aesthetic medicine

Original Article

Prospective clinical study and ultrasound assessment in patients with bruxism treated with botulinum toxin

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Abstract

Introduction: Bruxism (BRX) can be defined as clenching and/or grinding of the teeth in a particularly intense or involuntary way. It occurs interchangeably during sleep or while awake due to repeated contraction and/or hypertrophy of the masticatory muscles.
Treatments are mainly intended to limit induced temporomandibular joint (TMJ) damage and are manifold: irreversible occlusion, bite splints, pharmacological and/or cognitive therapies. However, botulinum toxin type A (BoNT-A) is especially effective.
The aim is to assess the attenuation or disappearance of BRX-related symptoms after injection of BoNT-A due to relaxation of the masticatory muscles (especially the masseter muscles).
Materials and Method: this is a clinical, prospective and longitudinal study on 43 adult female patients aged between 24 and 67 (37.0 ± 9.6). It was carried out from September 2018 to October 2019.
Assessment controls were performed before, two weeks and four months after the first treatment with BoNT-A, and two weeks and five months after the second treatment. Digital photographs were taken at each control visit, the Smith-Knight Tooth Wear Index was assessed and orthopantomography (OPG) was performed. Bigonial diameters were measured with a digital caliper. The masseter muscles were assessed bilaterally, at rest and during contraction, by ultrasound.
Results: after BoNT-A treatment, 26% of patients were free of BRX, whereas considerable improvements were observed in the remaining 74%. Adverse effects were mild and of short duration.
Conclusion: BoNT-A treatment was able to prevent lesions on orofacial structures (teeth, jaw muscles, TMJ), and at the same time relieve pain and associated symptoms induced by repeated muscle contraction in BRX.

Keywords

Bruxism, tooth wear, botulinum toxin type A, temporomandibular disorders, masseter muscle

Received for publication May 4, 2020; accepted September 14, 2020 - © Salus Internazionale ECM srl - Provider ECM no 763

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Introduction

Bruxism (BRX) is defined as a dysfunctional disorder of regular mouth movements together with the habits of clenching and/or grinding teeth due to the contraction of one or more muscle groups involved in mastication[1,2]. BRX induces an overload of the stomatognathic system, the temporomandibular joint (TMJ) in particular, considered the most contributing risk factor to TMJ instability[3]. The involvement of masticatory muscles and ligaments means that many patients report tension or pain during mastication and/or when getting up in the morning. Chronic pain and abnormal jaw mobility often occur together with tooth wear; in BRX, dental restorations, including dental implants, are not effective[5]. Headaches are common, with atypical pain distribution[6]. Some patients perceive this condition as an aesthetic alteration and focus their concern on the squarer shape of their faces. New diagnostic criteria are shown in *Table 1*.

Based on each patient, degenerative changes of TMJ in BRX result in different adaptive responses[7,8]. These may be classified according to three types:

1) ***TMJ Dysfunction*** and pain stemming from the masticatory muscles. This would be classified as myofascial pain.

2) ***Intrinsic Changes of TMJ***. There is joint anterior disc displacement, with or without reduction. In its evolution, this may result in joint luxation and condyle dislocation.

3) Finally, joint disorders cause chronic degeneration with or without symptomatic inflammation, resulting in cases of ***Osteoarthritis***.

BRX is closely associated with psychological factors and personality traits, stress being one of the most significant ones. Sleep BRX is usually associated with psycho-emotional disorders, conditioned by poor dental occlusion[9]. Some clinical studies, particularly in the United States, indicate that stress is the main reason for BRX patients seeking medical-psychological advice[8]. There are multiple BRX treatments, including bite splints, irreversible occlusion procedures, and pharmacological and/or cognitive-behavioral therapies[9,10]. They are all intended to reduce the side effects of BRX on biological structures involved.

Due to their different degrees of efficacy, dental splints are more a symptomatic treatment than an etiological one[9]. Cognitive-behavioral therapies show efficacy in the long term, resulting in high withdrawal rates[9,10]. Regarding the pharmacological treatment of BRX, the use of benzodiazepines and tricyclic antidepressants generates a high rate of dependency and their long-term efficacy is limited.

In the last years, good results have been obtained with BoNT-A injections in the masticatory muscles, particularly the masseter muscle, when they are hypertrophied or show a strong dynamic contraction[10–14]. BoNT-A reduces excessive muscle contraction, both at rest and during mastication. The relaxing effect of BoNT-A may be observed within two to four days after the initial injection; muscle relaxation may last up to six months, although it may be prolonged if sequential treatments of BoNT-A are regularly administered. In our preliminary study we already indicated that ultrasound measurements at the control visit four months after the first treatment, compared with initial measurements, served as predictive values for administering the second injection[15].

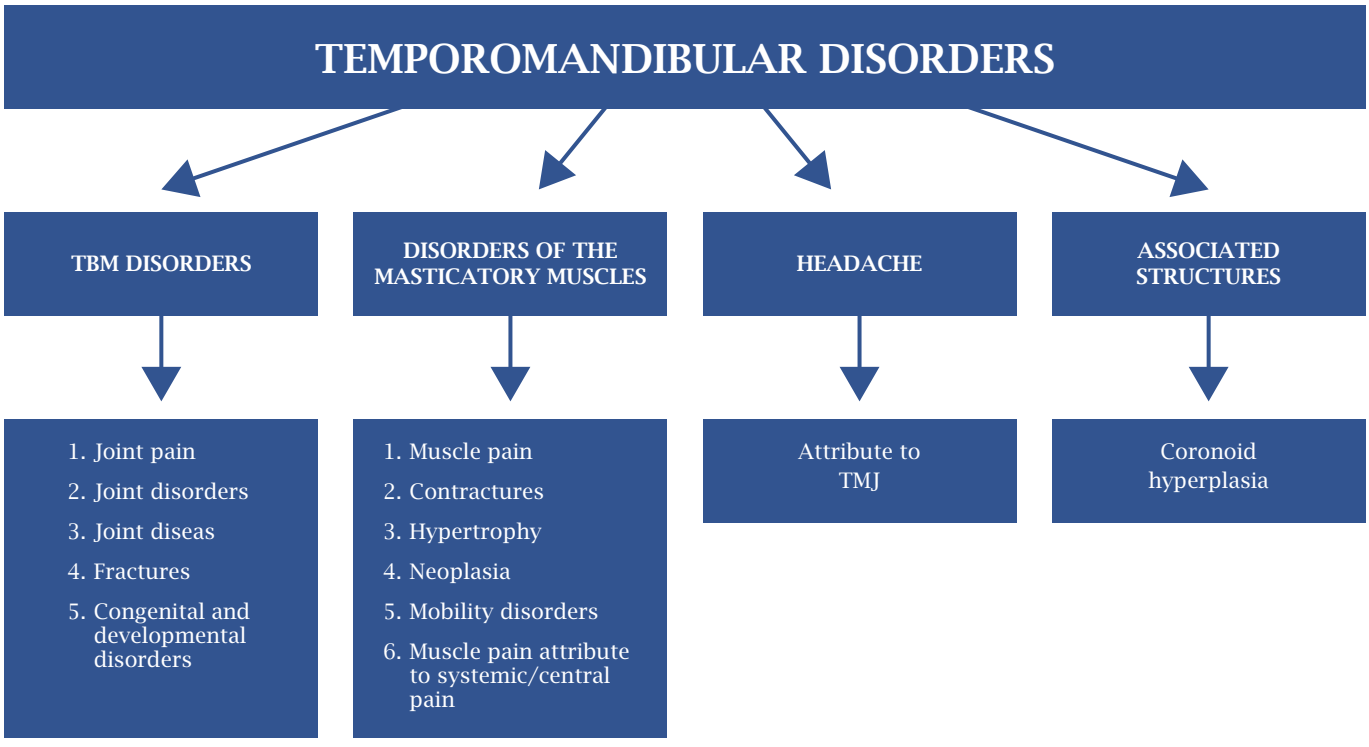

Table 1 *- Diagnostic criteria for temporomandibular disorders.*

Purpose

The purpose of the study is to assess the clinical benefit of muscle relaxation induced by BoNT-A injections in 43 patients with BRX. For this reason, controls were performed before, two weeks and four months after the first treatment session and two weeks and five months after the second treatment. Muscle hypertrophy patterns were assessed by ultrasound, considering the possible adverse effects attributable to the procedure.

Materials and method

This is a prospective and longitudinal study on 43 female patients between 24 and 67 years (mean age of 37.0 ± 9.6). They all reported pain and/or tension of a greater or lesser degree and more noticeable after waking up; some complained of mild-to-moderate pain during mastication. Six (14%) patients also stated they were unhappy with the squarer shape of their faces.
The study was conducted between September 2018 and November 2019 at Clínica Alcolea (Hospitalet de Llobregat, Barcelona) and Clínica Mona Lisa (Barcelona). Regarding the circadian cycle in relation to BRX, only one (2%) patient stated being aware of suffering it while awake; 11 (26%) patients experienced it during sleep (sometimes mentioned by their partners, and due to the feeling of tension when waking up); the remaining 31 (72%) presented with both awake and sleep BRX.
For this study, the following criteria were considered (*Figure 1*):

1) Tooth wear and excessive clenching or grinding of the teeth
2) Hypertrophy of the masseter muscles during voluntary contraction
3) Pain and radiation to neighboring structures in degrees, fatigue during mastication or rigidity tension when moving the jaw after waking up
4) Tooth hypersensitivity
5) Audible clicks or snaps, with or without locking of TMJ
6) Dental impression on the side of the tongue or cheeks, or without bleeding

Patient Assessment

Results were assessed at each control visit before, two weeks and four months after the first treatment with BoNT-A, and two weeks and five months after the second treatment. At each control visit, the following was systematically performed:

1) Taking of photographs with a digital camera (Canon®, D2000, Canon Inc, Tokyo, Japan) at rest and during contraction.
2) Assessment of the Tooth Wear Index (TWI). In 1984, Smith and Knight defined this concept by which all four visible surfaces (buccal, cervical, lingual and occlusal-incisal) of all teeth present are scored for wear, irrespective of how it occurred22 (*Table 2*).
3) Orthopantomography (OPG), which allows to diagnose and estimate:
   a. Potential degenerative bone disorders.
   b. Other more non-specific pathological disorders.
   c. Grade of pathological disorders found.
   d. Middle- or long-term efficacy of therapeutic measures taken.
   e. Other TMJ disorders (fractures, cysts, tumors, inflammation, aplasia, hypoplasia, hyperplasia and degenerative disorders)[23].
4) MRIs, the most reliable imaging diagnostic method. However, of the 43 patients that participated in the study, only five had an MRI due to the high cost of the test, the discomfort of the procedure and the fear of excessive radiation.
5) Modified bigonial diameter obtained using a digital caliper, which does not measure the distance between both angles of the jaw, but the mean between the points at rest and of maximum contraction of the masseter muscles. This measurement was well correlated with the one obtained by ultrasound for each masseter muscle (*Figure 2*).
6) Ultrasound measurements of each masseter muscle (and/or temporal muscle in case of treatment). Each masseter muscle was measured at rest and during maximum contraction[24]. An ultrasound machine (Sonosite® Micromaxx, Sonosite Inc, Irvine, CA, USA) with a 7-12- MHz multifrequency transducer was used. Ultrasound measurements were performed with the patient in a seated position and without touching the skin of their faces with the probe, with the transducer located 2 cm above and parallel to the edge of the jaw.

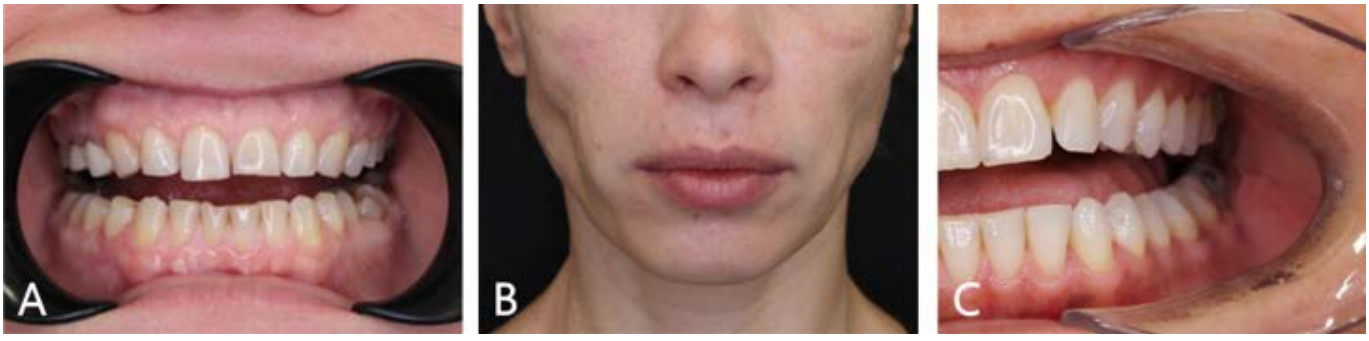

Figure 1 *- Usual findings in BRX. A. Visible tooth wear secondary to bruxism. B. Muscle hypertrophy during forced contraction of the masseter muscles shaped as a square jaw. C. Typical dental impression on the tongue.*

Grades	Surface	Criteria
0	B/L/O/I/C	Without loss of enamel characteristics Without loss of contour
1	B/L/O/I/C	Mild oss of enamel characteristics Minimum loss of contour
2	B/L/O/I/C	Loss of enamel with dentin exposure on less of 1/3 of the surface Loss in enamel by simple dentin exposure Defect with less than 1 mm of depth
3	B/L/O/I/C	Loss of enamel with dentin exposure on less of 1/3 of the surface Loss in enamel with substantial dentin loss Defect with 1-2 mm of depth
4	B/L/O/I/C	Complete loss of enamel and secondary pulp exposure Pulp or secondary dentin exposure Defect with higher than 1 mm of depth and pulp exposure secondary to dentin loss

Table 2 *- Grades and criteria used to estimate Smith and Knight's Tooth Wear Index of tooth surfaces: B, buccal; L, lingual; O, occlusal; I, incisal; C, cervical.*

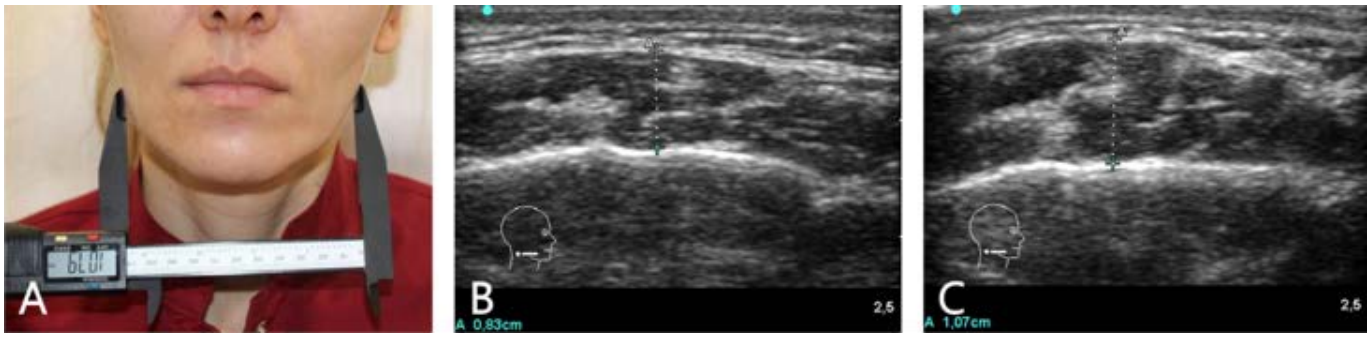

Figure 2 *- Study patient no. 6 (36 years old) A. Modified bigonial diameter obtained using a digital spreading caliper. B. Measurements taken by ultrasound of the right masseter muscle at rest and during contraction of the same patient.*

Injection Technique

Before administering the injection, the BoNT-A (Azzalure®, Galderma SA, Madrid) was reconstituted with 1 ml of saline. Each vial, containing 125 Speywood units (s.U.). BoNT-A, was bilaterally applied to each masseter muscle using an insulin syringe with an integrated 12-mm 30 G needle (Braun®, Melsungen, Germany).

The units of BoNT-A injected for each patient were estimated based on previously taken ultrasound measurements of each masseter muscle both at rest and during contraction. Total doses ranged from 35-85 s.U. per patient (57.5 ± 13.5). All three points of the lower third of each masseter muscle was injected with 7.5-12 s.U. based on the contraction previously shown by each muscle (*Figure 3*). Out of 43 treated patients, 11 (26%) required an additional injection of 5-7.5 s.U. of BoNT-A on one or two points of the masseter muscle, at the control visit, based on residual muscle activity measured by ultrasound.

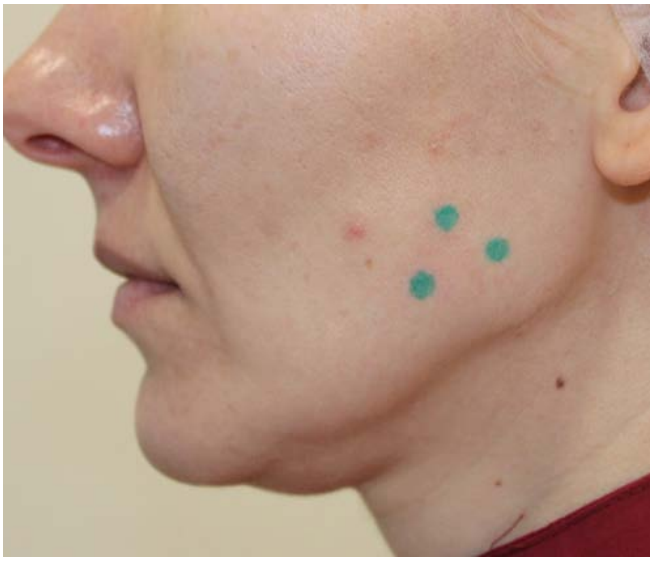

Figure 3 *- Marking of guide points for the injection of the left masseter muscle of study patient no. 6, based on the layout of the muscle fascicles.*

Result Assessment

The treatment, adverse effects and patient satisfaction were assessed according to the following scale: 0, No improvement; 1, Mild improvement; 2, Moderate improvement; 3, Significant improvement; 4, Free of bruxism. Adverse effects were quantified according to a 0-4 scale: 0, None; 1, Mild; 2, Moderate; 3, Severe; and 4, Very Severe. Patient satisfaction was also assessed on a 0-4 scale, where 0: Not satisfied, and 4: Very satisfied.

Statistical Analysis

An SPSS (v. 20) software for Windows was used. Variables were mean, minimum and maximum, range, percentage (%) and standard deviation (SD). Confidence intervals were set and a multivariate analysis was conducted for related samples (Student's t-test). Results were considered statistically significant ($p<0.05$).

Results

With the exception of age, data analysis showed small typical deviations with little dispersion from the arithmetic mean, indicating that it was representative of the sample. Under this premise, and in order to reduce the number of variables without losing information, a Student's t-test was performed. Ultrasound scans showed that thickness measurements of the masseter muscles at rest (1.22 mm ± 0.23) and during contraction (1.47 mm ± 0.26) before and two weeks after treatment (at rest: 1.04 mm ± 0.22; during contraction: 1.24 mm ± 0.26) were statistically significant ($p<0.05$). However, there were no differences between the control measurements two weeks and four months after treatment (at rest: 1.08 mm ± 0.19; during contraction: 1.26 mm ± 0.21) (Figure 4). The same process was carried out with the bigonial diameter variable: there was a significant difference between the values at rest before treatment (122.4 mm ± 6.5) and two weeks after treatment (118.9 mm ± 6.2), as well as during contraction (127.2 mm ± 6.8 and 123.0 mm ± 6.3, respectively), however there were no significant differences between results two weeks and four months after treatment (119.8 mm ± 6.0 and 123.3 mm ± 6.3) (*Figure 4*).

All patients underwent a second control four months after the first session; comparing these results with those obtained two weeks after the first treatment: although there was a decrease in bigonial diameter measurements (118.9 mm ± 6.5 at rest and 122.6 mm ± 6.3 during contraction), the difference was not significant[15]. When ultrasound measurements of the masseter muscle four months after the first session were compared to those five months after the second session, no statistically significant differences were found either (*Figure 5*). As expected, ultrasound and bigonial diameter measurements showed a similar evolution in their comparisons. Of all patients treated, 11 (26%) were free of bruxism; the remaining 32 (74%) obtained great improvement, with a satisfactory response to BoNT-A. When asked whether they would recommend the treatment or not: 41 (95%) patients

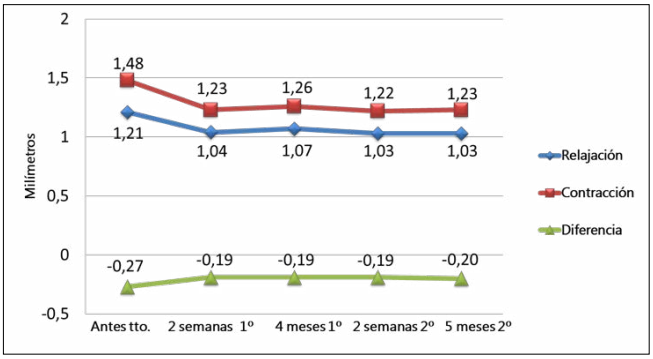

Figure 4 *- The chart shows the mean evolution of ultrasound measurements of both masseter muscles at rest and during contraction before and two weeks and four months after the first treatment with BoNT-A, and two weeks and five months after the second treatment.*

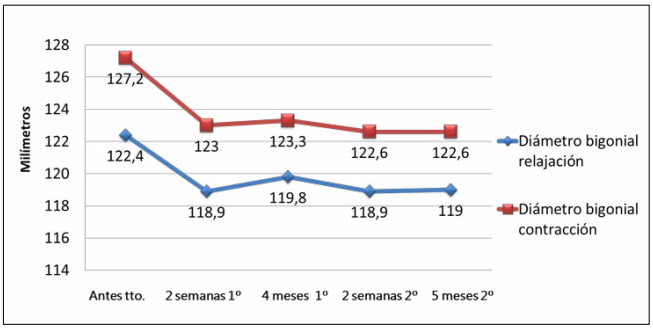

Figure 5 *- Evolution of bigonial diameter measurements before, two weeks and four months after the first treatment with BoNT-A, and two weeks and five months after the second treatment. Notice how the reduction achieved after the first treatment with BoNT-A varies very little throughout the study.*

reported they would, despite having experienced some adverse effects. Two patients stated that they would not recommend it, one due to moderate pain during the injection and ecchymosis that lasted one week; however, she admitted experiencing a considerable improvement of her initial condition. The other patient presented with muscle fatigue during mastication for 21 days, with full recovery. However, neither of these patients withdrew from the study. A 95% degree of satisfaction was reported, including both satisfied and very satisfied patients. It is remarkable that bigonial diameter and masseter muscle values were slightly better at control visits conducted five months after the second treatment than four months after the first treatment; although not statistically significant, patients could be treated at intervals longer than five months.

Adverse effects

In general, side effects after treatment with BoNT-A were mild and temporary (*Table 3*). No patients reported paresthesia or changes in facial expression. *Table 4* shows the correlation between patient satisfaction and clinical assessment: the fact that six (14%) patients reported being satisfied or very satisfied with the treatment, despite having experienced an adverse effect, is significant.

Adverse effects	N (%)	Duration (days)
Pain	7 (16%)	< 2
Ecchymosys	6 (14%)	4 - 10
Edema	3 (7%)	< 2
Muscle fatigue	7 (16%)	5 - 20

Table 3 *- Adverse effects.*

BRX treatment with TB-A		Patient satisfaction		
		Satisfied	Not satisfied	Total
Assessment clinic	No adverse effects	35 (81%)	1 (2,5%)	36 (84%)
	with adverse effects	6 (14%)	1 (2,5%)	7 (16%)
	total	41 (95%)	2 (5%)	43 (100%)

Table 4 *- Contingency table correlating patient satisfaction with clinical assessments. Notice that mild-to-moderate adverse effects do not have an impact on patient satisfaction regarding results.*

Photographic Results

Photographs taken were highly demonstrative of facial shape changes.
Figure 6 shows a series of three photographs of study patient no. 24 taken at control visits, in which the effect of relaxation four months after the first treatment (B) and five months after the second treatment (C) can be observed. A decrease in thickness of the left masseter muscle before and up to five months after the second treatment is also visible.
The patient was free of BRX and very satisfied with the more oval shape of her face. *Figure 7* is an OPG (A) from the same patient showing degenerative changes of the medial surfaces of both condyles due to disc flattening and displacement. Based on the Tooth Wear Index, the patient was classified as Grade 2, with enamel loss and dentin exposure on a third of tooth surface (B).
Figure 8 shows relaxation of the masseter muscles with BoNT-A, which spreads to the entire orofacial area. In this case, TMJ is normal and the Tooth Wear Index is minimum (*Figure 9*).
It is noteworthy that there is a strong correlation between the photographs, OPG, the Tooth Wear Index and the measurements obtained by ultrasound in all study patients.

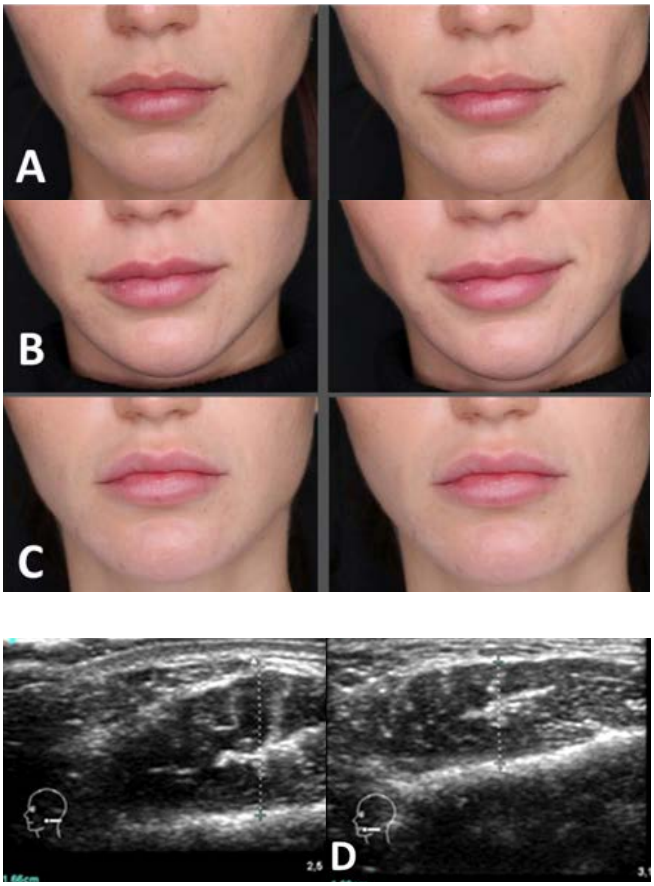

Figure 6 *- Study patient no. 26 (29 years old) treated with BoNT-A. The masseter muscles at rest and during contraction can be observed. A. Before treatment. B. Result four months after first treatment. C. Five months after second treatment. D. Notice the thickness reduction of the left masseter muscle at maximum contraction. Left: before treatment. Right: five months after the second treatment.*

Discussion

According to published data, this study shows that BRX treatment with BoNT-A is efficacious[22–25]. It has been rigorously conducted, both regarding the follow-up of potential adverse effects and the dosage and

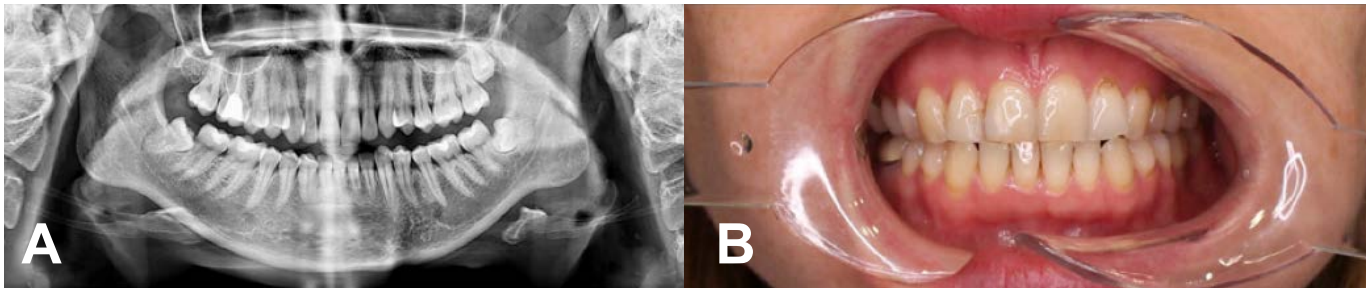

Figure 7 *- Patient no. 26. A. Normal joint disc in OPG. B. Grade 1 of tooth wear, with mild loss of surface enamel and minimum loss of contour.*

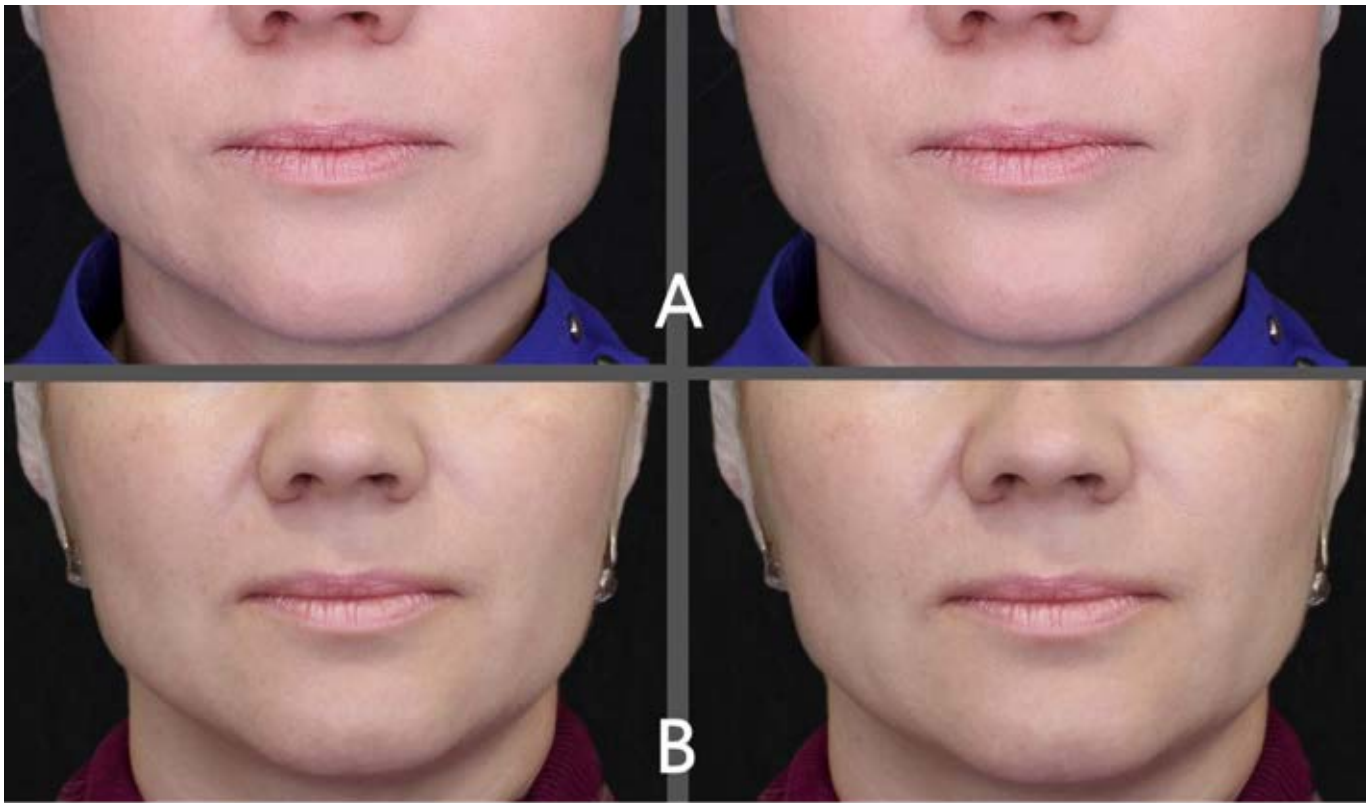

Figure 8 *- Study patient no. 40 (40 years old) treated with BoNT-A. A. Masseter muscles at rest and during contraction before treatment. B. Result four months after first treatment. There is relaxation of the masseter muscles as well as in the area around the mouth.*

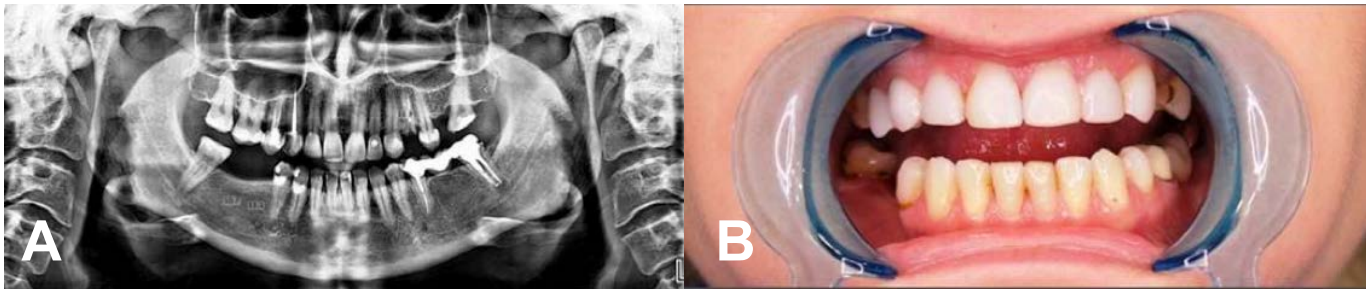

Figure 9 *- Study patient no. 40 (40 years old) treated with BoNT-A. A. Masseter muscles at rest and during contraction before treatment. B. Result four months after first treatment. There is relaxation of the masseter muscles as well as in the area around the mouth.*

Sleep BRX, associated with an important psycho-emotional component and often related with dental occlusion, is particularly harmful in dental attrition and TMJ[1-4]. Our research revealed that 26% of patients suffered from sleep BRX and 72% presented with awake and sleep BRX, of whom 84% had a significant improvement and the remaining 16% was free of BRX after treatment with BoNT-A.

BoNT-A should be considered a first-choice treatment for BRX due to the good results reported, which have been validated in this study, and the lack of relevant adverse effects[2-8,19,26,27]. BRX is a pathology that begins in adolescence and is highly prevalent in this stage; therefore early treatment would make sense in order to prevent any injuries to the TMJ. Although early treatment of BRX is advisable, we are aware of the need to provide additional thorough information both to minors and their parents or legal guardians, as well as of the fact that this population group has not been studied enough.

In stomatological practice, the usual complaints attributed to BRX include masticatory pain and teeth grinding, often mentioned by their partners. More than pain or anxiety, the main reason for consulting an aesthetic doctor is usually hypertrophy of the masseter muscles, together with a perception of the square shape of their faces[24,25].

Regarding the use of either tricyclic antidepressants and/or anxiolytics or dopaminergic agonists for the treatment of BRX, the former have associated analgesic properties[11-13], whereas the latter, through an increase of dopamine levels, help restore the modulation of the dopaminergic pathways in basal ganglia[27]. Despite the lack of rigorous studies supporting their use, both types are usually prescribed due to the high prevalence of BRX among adolescents[10,13].

Cognitive-behavioral therapies have a limited short-term effect, with a high rate of withdrawal before the achievement of visible muscle relaxation results[10]. Many of the studies conducted have very little evidence and are associated with a low-quality methodology[9,10]. Likewise, if the above-mentioned treatments are compared to the controlled and selective use of BoNT-A, the latter represents a better option for treating BRX due to both its efficacy and fast response. Evidently, when the condition occurs concomitantly with anxiety and/or depression, the risk/benefit ratio should be properly assessed before prescribing antidepressants and anxiolytics to adolescents.

BoNT-A is very easy to administer on patients who do not require any other medications. Injections may be administered every six months, during which time patients are free of BRX symptoms. Several studies have reported that BoNT-A injections are effective in controlling involuntary orofacial movements, reducing the adverse effects associated with the motor muscles of the jaw, and in decreasing any related pain[28,29].

Ultrasound assessments of results obtained after BoNT-A treatment four months after the first injection and five months after the second one enable the prediction of when to schedule each patient's visit, so as to prevent loss of efficacy[15]. When ultrasound values are near those reached at control visits, patients may wait 1-2 months until the next injection; if values are near the ones observed prior to treatment, it is recommended the injection is administered within a month.

Mean doses of BoNT-A used (57.5 ± 13.5 s.U.) in our patients are lower than those used in the aesthetic treatment of the upper third of the face. The possibility of BoNT-A migration is very limited since it is injected in muscles with volume, which are larger and thicker compared to flat muscles of the face. However, caution and proper dosage adjustment is advisable in order to prevent early fatigue during mastication, although said effect is usually mild, of limited duration and resolves in a few days.

We are aware that the beneficial effects on the Tooth Wear Index and TMJ disorders require lengthy follow-up periods, since changes in OPG and/or MRIs are only visible after some time.

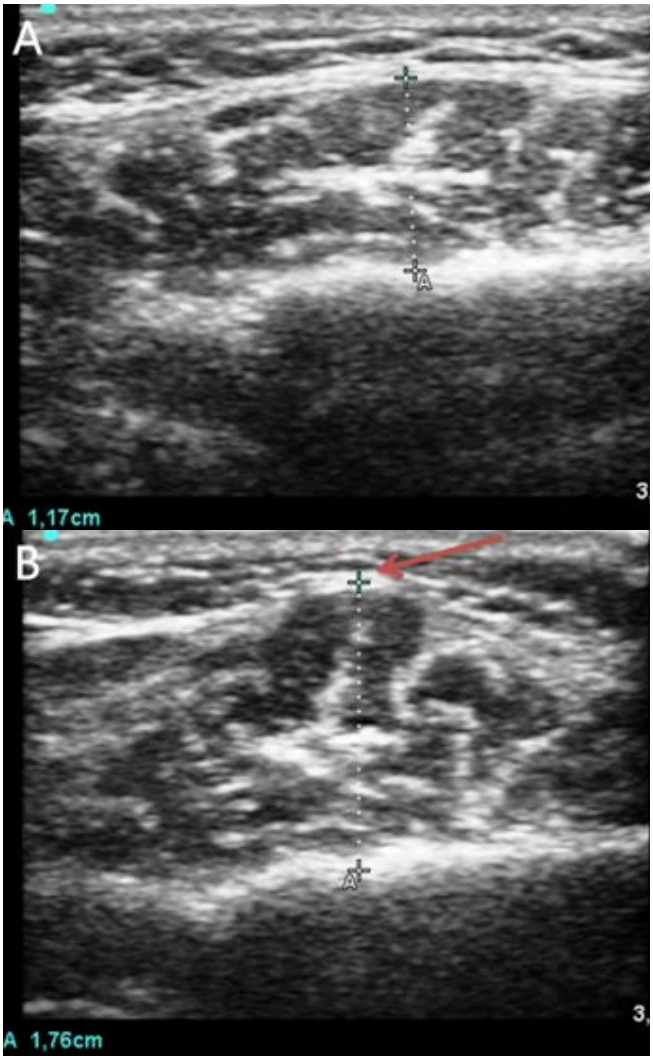

Figure 10 *- Study patient no. 26 (29 years old). Measurements of the right masseter muscle before treatment. A. At rest. B. Notice that at maximum contraction, a dome-shaped elevation of the middle fascicle of the masseter muscle occurs.*

Conclusions

Measurements of the masseter muscles obtained by ultrasound and digital caliper of bigonial diameter are well correlated with a decrease in muscle thickness and relief of BRX-associated symptoms.
All patients treated in this study had a significant improvement (74%) or were free of BRX (26%).
Results obtained in this study after one year of follow-up validate those reached at six months, indicating that ultrasound measurements may predict when to repeat the next treatment with BoNT-A.
Related adverse effects were mild and resolved a few days later. There were no changes in facial expression.
However, it is recommended that new studies with a larger number of patients and a longer duration are conducted.

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