disorders, which favors its indication [21]. However, this treatment has disadvantages such as high cost, the need for a professional specialized on pharmacological concepts and good anatomy knowledge, and the indication for cases of severe bruxism. Therefore, the obvious advantage of applying the toxin in other techniques has been reported, considering that patients with bruxism will continue to clench their teeth, while they will relax the masticatory muscles with the use of BTX. This aids osseointegration, because a great part of implant loss is due to masticatory trauma, in the case of a conservative procedure, with excellent results [22].

Despite the high success rate for the use of conventional implants, few studies describe the failures resulting from zygomatic implants or bone repair problems involving increased stress on implants during tissue repair. However, failure rates of inclined implants are higher and more frequent than conventional vertical methods, suggesting that the professional is more careful in planning and executing the procedures. Thus, the use of pharmacological mechanisms or tools, in this specific situation, may be useful for modulating masticatory intensity, contribute to the repair process, and prevent potential errors and repetitions of dental procedures that lead to disorders for the patient and discomfort for the professional.

This study followed this line of questioning, proposing a way to attenuate mandibular force for the accomplishment of prosthetic procedures

involving implants on the zygomatic bone. Our data show that BTX-A (onabotulinumtoxinA) significantly reduced the mandibular force and electrical activity of the masticatory muscles of all the muscle groups studied ($p < 0.001$). This showed the efficacy of the neurotoxin in motor behavior, according to previous studies [23], by the recruitment of fibers or motor units involving the participation of the alpha-motoneuron (voluntary movement). However, in the condition of mandibular rest position, the temporal muscles, which are responsible for determining the mandibular postural position, also suffered a significant reduction ($p < 0.05$) in electrical activity, suggesting that the toxin may also control the state of muscle contraction (tonus). Such mechanism involves the participation of gamma-motoneuron, with potential effects on neuromuscular spindles. To corroborate these findings, there was an increase in the mouth opening range, which suffers motor interference due to the muscle contraction of mandibular elevator and depressor muscles. Thus, tonus reduction will promote an increase in interincisal distance, as observed in the present study.

CONCLUSION

After evaluating the data obtained in this study, the hypothesis was confirmed, because of the reduction of masticatory force and the increase of mouth opening range after a single intramuscular administration of 15 U of onabotulinumtoxinA in masseter muscles and 5 U in temporal muscles.

It is concluded that using the therapy in question in patients rehabilitated with prostheses on zygomatic implants reduces both the risk of complications from the absence of proprioception in the rehabilitated areas and the presence of parafunctional habits.

Further studies on the use of botulinum toxin in zygomatic implant rehabilitation may show the reduction of implant failures, fracture of prosthetic components or prosthesis structure, and early wear of artificial teeth.

REFERENCES

- Albrektsson T. A multicenter report on osseointegrated oral implants. *J Prosthet Dent.* 1988;60(1):75-84.
- Nocini PF, Trevisiol L, D'Agostino A, Zanette G, Favero V, Procacci P. Quadruple zygomatic implants supported rehabilitation in failed maxillary bone reconstruction. *Oral and maxillofacial surgery.* 2016;20(3):303-8.
- Chrcanovic BR, Albrektsson T, Wennerberg A. Survival and Complications of Zygomatic Implants: an Updated Systematic Review. *J Oral Maxillofac Surg.* 2016 Oct;74(10):1949-64. doi: 10.1016/j.joms.2016.06.166..
- Davo R, Pons O. 5-year outcome of cross-arch prostheses supported by four immediately loaded zygomatic implants: a prospective case series. *Eur J Oral Implantol.* 2015 Summer;8(2):169-74.
- Sartori EM, Padovan LE, de Mattias Sartori IA, Ribeiro PD, Jr., Gomes de Souza Carvalho AC, Goiato MC. Evaluation of satisfaction of patients rehabilitated with zygomatic fixtures. *J Oral Maxillofac Surg.* 2012;70(2):314-9.
- von der Gracht I, Derks A, Haselhuhn K, Wolfart S. EMG correlations of edentulous patients with implant overdentures and fixed dental prostheses compared to conventional complete dentures and dentates: a systematic review and meta-analysis. *Clin Oral Implants Res.* 2017 Jul;28(7):765-773. doi: 10.1111/clr.12874. Epub 2016 Jun 14.
- Uram-Tuculescu S, Cooper LF, Foegeding EA, Vinyard CJ, De Kok IJ, Essick G. Electromyographic evaluation of masticatory muscles in dentate patients versus conventional and implant-supported fixed and removable denture wearers- a preliminary report comparing model foods. *Int J Prosthodont.* 2015;28(1):79-92.
- Luraschi J, Schimmel M, Bernard JP, Gallucci GO, Belser U, Muller F. Mechanosensation and maximum bite force in edentulous patients rehabilitated with bimaxillary implant-supported fixed dental prostheses. *Clin Oral Implants Res.* 2012;23(5):577-83.
- Freund B, Schwartz M, Symington J. Botulinum toxin: new treatment for temporomandibular disorders. *Br J Oral Maxillofac Surg.* 2000 Oct;38(5):466-71.
- Hermens HJ, Freriks B, Merletti R, Stegeman D, Blok J, Rau G, et al. European recommendations for surface electromyography. *Roessingh research and development.* 1999;8(2):13-54.
- Buzinelli R, Berzin F. Electromyographic analysis of fatigue in temporalis and masseter muscles during continuous chewing. *J oral rehabil.* 2001;28(12):1165-7.
- Kroll CD. Avaliação da ansiedade e da atividade eletromiográfica dos músculos elevadores da mandíbula em mulheres com disfunção temporomandibular: um estudo psicofísico. 2009. [thesis] Campinas (SP): Universidade Estadual de Campinas, Faculdade de Odontologia de Piracicaba, Piracicaba, SP. Disponível em <http://libdigi.unicamp.br/document/?code000047005>
- Giannasi LC, Matsui MY, Freitas SRB, Caldas BF, Grossmann E, Amorim JBO, et al. Effects of neuromuscular electrical stimulation on the masticatory muscles and physiologic sleep variables in adults with cerebral palsy: a novel therapeutic approach. *PLoS one.* 2015;10(8):e0128959.
- Branemark PI. Tooth replacement by oral endoprostheses: clinical aspects. *Int J Oral Implantol.* 1988;5(2):27-9.
- Penarrocha M, Uribe R, Garcia B, Marti E. Zygomatic implants using the sinus slot technique: clinical report of a patient series. *Int J Oral Maxillofac Implants.* 2005;20(5):788-92.
- Chow J, Hui E, Lee PK, Li W. Zygomatic implants--protocol for immediate occlusal loading: a preliminary report. *J Oral Maxillofac Surg.* 2006;64(5):804-11.
- Ferrara ED, Stella JP. Restoration of the edentulous maxilla: the case for the zygomatic implants. *J oral maxillofac surg.* 2004;62(11):1418-22.
- Malevez C, Abarca M, Durdu F, Daelemans P. Clinical outcome of 103 consecutive zygomatic implants: a 6–48 months follow up study. *Clin oral imp res.* 2004;15(1):18-22.
- Lang R, White PJ, Machalíček W, Rispoli M, Kang S, Aquilar J, et al. Treatment of bruxism in individuals with developmental disabilities: a systematic review. *Res Dev Disabil.* 2009 Sep-Oct;30(5):809-18. doi: 10.1016/j.ridd.2008.12.006.
- Park HU, Kim BI, Kang SM, Kim ST, Choi JH, Ahn HJ. Changes in masticatory function after injection of botulinum toxin type A to masticatory muscles. *J Oral Rehabil.* 2013;40(12):916-22.
- Tan EK, Jankovic J. Treating severe bruxism with botulinum toxin. *Journal of the American Dental Association (1939).* 2000;131(2):211-6.
- Manganello-Souza L, Oliveira A, Alpire M, Trigo-Merida J. Hipertrofia do músculo masseter. *Rev Bras Cir Plást.* 2001;15(1):51-4.
- Long H, Liao Z, Wang Y, Liao L, Lai W. Efficacy of botulinum toxins on bruxism: an evidence-based review. *Int dent J.* 2012;62(1):1-5.

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