ORIGINAL RESEARCH

Assessment of Electromyographic Changes in a Patient with Masseter Hypertrophy and Muscle Pain after Botulinum Injections: A Case Report and 5 Months Follow-up

Edoardo Bianco[1], Ruggero Tagliabue[2], Luca Mirabelli[3], Marcello Maddalone[4]

Abstract

Aim: To determine if botulinum injections in masseters could be an option to avoid surgery and prolonged treatment with occlusal splints and/or drugs to care for both painful bruxism and cosmetic improvement in a patient with a square jaw, bruxism, and orofacial pain.

Background: Masseter muscle hypertrophy (MMH) is a benign, unilateral, or bilateral, painless enlargement in the lower face. It presents as a symmetrical or asymmetrical increase in the masseter muscle. Masseter muscle hypertrophy (MMH) sometimes can be related to bruxism symptoms like muscle and/or temporomandibular joint (TMJ) pain.

Case description: A 38-year-old woman complained of bilateral pain at palpation in the masseter body. She also complained about esthetics because of the prominent masseter muscle in the face and square face shape. A diagnosis of bruxism-related myalgia was performed, and treatment with botulinum injections into the masseter muscles was opted for. An oral electromyography was performed to detect the electrical muscular activity of masseter muscles over time.

Conclusion: After a drastic reduction in the mean electrical activity immediately after the botulinum injections, a progressive increase in strength over time was noted, testifying about the decrease in the effect of botulinum over time. The pain disappeared for 5 months after the injections of botulinum. The reduction of the masseter muscle mass led to a softening of the face shape.

Clinical significance: This case report shows that treatment with botulinum can lead, in the short term, to a reduction in orofacial pain due to a decrease in muscle electrical activity.

Keywords: Botulinum toxin, Dental esthetics, Masseter, Occlusion, Orofacial pain, Sleep bruxism.

The Journal of Contemporary Dental Practice (2022): 10.5005/jp-journals-10024-3296

Introduction

The masseter muscle is the main mastication muscle, and its hypertrophy may cause undesired cosmetic alterations in the shape of the face.[1]

Masseter muscle hypertrophy (MMH) is a benign, unilateral, or bilateral, painless enlargement in the lower face.[2] Lower facial contour is shaped by the mandibular bone and by soft tissues, such as skin, subcutaneous tissue, and muscles. Masseter muscle hypertrophy is also called squared face or square jaw. It is called so because in this condition the lower jaw results as inspissated antero-posteriorly and bilaterally from the lateral and frontal view, respectively, thus making a squared shape of the face.

Prevalence data are scarce but a recent systematic review observed that the majority of the patients with masseter hypertrophy were Asian, with a male to female ratio of 1:1.[3]

The square jaw is divided into two forms: one is benign masseteric hypertrophy or simply masseteric hypertrophy, a condition where the muscles are aggrandized; the other is prominent mandibular bone, where the bony part is enlarged. Mixed types of both forms are also often clinically observed. In clinical terms, masseter hypertrophy presents as a symmetrical or asymmetrical increase in the masseter muscle.[3]

Masseter muscle hypertrophy (MMH) may also be related to bruxism symptoms.

Bruxism, clenching or grinding of the teeth, is a common problem in the adult population. Although the etiology is still uncertain, anxiety and stress, asymmetry of teeth, and digestive and sleep disturbances are related to bruxism.[4–6] Since 2018, the international community of bruxism experts has defined sleep bruxism as "a masticatory muscle activity during sleep that is characterized as rhythmic (phasic) or nonrhythmic (tonic) and is not a movement disorder or a sleep disorder in otherwise healthy individuals", and awake bruxism has been defined as "a masticatory muscle activity during wakefulness that is characterized by repetitive or sustained tooth contact and/or by bracing or thrusting of the mandible and is not a movement disorder in otherwise healthy individuals".[7]

Muscle hyperactivity can be the cause of intra-articular and muscular disorders. The overload on the stomatognathic

[1–4]Department of Medicine and Surgery, University of Milano Bicocca, Monza, Italy

Corresponding Author: Edoardo Bianco, Department of Medicine and Surgery, University of Milano Bicocca, Monza, Italy, Phone: +39 3487268209, e-mail: edoardo.bianco@unimib.it

How to cite this article: Bianco E, Tagliabue R, Mirabelli L, *et al.* Assessment of Electromyographic Changes in a Patient with Masseter Hypertrophy and Muscle Pain after Botulinum Injections: A Case Report and 5 Months Follow-up. J Contemp Dent Pract 2022;23(2): 226–231.

Source of support: Nil

Conflict of interest: None

structures, in patients with bruxism, can lead to pain and spasm in masticatory muscles, headache, neck pain, and functional limitation in movement of the mandible.[8,9]

Muscular surgical reduction for the correction of MMH was a common choice in the past, but the risk of damaging the facial nerve with this kind of intervention is quite high. Other disadvantages of a surgical correction are the risks associated with general anesthesia, postoperative hemorrhage, edema, hematoma, infection, and scarring. Therefore, medical management utilizing botulinum toxin A started to be successfully used to correct hypertrophy of the masseter muscle.[10,11]

Botulinum toxin (*abobotulinum*) is a neurotoxic protein produced by the *Clostridium botulinum* bacterium. Its mechanism of action is expressed through the denaturation of the Snap 25 protein of the SNARE complex with consequent blocking of the release of acetylcholine in the neuromuscular plaque, thus preventing the transmission of the nerve impulse to the muscle fibers, it is, therefore, a presynaptic block. The result will be that of flaccid paralysis of the muscle.[12,13]

The authors present a case in which a 38-year-old woman with bilateral MMH and bruxism and local pain was treated with botulinum toxin A to correct masseteric hypertrophy and functional impairment.

Electromyography (EMG) is a noninvasive exam, which evaluates the masticatory muscle activity by facial application on the cleaned skin of sensors, close to the masseter muscle, and anterior temporal muscle. In the present case, it was used to analyze the changes in muscular activity before and after the treatment with botulinum toxin A.[14–16]

Case Description

The patient, a 38-years-old woman, presented to the Dental Clinic of San Gerardo Hospital in Monza because of localized bilateral facial pain that has been present for about 6 months. The clinical practice followed the principles of Helsinki for human experimentation.

History

No signs or symptoms of TMJ pain, noises, or locking were detected. Mandibular movements were in the normal range and there was no history of temporomandibular joint clicking and no family history of masseter hypertrophy. No history of TMJ or masseter muscle pain was reported.

Clinical Examination

Muscle pain at palpation in the masseter body was present bilaterally, leading to a diagnosis of myalgia according to diagnostic criteria for temporomandibular disorders (DC/TMD). The diagnosis of bruxism was made with the diagnostic criteria for sleep bruxism of the American Academy of Sleep Medicine. These criteria are the referral of sounds of tooth-grinding during sleep, which must be confirmed by a roommate, plus a report of one criterion between masticatory muscle fatigue or pain on waking, masseteric hypertrophy, and abnormal tooth wear.[17] Bilateral masseter muscle hypertrophy was also noted, thus suggesting a connection with the bruxism-related pain. Among the aforementioned criteria, only tooth wear was not present in this case report.

The patient also complained about esthetics because of the prominent masseter muscle in the face and square face shape.

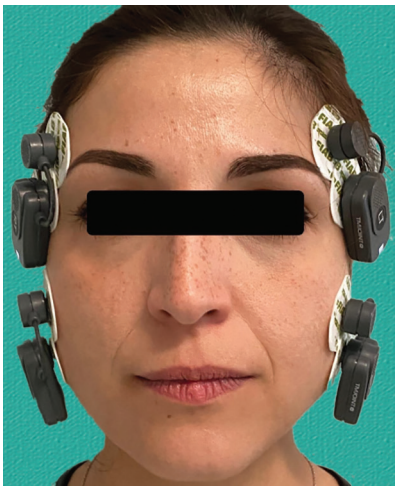


Fig. 1: Sensors placed on masseters and temporal muscles

Treatment

Since the problem concerned both muscle pain and facial esthetics, treatment with botulinum injections into the masseter muscles was opted for.

The patient signed an informed consent form and the therapeutic protocol followed the Helsinki principles of medical ethics.

An oral electromyography was performed to detect the electrical activity of masseter muscles in μV. A four-canal surface EMG was performed using BTS TMJoint® (BTS Bioengineering) oral electromyograph. Bipolar circular-shaped electrodes with a diameter of 1 cm and pre-gelled with saline base conductive gel were used. The skin was first cleansed with denatured ethyl alcohol. The electrodes were placed at the belly of the masseters (at the intersection of the tragus-commissure labial and exocanthion-gonion lines) and along the anterior border of the temporal muscle, at the level of the coronal suture, after palpation of the muscles in maximum clenching to feel their anatomy. The inter-electrode distance was kept constant at 2 cm (Fig. 1).

The acquisition protocol consisted of two tests with a duration of 5 seconds each:

- Clenching test on cotton rolls (COT), to be placed between upper and lower premolars and molars, both on the left and right side, without constraining the canine guidance and not too close to the cheeks not to alter proprioception.
- Test in maximum bite force, also known as maximum voluntary clenching (CLE), on teeth.

During the test, the patient was seated on a straight-back chair without metal structures, with the eyes closed, the feet touching the floor, the hands along the thighs, and the head straight. During the 5 seconds of each test, the patient was continuously encouraged to keep the maximum clenching strength. Measurements taken using EMG were processed by Dental Contact Analyzer® (BTS Bioengineering) software which returns numerical values of the muscular electrical activity analyzed.

The Dental Contact Analyzer® (BTS Bioengineering) software provides the following data:

- Mean activity of each muscle (left and right masseter, left and right temporalis) during the 5 seconds of each EMG record expressed in μV*sec.
- Total muscular activity during the EMG recording time expressed in μV*sec.

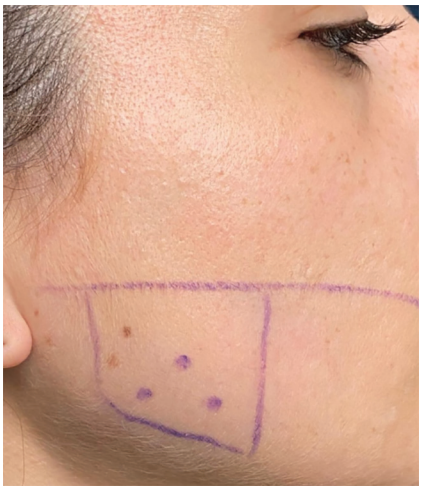


Fig. 2: Injection points on the right masseter located to form a triangle with a lower base

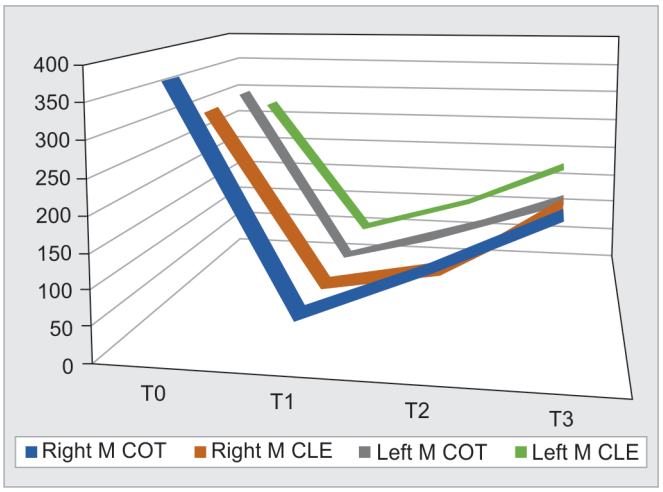


Fig. 3: Mean electrical activity of left and right masseter at T0–T3. COT, cotton rolls; CLE, maximum voluntary clenching; M, masseter

Table 1: Mean electrical activity of left and right masseter at T0–T3

	T0	*T1*	*T2*	*T3*
Right M. COT.	374.4	56.17	126.85	208.17
Right M. CLE.	311.11	48.15	79.81	185.41
Left M. COT.	316.7	48.4	95.39	154.01
Left M. CLE.	279.35	55.1	103.37	177.54

COT, cotton rolls; CLE, maximum voluntary clenching; M, masseter

The aim of this first electromyographical recording (T0) was to assess a baseline so that changes in masseter muscular activity could be determined. Temporal muscle activity was recorded as well because of the four-canal surface EMG protocol. Photos were taken after the positioning of the electrodes so that they could be repositioned in the identical position in the successive tests.

The patient was treated with *abobotulinumtoxin A* (BTX-A), following a codified protocol.

The infiltration points have been identified, 3 for each muscle, located to form a triangle with a lower base (Fig. 2).

At T0, immediately after the first electromyography, 18 Speywood Units were infiltrated for each injection point for a total of 54 US per muscle.

A check was carried out 14 days after T0 and further infiltration of BTXA of 8 US per injection point was carried out for a total of 24 Speywood Units per side.

Follow-up

Further electromyographic exams were made 1 (T1), 3 (T2), and 5 (T3) months after the treatment with botulinum toxin to see the duration of the effects of the treatment (Table 1).

The examination of painful muscle sites was performed at each visit by the same specialist on the basis of the masseter muscle sites determined by DC/TMD. These sites are the upper, middle, and lower parts of the masseter muscle (with 1 kg palpation pressure). During palpation, the patient's mandible was in a rest position, with the teeth out of contact.[18]

Electromyographic Activity

From T0 to T1, the mean electrical activity of the right masseter muscle decreased by 85% and the mean electrical activity of the left masseter muscle decreased by 84.53%. At T2, the mean electrical activity was 33.88% of the initial (T0) mean electrical activity for the right masseter and 25.65% for the left masseter, while at T3 the mean electrical activity was 55.6% of the initial (T0) mean electrical activity for the right masseter and 59.59% for the left masseter, highlighting a progressive increase in strength over time (Fig. 3).

Pain Assessment

With regards to the muscle pain, before the treatment with botulinum, the pain sites examined on the basis of DC/TMD were 6 out of a total of 6. They decreased to 0 at T1, remained unvaried at 0 at T2, and then increased to 2 at T3. The patient didn't refer pain at temporal muscle sites.

Esthetic Result

The treatment of the masseter muscle with BTX and the consequent functional decrease of the same has led to a decrease in muscle mass. This significantly affected the esthetics of the patient. The reduction of the masseter muscle mass caused a positive effect on the patient, thanks to a reduction in the thickness of the preauricular region with a softening of the face shape and reduction of the square jaw (Fig. 4).

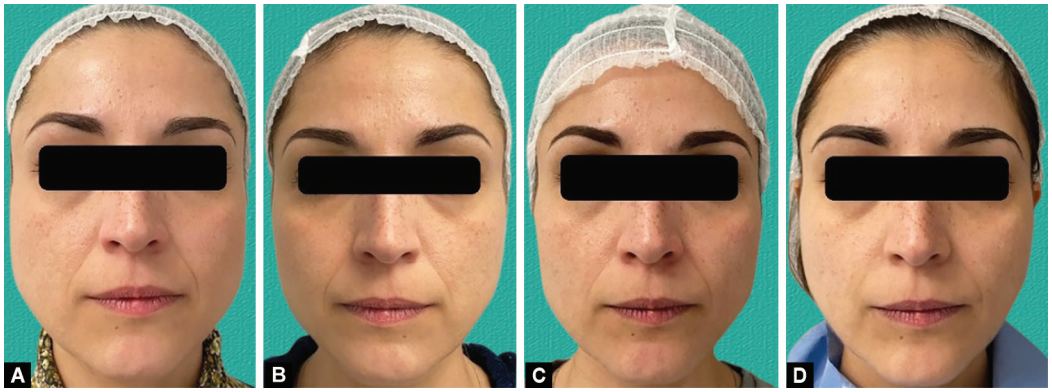
Discussion

Bruxism is one of the main risk factors for myofascial pain in the masticatory muscles and temporomandibular joint disorders.[19]

The origin of MMH is unclear. It may be a consequence of masticatory muscle hyperactivity or para functions and dysfunctions in the stomatognathic system, even though they cannot be verified in all cases of hypertrophy.

Hyperactivity of some muscles related to their continuous activation during parafunctions like bruxism can modify their anatomical characteristics because of the stimuli to which they are subjected, leading to changes in the size of fibers guided by the central nervous system. A relation with stress has been assumed in some cases.[15,20,21] Some cases of MMH may also be congenital.

The most common treatments for the management of bruxism are conservative symptomatic therapeutic modalities such as behavioral and physical treatments, sleep hygiene measures combined with relaxation methods, occlusal splint therapy,



Figs 4A to D: (A) Esthetic situation at baseline; (B) After 1 month; (C) After 3 months; and (D) After 5 months

pharmacological management, methods to increase an individual's awareness, reliant electrical stimulation, and physiotherapy.[15,22,23]

Chronic local muscular contracture has been known to cause inflammation and localized muscular hypoxia leading to chronic myofascial pain.[15,24]

In addition, bruxism also leads to some diseases pertaining to the teeth, such as tooth wear, tooth pain, damage to an implant-supported prosthesis, and periodontal disease, which can be approached in different ways with several techniques.[25–32]

Prominent benign masseteric muscle hypertrophy and related increased painful muscle tone can lead the patient to complain about undesired cosmetic alterations in the shape of the face.[1,33,34]

If the patient complains about esthetics, MMH can be treated with surgical or nonsurgical methods. It is difficult to assess the amount and depth of resection of the masseter muscle during surgical excision. Moreover, the surgery is complex and may result in postoperative complications, including bleeding, hematoma, facial nerve damage, asymmetry, and the inability to masticate.[35,36] Botulinum toxin A injection for the treatment of masseteric hypertrophy is a popular alternative due to the simplicity of the procedure and the rapid postoperative recovery times.[37,38]

In this case report, the authors opted for an option to avoid surgery and prolonged treatment with occlusal splints and/or drugs to care for both painful bruxism and cosmetic improvement.

Several meta-analyses and reviews demonstrated that botulinum is effective in diseases characterized by increased painful muscle tone, and it might be indicated in bruxers and in patients with myofascial pain.

Sendra et al., in a systematic review of the available literature without language or date restrictions until October 2019, stated that botulinum toxin type A injections are effective in the treatment of the symptoms of primary bruxism in adults.[39]

In a meta-analysis by Cheng et al., the authors found that the pain from bruxism was significantly relieved after BTX-A injection and that BTX-A could reduce the events of sleep bruxism.[19]

Kwon et al. in a review of the application of botulinum toxin in the maxillofacial field in South Korea stated that botulinum toxin effectively decreases square jaw, corrects the patterns of muscle work, and gives relief from pain.[40]

On the contrary, a systematic review relating the effectiveness and efficacy of BTX-A with bruxism stated that the current literature is inconclusive and does not show enough evidence that bruxism can be treated effectively with BTA injections, even though promising results were shown in individual studies.[41]

BTX-A can be used as an alternative to an occlusal splint in achieving pain relief. Jadhao et al. didn't find a significant difference in the treatment of pain levels in the comparison of a group treated with BTX-A and a group treated with an occlusal splint; according to their research, the use of occlusal splints was as effective as BTX-A application in pain control.

Yurttutan et al. divided 73 patients into three groups. The patients in the first group were given occlusal splints, the patients in the second group were treated with infiltrations of botulinum toxin in the masseter muscles, and the patients in the third group were treated with botulinum toxin together with occlusal splints. At the end of 6 months, questionnaires to evaluate pain showed a significant decrease in the complaints of the patients in the second and third groups. This result led the authors to state that there is a necessity to further analyze the use of occlusal splints to recover from pain in patients with bruxism.[42]

In the clinical case presented in this paper, the patient was not suggested to wear an occlusal splint during nighttime because the muscle activity during maximum voluntary clenching was remarkably decreased as noted by electromyography.

As regards an instrumental point of view, we can find in literature studies stating that BTX-A is effective in reducing muscle activity. Lee et al. demonstrated that episodes of sleep bruxism analyzed with electromyography significantly dropped in the masseter muscle after BTX-A injection, and this reduction was still detectable at 12 weeks, being in line with the duration of BTX-A.[43] Similar results were obtained by Jadhao et al., where the maximal voluntary clenching force was significantly lower in the group treated with BTX-A when compared to both the placebo group and the controls at 3 months after treatment, and after 6 months the decrease was still significant as seen via electromyographic analyses.

Even though protocols on its use have yet to be drawn up, the authors noted that a BTX-A injection is effective in reducing muscle hypertrophy, and this result is esthetically visible and recorded with surface EMG. The aim of cosmetic and pain improvement is thus reached. The only problem is that treatment must be repeated every 4/6 months for consecutive 2–3 years before having stable benefits. In fact, in a variable period between 2 and 12 months after the treatment, the patients, as reported in the literature, have a gradual recurrence of the symptoms and restitutio ad integrum (restoration to original condition) of the neuromuscular plaque.[21,44–48]

Preliminary evidence suggests that muscle activity by a patient after the injection may be beneficial, but concerns that botulinum

administration can lead to osteopenic changes in the condyles and the sites of muscle attachment still exist.

The allergy to the toxin and the presence of inflammation or infection at the injection site is the only real absolute contraindication to the use of botulinum toxin.

Side effects of BTX-A are usually transient, well-tolerated, and related to the spread of the drug in adjacent muscle groups. Dysphagia is the most frequently reported side effect in the literature, but dry mouth, dizziness, and visual disturbances have also been described. Generalized fatigue or the development of severe electromyographic changes is rare. A small percentage of patients (0.28–0.49%) can develop neurotoxin neutralizing antibodies.

Future Directions

Additional, well-designed, adequately powered, controlled randomized studies should be performed to determine the efficacy and long-term outcomes of the use of BTX-A in some temporomandibular disorders and to compare them with other therapeutic alternatives.[49–53]

Follow-up and other electromyographic evaluations are necessary to determine whether to intervene with occlusal splint treatment when the masseter activity recurs to initial values. Another option is the new administration of BTX-A.

Clinical Significance

The most recent reviews of the literature demonstrate that all the studies analyzed show promising results of botulinum toxin type A injections on primary bruxism and increased painful muscle tone with esthetic alterations due to masticatory muscle hyperactivity, even though further research in this area is needed.[39,41] Randomized clinical trial studies involving larger groups and long period follow-ups are still needed to establish effective protocols.

With the analysis of muscle activity by surface EMG, the clinician is provided with important information regarding muscle activity changes after BTX-A injection, thanks to a simple, noninvasive, and quick exam.

This case report shows that treatment with BTX-A can lead, in the short term, to a reduction in orofacial pain due to a decrease in muscle electrical activity detected with an oral electromyograph. Because of her esthetic request, the esthetic result obtained in this young female patient is equally valuable.

Acknowledgments

All authors gave their final approval and agreed to be accountable for all aspects of the work.

References

1. Quezada-Gaon N, Wortsman X, Peñaloza O, et al. Comparison of clinical marking and ultrasound-guided injection of Botulinum type A toxin into the masseter muscles for treating bruxism and its cosmetic effects. J Cosmet Dermatol 2016;15(3):238–244. DOI: 10.1111/jocd.12208.
2. Bayrak NB, Zeybek M, Sanlioglu I, et al. Assessment of changes in masseter muscle by three-dimensional close-range photogrammetry after Botulinum toxin type-A injection: a case report with review of literature. J Pak Med Assoc 2019;69(3):418–422. PMID: 30890839.
3. Fedorowicz Z, vanZuuren EJ, Schoones J. Botulinum toxin for masseter hypertrophy. Cochrane Database of Systematic Reviews 2013, Issue 9. Art. No.: CD007510. DOI: 10.1002/14651858.CD007510.pub3.
4. Diracoglu D, Sahbaz T, Alptekin K, et al. Effects of ultrasound-assisted botulinum neurotoxin-A injection in patients with bruxism and masseter hypertrophy. Turk J Phys Med Rehabil 2021;67(3):351–356. DOI: 10.5606/tftrd.2021.6288.
5. Yap AU, Chua AP. Sleep bruxism: current knowledge and contemporary management. J Conserv Dent 2016;19(5):383–389. DOI: 10.4103/0972-0707.190007.
6. Cortese M, Pigato G, Casiraghi G, et al. Evaluation of the oropharyngeal airway space in Class II malocclusion treated with mandibular activator: a retrospective study. J Contemp Dent Pract 2020;21(6):666–672. PMID: 33025936.
7. Manfredini D, Ahlberg J, Lobbezoo F. Bruxism definition: past, present, and future-what should a prosthodontist know? J Prosthet Dent 2021;S0022–3913(21)00074–3. DOI: 10.1016/j.prosdent.2021.01.026.
8. Kaya DI, Ataoglu H. Botulinum toxin treatment of temporomandibular joint pain in patients with bruxism: a prospective and randomized clinical study. Niger J Clin Pract 2021;24(3):412–417. DOI: 10.4103/njcp.njcp_251_20
9. Bianco E, Nanussi A, Bellotti D, et al. Clinical and functional analyses of the musculoskeletal balance with oral electromyography and stabilometric platform in athletes of different disciplines. World J Dent 2020;11(3):166–171. DOI: 10.5005/jp-journals-10015-1722.
10. Ham JW. Masseter muscle reduction procedure with radiofrequency coagulation. J Oral Maxillofac Surg 2009;67(2):457–463. DOI: 10.1016/j.joms.2006.04.012.
11. Beckers HL. Masseteric muscle hypertrophy and its intraoral surgical correction. J Maxillofac Surg 1977;5(1):28–35. DOI: 10.1016/s0301-0503(77)80072-6.
12. Nigam PK, Nigam A. Botulinum toxin. Indian J Dermatol 2010;55(1):8–14. DOI: 10.4103/0019-5154.60343.
13. Bhattacharjee K, Singh M, Bhattacharjee H. Extended effect after a single dose of type A botulinum toxin for asymmetric masseter muscle hypertrophy. Indian J Plast Surg 2015;48(2):196–199. DOI: 10.4103/0970-0358.163061
14. Ferrario VF, Sforza C, Colombo A, et al. An electromyographic investigation of masticatory muscles symmetry in normo-occlusion subjects. J Oral Rehabil 2000;27(1):33–40. DOI: 10.1046/j.1365-2842.2000.00490.x.
15. Maddalone M, Bianco E, Nanussi A, et al. Treatment of temporomandibular disorders of muscular origin with a silicon oral device (Alifix®): electromyographic analysis. J Contemp Dent Pract 2019;20(12):1367–1374. PMID: 32381834.
16. Maddalone M, Nanussi A, Varisco M, et al. Electromyographic evaluation of masticatory muscles in a young patient with crossbite treated with rapid palatal expander: a case report. J Contemp Dent Pract 2020;21(11):1279–1283. PMID: 33850076.
17. Beddis H, Pemberton M, Davies S. Sleep bruxism: an overview for clinicians. Br Dent J 2018;225(6):497–501. DOI: 10.1038/sj.bdj.2018.757.
18. Ohrbach R (ed.). Diagnostic Criteria for Temporomandibular Disorders: Assessment Instruments. Version 15 May 2016. www.rdc-tmdinternational.org.
19. Cheng Y, Yuan L, Ma L, et al. Efficacy of botulinum-A for nocturnal bruxism pain and the occurrence of bruxism events: a meta-analysis and systematic review. Br J Oral Maxillofac Surg 2022;60(2):174–182. DOI: 10.1016/j.bjoms.2021.03.005.
20. Frank AS. Masticatory muscle hyperactivity and temporomandibular joint dysfunction. J Prosthet Dent 1965;15(6):1122–1131. DOI: 10.1016/0022-3913(65)90188-5.
21. Graziano P, Dell'Aversana Orabona G, Astarita F, et al. Bilateral hypertrophy of masseteric and temporalis muscles, our fifteen patients and review of literature. Eur Rev Med Pharmacol Sci 2016;20(1):7–11. PMID: 26813447.
22. Dias R, Vaz R, Rodrigues MJ, et al. Utility of smartphone-based real-time report (Ecological Momentary Assessment) in the assessment and monitoring of awake bruxism: a multiple-week interval study in a Portuguese population of university students. J Oral Rehabil 2021;48(12):1307–1313. DOI: 10.1111/joor.13259.

23. Lobbezoo F, van der Zaag J, van Selms MKA, et al. Principles for the management of bruxism. J Oral Rehab 2008;35(7):509–523. DOI: 10.1111/j.1365-2842.2008.01853.x.
24. Jadhao VA, Lokhande N, Habbu SG, et al. Efficacy of botulinum toxin in treating myofascial pain and occlusal force characteristics of masticatory muscles in bruxism. Indian J Dent Res 2017;28(5):493–497. DOI: 10.4103/ijdr.IJDR_125_17.
25. Azeez AA, Sherif S, Franca R. Statistical estimation of wear in permanent teeth: a systematic review. Dent Rev 2021;1(1). https://doi.org/10.1016/j.dentre.2021.100001.
26. Mostafa D, Fatima N. Gingival recession and root coverage up to date: a literature review. Dent Rev 2021;1(1). https://doi.org/10.1016/j.dentre.2021.100008.
27. Bilgin Çetin M, Sezgin Y, Maraş E, et al. Association of probable bruxism with periodontal status: a cross-sectional study in patients seeking periodontal care. J Periodontal Res 2021;56(2):370–378. DOI: 10.1111/jre.12829.
28. D'Errico G, Bianco E, Tregambi E, et al. Usage of Lactobacillus reuteri DSM 17938 and ATCC PTA 5289 in the treatment of the patient with black stains. World J Dent 2021;12(1):32–37. DOI: 10.5005/jp-journals-10015-1800.
29. Bianco E. Factors influencing immediate maxillary dental implant placement and bone resorption: a review of the literature and an outlook on the clinical possibilities. Dent Med Probl 2016;53(3):408–412. DOI: 10.17219/dmp/63185.
30. Bianco E, Calvelli C, Citterio CL, et al. Evaluation with micro-CT of the canal seal made with two different bioceramic cements: guttaflow bioseal and bioroot RCS. J Contemp Dent Pract 2020;21(4):359–366. PMID: 32584269.
31. Scavia S, Roncucci R, Bianco E, et al. Minimal invasive flapless piezotome alveolar crest horizontal split technique: preliminary results. J Contemp Dent Pract 2020;21(1):28–35. PMID: 32381797.
32. Marcello M, Luca M, Sara B, et al. Radiographic evaluation of the bone remodeling on tilted osseointegrated implants: follow-up at 1 year. J Contemp Dent Pract 2020;21(4):463–470. PMID: 32584287.
33. Testut L. Anatomy of the face. In: Testut L, Jacob O (eds). Topographic Anatomy. Barcelona: Editores Salvat;1981;2:pp. 223–33.
34. Abraham S, Moideen F, Arunima PR, et al. Lip repositioning surgery–a boon in perioesthetics. Case Rep Dent Sci 3(1):35–46. PMID: 1845036.
35. Hakam MM, Beheiry MG, Helmy ES. Surgical management of benign masseteric hypertrophy (B.M.H.). Egypt Dent J 1995;41(4):1435–1440. PMID: 9497694.
36. Hashimoto T, Kuroda S, Kamioka H, et al. Bimaxillary protrusion with masseter muscle hypertrophy treated with titanium screw anchorage and masseter surgical reduction. Am J Orthod Dentofacial Orthop 2009;135(4):536–548. DOI: 10.1016/j.ajodo.2006.10.043.
37. Huang J-L, Chen G, Chen X-D, et al. A comparative study of the efficacy and safety of radiofrequency ablation and botulinum toxin A in treating masseteric hypertrophy. Exp Ther Med 2014;7(5):1203–1208. DOI: 10.3892/etm.2014.1552.
38. Shetty N, Malaviya RK, Gupta MK. Management of unilateral masseter hypertrophy and hypertrophic scar-a case report. Case Rep Dent 2012;2012:521427. DOI: 10.1155/2012/521427.
39. Sendra LA, Montez C, Vianna KC, et al. Clinical outcomes of botulinum toxin type A injections in the management of primary bruxism in adults: a systematic review. J Prosthet Dent 2021;126(1):33–40. DOI: 10.1016/j.prosdent.2020.06.002.
40. Kwon K-H, Shin KS, Yeon SH, et al. Application of botulinum toxin in maxillofacial field: part I. Bruxism and square jaw. Maxillofac Plast Reconstr Surg 2019;41(1):38. DOI:10.1186/s40902-019-0218-0.
41. Ågren M, Sahin C, Pettersson M. The effect of botulinum toxin injections on bruxism: a systematic review. J Oral Rehabil 2020;47(3):395–402. DOI: 10.1111/joor.12914.
42. Yurttutan ME, Tütüncüler Sancak K, Tüzüner AM. Which treatment is effective for bruxism: Occlusal splints or botulinum toxin? J Oral Maxillofac Surg 2019;77(12):2431–2438. DOI: 10.1016/j.joms.2019.06.005.
43. Lee SJ, McCall WD, Kim YK, et al. Effect of botulinum toxin injection on nocturnal bruxism: a randomized controlled trial. Am J Phys Med Rehabil 2010;89(1):16–23. DOI: 10.1097/PHM.0b013e3181bc0c78.
44. Wei J, Xu H, Dong J, et al. Prolonging the duration of masseter muscle reduction by adjusting the masticatory movements after the treatment of masseter muscle hypertrophy with botulinum toxin type a injection. Dermatol Surg 2015;41(Suppl 1):S101–S109. DOI: 10.1097/DSS.0000000000000162.
45. Mathevon L, Michel F, Decavel P, et al. Muscle structure and stiffness assessment after botulinum toxin type A injection. A systematic review. Ann Phys Rehabil Med 2015;58(6):343–350. DOI: 10.1016/j.rehab.2015.06.002.
46. To EW, Ahuja AT, Ho WS, et al. A prospective study of the effect of botulinum toxin A on masseteric muscle hypertrophy with ultrasonographic and electromyographic measurement. Br J Plat Surg 2001;54:197–200. DOI: 10.1054/bjps.2000.3526.
47. Dover JS, Monheit G, Greener M, et al. Botulinum toxin in aesthetic medicine: myths and realities. Dermatol Surg 2018;44(2):249–260. DOI: 10.1097/DSS.0000000000001277.
48. Pirazzini M, Rossetto O, Eleopra R, et al. Botulinum neurotoxins: biology, pharmacology, and toxicology. Pharmacol Rev 2017;69(2):200–235. DOI: 10.1124/pr.116.012658.
49. NIH Panel. Clinical Use of Botulinum Toxin. NIH Consens Statement, 1990 November 12–14;8(8):1–20.
50. Lange O, Bigalke H, Dengler R, et al. Neutralizing antibodies and secondary therapy failure after treatment with botulinum toxin type A: much ado about nothing? Clin Neuropharmacol 2009;32(4):213–218. DOI: 10.1097/WNF.0b013e3181914d0a.
51. Naumann M, Carruthers A, Carruthers J, et al. Meta-analysis of neutralizing antibody conversion with onabotulinumtoxinA (BOTOX®) across multiple indications. Mov Disord 2010;25(13):2211–2218. DOI: 10.1002/mds.23254.
52. Dressler D, Wohlfahrt K, Meyer-Rogge E, et al. Antibody-induced failure of botulinum toxin a therapy in cosmetic indications. Dermatol Surg 2010;36(Suppl 4):2182–2187. DOI: 10.1111/j.1524-4725.2010.01710.x.
53. Kun-Darbois J-D, Libouban H, Chappard D. Botulinum toxin in masticatory muscles of the adult rat induces bone loss at the condyle and alveolar regions of the mandible associated with a bone proliferation at a muscle enthesis. Bone 2015;77:75–82. DOI: 10.1016/j.bone.2015.03.023.