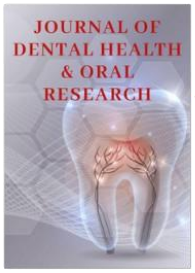

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Review Article

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Botulinum Toxin in Dentistry: From Therapeutic Applications to Clinical Considerations

Julissa Cruz[1], Monserrat Ovalles[2], Johanny Encarnación[3], Oriana Agostini[4], Pierina Morales[5], Sara Fernandez[3], Luisana Rodríguez[6]*

[1]Universidad Católica Madre y Maestra, Rep. Dominicana

[2]Universidad de Carabobo, Venezuela

[3]Universidad Santa Maria, Venezuela

[4]Universidad José Antonio Páez, Venezuela

[5]Universidad Gran Mariscal de Ayacucho, Venezuela

[6]Boston University, United States, DDS - Universidad de Carabobo, Venezuela

***Correspondence author:** Luisana Rodríguez, DMD - Boston University, United States, DDS - Universidad de Carabobo, Venezuela;
E-mail: lrodriguezc.29@gmail.com

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Abstract

This narrative review evaluates the therapeutic and aesthetic applications of Botulinum Toxin Type A (BoNT-A) in modern dentistry. By inhibiting acetylcholine release at the neuromuscular junction, BoNT-A provides a minimally invasive solution for conditions including hyperactive gingival smiles, masseter hypertrophy and bruxism-related myofascial pain. While clinical evidence supports its efficacy in reducing bite force and muscle-related discomfort, its effects are transient, typically lasting 3–6 months. Recent literature highlights emerging concerns regarding localized bone density reduction and muscle atrophy following repeated injections. This review concludes that while BoNT-A is a valuable adjunct, it should complement rather than replace, traditional dental therapies, requiring rigorous patient selection and informed consent regarding its limitations.

Keywords: Botulinum Toxin; Gingival Smile; Bruxism; Myofascial Pain; Dentistry; Parafunctions; Prosthetic; Rehabilitation

Introduction to Botulinum Toxin: Fundamentals and Mechanism of Action

Botulinum toxin works by temporarily relaxing overactive muscles, which can reduce pain and tension associated with jaw clenching and TMJ disorders. For patients who do not find relief through traditional methods, botulinum toxin has emerged as a modern dental treatment for issues like jaw clenching, muscle-related TMJ disorders, lockjaw (trismus) and related headaches [1-3]. This toxin is a purified substance produced by the bacteria *Clostridium botulinum*, the same agent responsible for botulism. While scientists have identified seven different versions of the neurotoxin, only Types A and B are sold for medical use. Type A was the standard prescription for years, but Type B is now also commercially available [2,3].

Produced by the Gram-positive bacterium *C. botulinum*, botulinum toxin is a potent poison categorized into seven distinct types (A through G). While Type A is the most researched, Types A, B, E and occasionally F are typically responsible for human illness, whereas Types C and D generally affect animals [2]. Botulism can be contracted through contaminated food, wound infections or intestinal colonization in infants. Once inside the body, the toxin migrates to nerve endings and blocks the release of acetylcholine, leading to symmetrical muscle paralysis that moves downward. Symptoms usually appear 18 to 36 hours after ingestion, though the toxin is heat-sensitive and can be neutralized by thorough cooking [1].

Botulinum toxin is a potent neurotoxin with a well-defined life cycle from its bacterial origin to its reversible paralytic effects in humans.

Origin and Composition

It is an exotoxin produced by the anaerobic, Gram-positive bacterium *Clostridium botulinum*, the active neurotoxin is a 150 kDa protein composed of a 100 kDa heavy chain and a 50 kDa light chain, linked by a disulfide bond, there are eight known serotypes (A–H), but Type A (BoNT-A) is the most widely used in clinical and aesthetic medicine due to its high potency and long-lasting effects [2,3].

Mechanism of Action

The toxin causes "chemical denervation" through a highly specific four-step process at the neuromuscular junction:

a. Binding: The heavy chain binds irreversibly to high-affinity receptors (gangliosides and SV2 proteins) on the presynaptic membrane of cholinergic neurons
b. Internalization: The toxin is taken into the nerve terminal via receptor-mediated endocytosis
c. Translocation: Inside the acidic environment of the endosome, the light chain is released into the neuron's cytosol
d. Cleavage (The Blockade): The light chain acts as a zinc-dependent protease that cleaves SNAP-25, a member of the SNARE protein complex. Since SNAP-25 is essential for docking neurotransmitter vesicles, its destruction prevents the release of acetylcholine. Without acetylcholine, the muscle does not receive the signal to contract, resulting in flaccid paralysis [4,5]

Duration and Recovery

Onset: Clinical effects typically begin within 24–72 hours, reaching a peak effect at approximately 1-4 weeks with average duration The paralytic effect generally lasts 3 to 6 months, the effect is temporary because the nerve terminal is not destroyed. Recovery takes place via two principal processes:

a. Axonal Sprouting: The nerve grows new, temporary terminals (sprouts) to re-establish contact with the muscle
b. Synaptic Regeneration: Eventually, the original neuromuscular junction recovers its function as the light chain is degraded and new SNARE proteins are synthesized [4,5]

Botulinum Toxin and Temporomandibular Disorders (TMD)

An umbrella review demonstrated that botulinum toxin A effectively reduces the intensity of myofascial pain in patients with Temporomandibular Disorders (TMDs) when compared with patients who only received a placebo; however, when the results were compared with conventional therapies, there was no relevant difference [6]. When studying the effect of BTX-A and its relationship with its application in the treatment of masseter muscle intensity, it is known that the use of this toxin is effective as early as one month after application [7]. Several articles support that the use of botulinum toxin is indeed a good option to treat the muscle hyperactivity of the muscles associated with TMDs, such as the masseter [8].

Regarding the use of botulinum toxin to treat masseter muscle hyperactivity, it is beneficial because it reduces occlusal force, which is responsible for clenching the teeth and causing this condition [9]. Studies that compare treatments with botulinum toxin and conventional devices such as occlusal guards and laser treatment have demonstrated that there is no significant difference between the treatments; therefore, greater benefits cannot be attributed to botulinum toxin when pain scores were measured [6].

Limitation

Most studies revealed limitations related to the quality of the studies, since temporomandibular disorders are difficult to classify due to the multiple factors involved, which makes their evaluation complex [7]. Therefore, higher-quality studies are needed to better evaluate the effects of botulinum toxin in temporomandibular disorders [9]. Despite the benefits that the indication of botulinum toxin may provide in patients with temporomandibular disorders, it is not considered the first treatment option for this condition. Due to the previously mentioned limitations, more conventional treatments continue to be preferred as the first line of therapy [10].

Botulinum Toxin Bruxism and Muscular Hyperactivity

Although the etiopathogenesis of bruxism remains under investigation, it is thought to be multifactorial, involving dental, physiological, psychological and neurological factors. The repetitive activity of the masticatory muscles and the jaw-muscle

contractions characteristic of bruxism lead to increased occlusal forces and excessive stress on the dentition and temporomandibular joint. As a result, patients experience tooth structure loss, involuntary clenching or grinding of teeth, headaches, temporomandibular disorders and muscular pain and strain. The masseter muscle, a pivotal component in the process of mastication, is often the target of BTX-A treatment to alleviate the symptoms and consequences of bruxism and myofascial pain dysfunction syndrome [11].

Injection into the Masseter Muscle to Reduce Occlusal Forces

When injected into the masseter muscle, BTX-A can inhibit acetylcholine release at the neuromuscular junction, resulting in temporary muscle relaxation and reduced contraction strength. A single-arm study assessed the effect of BTX-A injection into the masseter muscle on bite force reduction and orofacial pain. The pain and discomfort experienced by patients with bruxism significantly decreased following botulinum toxin injection and the reduction in occlusal forces observed correlates with the temporary weakening of the masseter muscle, reducing muscle contraction and, consequently, lowering occlusal bite forces. [11] Other studies reported a decrease in bite force after injection, lasting 15-, 90- and 120-days post-treatment in comparison with baseline, highlighting BTX-A injection as somewhat effective in the short-term management of bruxism [12]. By reducing occlusal force, BTX-A may indirectly reduce the progression of occlusal wear caused by bruxism, although direct evidence regarding its long-term effect remains limited.

Evidence Supporting Reduced Pain and Occlusal Wear

Bruxism may lead to pain across the head, neck, jaw, teeth and temporomandibular joint, attributed to increased masticatory muscle activity. Intramuscular injection of botulinum toxin may temporarily reduce muscle contraction, promote muscle relaxation and contribute to pain relief [13]. In addition, BTX-A may inhibit the release of pain-related neurotransmitters and reduce the transport of transient receptor potential to neuronal cell membranes. Clinical studies have reported significant reduction of pain levels following botulinum toxin injections, with these effects persisting during follow-up periods, suggesting a sustained analgesic effect in patients with bruxism [11].

Risks

a. Excessive muscle atrophy

A potential concern associated with botulinum toxin injections into the masseter muscle is the development of excessive muscle atrophy. Clinical studies have suggested that BTX-A administration can reduce lower facial volume by decreasing masseter muscle activity, improving patient satisfaction without compromising perceived masticatory function in the short term. However, the long-term functional implications remain uncertain [14]. Experimental studies indicate that BTX-A injection-induced muscle atrophy may be associated with structural changes in histological composition, resulting in increased mRNA levels of molecular markers of atrophy and neurogenic atrophy and a reduction in muscle fiber diameter and muscle mass. It is suggested that repeated injections in shorter intervals may increase the risk of permanent changes in masticatory performance and a decrease in muscle thickness. Although a degree of volume reduction may be therapeutically desirable, it remains unknown whether the changes are irreversible or require a longer recovery than currently suggested, emphasizing the need for cautious application and further long-term studies [15].

b. Changes in mandibular bone density

While BTX-A injections are commonly used for aesthetic purposes, the functional implications remain a subject for debate. A systematic review raised concerns about potential functional consequences of repeated applications, irrespective of the administered dose, suggesting that low doses may be sufficient to achieve aesthetic improvement [16]. Current clinical data do not conclusively demonstrate significant bone loss; the potential relationship between reduced muscle performance, impaired occlusal forces, bite forces and mandibular bone remodeling requires long-term studies to understand the skeletal implications of BTX-A treatment better [17].

c. Duration of Effect and Need for Retreatment

The duration of the therapeutic effect of BTX-A in the management of bruxism and muscle hyperactivity is generally temporary, which often requires retreatment. A randomized clinical trial demonstrated that BTX-A is effective in reducing persistent myofascial pain over 24 weeks. Variability in the duration of BTX-A therapeutic effect may be influenced by injection technique, dosage and individual variations in metabolism, as some patients may metabolize the toxin more quickly [17]. Consequently,

although BTX-A can provide meaningful symptomatic relief, its temporary action means that periodic retreatment is often required to maintain clinical benefits [16].

Botulinum Toxin and Applications in Functional and Esthetic Dentistry

Gingival Smile Correction and Management of Facial Asymmetries

In recent years, botulinum toxin has been used as a treatment for gingival smile caused by upper lip hyperfunction, which affects the patient's aesthetics. Although it is a fast-acting procedure, it has some limitations, since its effect is reversible and requires several applications to maintain the results. It has been observed that the effects can last up to 12 weeks after application [18].

Botulinum toxin is a conservative alternative to surgery, but each case must be evaluated individually, since gingival smile has different causes and a detailed analysis of each patient is necessary. It has been shown that it significantly reduces gingival smile by a mean of 2.51 mm [19] and results can be observed from 2 weeks after application [18]. The key muscles for the block are the levator labii superioris, levator labii superioris, alar nasalis and zygomaticus minor, with doses ranging from 1.25 to 7.5 units per side [19].

Control of Forces in Implants in Patients with Parafunction and Prosthetic Rehabilitation

Another important use of botulinum toxin is in patients with bruxism, especially in patients who have been prosthetically rehabilitated on implants, since bruxism is one of the risk factors that cause prosthesis failures due to fractures and wear, which leads to loss of retention. The application of the toxin acts at a neuromuscular level, resulting in a decrease of muscle contractions [20]. That said, botulinum toxin does not eliminate bruxism, but it does reduce the intensity of these contractions, so a significant improvement in sleep quality is observed, along with a reduction in pain and in the frequency of episodes, preventing TMJ problems [21].

When applied, there is less chance of excessive tooth wear. Also, the effect is still temporary and reversible and it has been shown to decrease after 3.5 months of application. However, it is a good option for patients who do not respond well to conventional therapies like splints [21]. It is also a minimally invasive alternative to maintain balance, help prostheses last longer and avoid compromising the patient's aesthetics. The areas treated in these cases are the masseter and temporalis muscles, where the injection is placed to weaken their contraction [20].

Ethical Considerations: Therapeutic vs Cosmetic Use

While botulinum toxin has many benefits, it is important to evaluate each case individually and not focus only on aesthetics. From there, a proper diagnosis can be made and the etiology can be determined, whether it is bone, muscular or dental [22]. When comparing botulinum toxin with surgery, similar results have been observed in the first weeks; however, over the months patients treated with botulinum toxin show a progressive reduction in their results, while those treated surgically maintain theirs [23].

Surgery has been recommended for severe cases and botulinum toxin for mild cases, avoiding unnecessary invasive procedures [24]. Patient autonomy should always be respected and, if they refuse surgical treatment, offering less invasive and safer alternatives that allow patients to return to their routine quickly, explaining its limitations, with emphasis on informed consent and making it clear that results are temporary and gradually decrease [24].

Complications, Regulation and Ethics Associated to BT.

Adverse Effects

Adverse effects of Botulinum Toxin (BT) typically stem from the properties of the product, insufficient professional knowledge and skills and facial anatomical irregularities. Common side effects include hematomas and ecchymosis, muscle hypotonia and antagonist muscle hypertonia, blepharoptosis and ectropion, headache and ophthalmological changes, urticaria, anaphylaxis, dyspnea and soft tissue edema [25,26]. Additional complications include velopharyngeal insufficiency, brachial plexopathy, generalized muscular hypotonia resembling botulism, necrotizing fasciitis, myasthenic crisis, marked bilateral blepharoptosis and speech and chewing impairment. At the injection site, patients commonly experience redness, tingling, bruising, pain, swelling or tenderness [25].

Unwanted Muscular Weakness

BT acts at peripheral cholinergic motor nerve endings by blocking the release of acetylcholine. This prevents motor nerve impulses from reaching muscle fibers, which leads to clinical muscle weakness. Clinicians can avoid unintended muscle weakness by applying proper patient selection criteria [26]. Precise injection technique is essential, as the toxin may spread beyond the intended injection site. Excessive dosing can weaken adjacent muscles, which may result in functional disability or pose serious health risks to patients [27].

Masticatory Dysfunction

Botulinum Toxin (BT) is a non-surgical treatment option that can help reduce pain and discomfort related to Temporomandibular Disorders (TMD). Multiple studies have shown a connection between occlusal factors and Temporomandibular Joint (TMJ) symptoms, including myogenous pain and functional impairments. Maintaining occlusal stability is important for the masticatory system to function properly, since it supports proper muscle activity [27].

Bruxism is one of the common conditions associated with TMD. Among the different treatment alternatives to manage this condition, botulinum toxin type A (BTX-A) can be useful in certain cases. Clinicians often target the masseter muscle in BTX-A therapy, as this muscle plays an important role in mastication and is commonly involved in bruxism and myofascial pain dysfunction syndrome. This treatment can improve maximum mouth opening, reduce muscle contraction strength and lower occlusal bite force [29]. However, because BTX-A reduces the contractile activity of the masticatory muscles, it can also lead to temporary alterations in chewing efficiency and bite force. These changes tend to be more noticeable when higher doses of TB are used or when injections target major masticatory muscles such as the masseter directly [28].

Facial Asymmetry

Beyond its role in bruxism and TMD, BTX-A can also address certain idiopathic conditions such as Masseter Hypertrophy (MH). This condition involves an abnormal enlargement of the masseter muscle that can affect both the function of the masticatory system and facial appearance. MH is often associated with muscle stiffness, as well as psychological distress caused by facial asymmetry [30,31].

BTX-A treatment reduces muscle size and improves facial contours. By weakening the masseter muscle, this approach may change the function of other masticatory muscles, particularly the temporalis muscle which acts in conjunction with the masseter muscle during jaw movements. In consequence, the temporalis muscle can increase its activity and volume as a compensatory response, which may affect aesthetics and functionality [29].

Contraindications

There are numerous contraindications to Botulinum Toxin (BT) treatment, including keloidal scarring, neuromuscular disorders, botulinum toxin allergies, body dysmorphic disorder, pregnancy and breastfeeding, as well as amyotrophic lateral sclerosis and myopathies. Beyond these, clinicians should also consider additional warnings and precautions for certain patient populations [28]. For example, patients with renal impairment, overactive bladder or pediatric patients may still receive treatment, but only under special circumstances [30].

Specialized Training Required

The use of BTX-A and other Non-Surgical Treatments (NST) in aesthetic medicine has grown exponentially over the last two decades. The new standard of care in this field is often associated with wellness and regular self-care, creating a growing market where clinicians frequently lack standardized and regulated training for the application of these treatments [31].

Limited or informal training tends to increase the likelihood of adverse effects and unsafe outcomes, including complications that result from incorrect injection techniques. Across the United States, different healthcare providers are certified to apply NST. This includes physicians, Nurse Practitioners (NPs), Physician Assistants (PAs), Registered Nurses (RNs) and dentists, for whom NST was traditionally not part of their core curriculum [30]. As a result, many providers rely on short training programs that do not always offer sufficient hands-on exposure to properly develop these clinical skills. From a legal and ethical standpoint, formal training should cover proper patient selection criteria, informed consent procedures, ethical practices and transparency regarding outcomes and potential risks [32].

To date, no national or international regulatory body offers a standardized certification in this area. This leaves aesthetic training in the hands of private institutions, individual educators or other providers with no quality control, which creates significant disparity in competency levels across practitioners [33].

Regulatory framework in the United States (approved and off-label use)

According to FDA data, Botulinum Toxin (BT) has several approved indications. These include prophylaxis of headaches in adult patients with chronic migraine, treatment of upper limb spasticity and cervical dystonia in adults, reduction of abnormal head position and neck pain and management of severe axillary hyperhidrosis that topical agents cannot adequately control [34]. Additionally, BT is approved for the treatment of blepharospasm associated with dystonia and strabismus in patients aged 12 years and older. In terms of dosage, the total amount administered should not exceed 360 units every 12 to 16 weeks or at longer intervals [35].

Beyond its approved uses, clinicians also apply BT in several off-label contexts. These include neurogenic thoracic outlet syndrome, epicondylitis, post-stroke pain, post-herpetic neuralgia, diabetic neuropathy, trigeminal neuralgia, neuropathic pain, spinal cord injury, myofascial pain and bladder pain [34].

Professional Responsibility of the Dentist

Dental professionals have a responsibility to pursue proper and adequate training before offering BTX-A and other NST [36]. Their background in anatomy gives them a potential advantage in recognizing orofacial muscle structure. However, limited expertise in facial muscle injection areas can still present significant challenges. Safe and effective application of NST requires a broad understanding of facial anatomy. Since anatomical arrangements can facilitate the unintended diffusion of BTX-A to surrounding structures, clinicians need to develop a strong command of this knowledge before performing these treatments [36].

Limitations of the Evidence and Future Directions

The use of botulinum toxin Type A in dentistry has grown; however, the current body of scientific evidence presents several limitations that must be considered when evaluating its clinical applications [37]. One of the biggest challenges that has been present is the limited number of well-designed Randomized Controlled Trials (RCTs) with long term follow up. Even though several clinical studies and systematic reviews have investigated the therapeutic use for conditions such as Temporomandibular Disorders (TMD) and bruxism, the overall quality of evidence remains moderate to low [37-38]. Many studies include small sample sizes, short follow-up periods and methodological heterogeneity, which limits the strength of clinical recommendations. As a result, more randomized controlled trials with standardized methodologies are necessary to better establish the efficacy and safety of botulinum toxin in dental practice [38].

On another hand, another important limitation in the present literature is the lack of standardized protocols regarding dosage and frequency of administration. Clinical studies evaluating its use for bruxism and masticatory muscle disorder often use different dosing strategies, injections intervals and treatment regimens [39]. This could make it difficult to compare results and prevents the development of clear evidence-based guidelines. Establishing consistent dosage recommendations would help clinicians to achieve more predictable therapeutic results while minimizing potential adverse effects [40]. Additional randomized clinical trials are necessary to establish optimal dosage, treatment frequency and standardized clinical protocols [40].

Variability in Injection Techniques and Anatomical Injection Sites

This represents a significant limitation in the available evidence. Clinical trials evaluating the use of injections for myofascial pain have demonstrated that both intraoral and extraoral approaches may be effective, however, differences in techniques, anatomical landmarks and guidance methods may influence the treatment outcomes [39]. In some cases, to improve injection accuracy the use of imaging such as ultrasound has been suggested and applied. It is important to reinforce the standardized injections protocols with each patient [41].

Potential Long-Term Effects on Bone and Muscle Tissues

Botulinum toxin acts primarily by reducing muscular activity through neuromuscular blockade, prolonged muscle inactivity may influence bone remodeling process in the craniofacial region [42]. Experimental and clinical studies have suggested that repeated injections in masticatory muscles may lead to changes in mandibular bone density or volume [41]. A review evaluating

the impact on mandibular bone structure reported that some studies observed decreases in bone and density, although the overall evidence remains limited and inconclusive. These findings highlight the importance for long-term studies evaluating the potential effects [42].

Importance of Multidisciplinary Approaches in the Management of Orofacial Pain and Parafunctional Disorders

Conditions such as bruxism and TMD sometimes involve complex interactions between neuromuscular, psychological and biomechanical factors. As a result, the use of botulinum toxin should be considered just a part of a comprehensive management strategy involving dental professionals, neurologists, physical therapists and pain specialists to optimize patient outcomes and expand therapeutic possibilities [43].

A recent systematic review and meta-analysis investigating the use of botulinum toxin for bruxism found evidence supporting short-term clinical benefits, particularly in reducing muscle activity and associated symptoms. Nevertheless, the available data mainly cover short follow-up periods (up to 24 weeks) and there is limited evidence regarding repeated treatments or long-term outcomes [43].

Overall, while botulinum toxin represents a promising therapeutic tool in dentistry, the current evidence base remains limited by methodological variability, lack of standardized treatment protocols and insufficient long-term data. Addressing these limitations through well-designed clinical trials and interdisciplinary research will be essential for establishing evidence-based guidelines and ensuring the safety of botulinum toxin therapy into modern dental practice [44-47].

Conclusion

Botulinum toxin type A has established itself as a clinically valuable adjunct in modern dental practice, offering a minimally invasive approach to conditions including bruxism, temporomandibular disorders, masseter hypertrophy and hyperactive gingival smiles. Its mechanism of reversible neuromuscular blockade provides predictable short-term benefits, including reduced bite force, myofascial pain relief and improved patient comfort, with effects generally lasting three to six months. When integrated into prosthetic rehabilitation, BoNT-A may also help protect implant-supported restorations by attenuating parafunctional forces in patients who do not respond adequately to conventional splint therapy.

Nevertheless, the transient nature of its effects, the need for periodic retreatment and emerging concerns about localized muscle atrophy and mandibular bone density changes with repeated injections necessitate cautious patient selection and long-term follow-up. BoNT-A should be regarded as a complement to, rather than a substitute for, evidence-based first-line therapies such as occlusal splints, physiotherapy, and, where indicated, surgical intervention. Ethical practice demands comprehensive patient education and informed consent that clearly addresses the temporary and dose-dependent nature of outcomes.

From a regulatory and training standpoint, the expanding use of BoNT-A in dentistry underscores the urgent need for standardized certification programs and clearly defined scope-of-practice guidelines. Dental professionals possess relevant anatomical expertise, but must pursue structured, supervised training before incorporating these treatments into clinical practice. Future research should prioritize well-designed randomized controlled trials with extended follow-up periods, standardized dosing protocols and multidisciplinary outcome measures to consolidate the evidence base and guide safe, effective integration of botulinum toxin therapy into comprehensive dental care.

Conflict of Interest

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Ethical Statement
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Informed Consent Statement
Informed consent was taken for this study.

Authors' Contributions
All authors contributed equally to this paper.

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