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Posted Date: 19 February 2025

doi: 10.20944/preprints202502.1536.v1

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Durability of Botulinum Toxin Type A and Qualitative Analysis for the Treatment of Gummy Smile due to Muscle Hyperfunction

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ABSTRACT: This study evaluated the durability of botulinum toxin type A in 16 patients (n=16), with 08 units bilaterally, at different time points, through photographs and measurements at T0 (before application), T1 (20 days), T2 (2 months), and T3 (4 months). Two distance measurements were taken: (a) the distance from the anterior nasal spine to the lower edge of the upper lip, and (b) the distance from the lower edge of the upper lip to the incisal edge of the upper right central incisor. The effect of botulinum toxin type A on improving quality of life was assessed by analyzing patient satisfaction using the visual analog scale (VAS). The results indicate that, when measuring the distance from the anterior nasal spine to the lower edge of the upper lip at T3 (14.95 mm), the average distance was greater than at T0 (14.82 mm) but lower than at T1 (16.53 mm) and T2 (15.42 mm). Regarding the average distance between the lower edge of the upper lip and the incisal edge of the upper right central incisor, T3 (11.23 mm) was lower than T0 (12.11 mm) but higher than T1 (8.94 mm) and T2 (8.52 mm). In terms of patient satisfaction, the VAS score at T3 (10) was higher than at T0 (4.5), T1 (8.5), and T2 (9). Botulinum toxin type A qualitatively improved the patient's quality of life and exhibited a durability of at least four months.

Keywords: Botulinum Toxin; Smiling; Quality of Life

INTRODUCTION

The beauty standards imposed by society have exerted significant pressure on individuals worldwide. Since ancient times, society has established aesthetic ideals that define what is considered beautiful or attractive. In many cases, such standards are unrealistic and unattainable for most people. Media, advertising, and social networks play a fundamental role in disseminating these norms, leading many individuals to a constant pursuit of perfection and aesthetic balance (Ma et al., 2023).

In an effort to conform to prevailing beauty standards, many patients seek aesthetic procedures to enhance their appearance. This relentless pursuit of an idealized image can lead to anxiety, low self-esteem, and, more importantly, mental health disorders. In this context, the orofacial harmonization specialist dentist (OHD) plays a crucial role. This professional possesses specific knowledge to work with facial structures. The specialty aims to balance and enhance facial aesthetics through non-invasive procedures, such as fillers, botulinum toxin, and others. The objective is to provide patients with a more harmonious and balanced appearance while respecting their individual characteristics and preserving their identity (Bakke, 2023).

Among the various aesthetic concerns, the gummy smile (GS) is a common issue for many patients, requiring the intervention of an OHD who can address it in the least invasive manner possible. In this context, botulinum toxin type A (BTXA) plays a fundamental role. Its use induces relaxation of the muscles responsible for lifting the upper lip, thereby reducing excessive gum exposure when smiling. This procedure helps balance the GS, providing a more harmonious aesthetic outcome and improving the patient's self-confidence (Polo, 2022).

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It is important to highlight that facial and smile aesthetics are not merely superficial concerns; they also impact patients' quality of life. A harmonious smile can positively influence social interactions, self-image, and even emotional health. By seeking to balance the GS and improve facial aesthetics, the OHD contributes to enhancing patients' self-confidence and overall quality of life, allowing them to feel more secure and satisfied with their appearance. This aspect of orofacial harmonization reinforces the importance of considering not only aesthetics but also the emotional and psychological well-being of patients (Negruțiu et al., 2022).

Therefore, the present research is significant in the current social and health landscape, considering the aesthetic needs of patients who seek GS correction in a less invasive and non-surgical manner, avoiding undesirable signs and symptoms while positively impacting their quality of life. Additionally, it is necessary to determine the optimal dosage for achieving the desired effectiveness.

BTXA functions by blocking the fusion of vesicles containing acetylcholine with the terminal membrane of motor neurons, thereby interrupting neuromuscular transmission (Alcolea & Mkhitaryan, 2019) without affecting neurotransmitter synthesis. The toxin's injection into muscles reduces their activity by decreasing acetylcholine release at cholinergic nerve endings and preventing vesicle fusion with the membrane necessary for neurotransmitter release (Beltrão, 2017). The reversal of this blockade primarily occurs through neural sprouting, the formation of new terminal plates with muscle reinnervation, and the regeneration of binding proteins (Colhado et al., 2009; Gazerani, 2022).

Given these factors, the importance of the proposed analysis becomes evident, as it evaluates the outcomes obtained after BTXA application for GS due to muscle hyperfunction. Furthermore, this study justifies itself by providing the scientific literature with additional research on this topic, given the limited number of publications addressing this specific subject.

OBJECTIVE

To quantitatively evaluate the improvement in aesthetics and the lowering of the upper lip following GS treatment for muscle hypercontraction using BTXA from the commercial brand Botulift®. Additionally, a qualitative analysis of the outcome will be performed using the VAS scale. The null hypothesis of this study is that the application of BTXA at the specified points and units does not result in sufficient aesthetic improvement to justify its indication and recommendation.

METHODS

This study is supported by the Ethics Committee of the Plataforma Brasil, registered under CAAE 26291119.0.0000.0081. The research was conducted in a private clinic located at Rodovia Raposo Tavares, KM 22.5 – Bloco F, Sala 315, Cotia, Granja Viana/SP, CEP 06.709-015.

Designed to suggest aesthetic improvement of the smile and the durability of the effect after the application of TXBA for the treatment of GS due to muscle hypercontraction, a standardized neurotoxin application protocol was implemented. This protocol involved targeting the muscles responsible for gingival exposure (one centimeter lateral to the nasal ala and the Yonsei point) in 21 patients (n=21) at four time points: T0 (pre-application), T1 (15 days), T2 (60 days), and T3 (120 days). Two international units of TXBA were applied per point, totaling eight units bilaterally, following the parameters established by Hexsel et al., 2021.

It is noteworthy that, although the study initially included 21 patients, only 16 (n=16) completed the research, as five patients were lost to follow-up. The diagnosis of GS was established by ruling out other potential causes, with exclusion criteria including (a) altered passive eruption, (b) excessive vertical maxillary growth, (c) alveolar extrusion, and (d) previous TXBA treatment for GS. Muscle palpation during function confirmed the involvement of specific muscles, ensuring that all patients presented GS with more than 3 mm of gingival exposure and keratinized tissue exposure in the anterior and posterior regions of the dental arch. All participants signed an informed consent form before treatment.

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Gummy Smile Diagnosis

Initially, patients underwent a detailed anamnesis, clinical examination, and inquiries regarding the aesthetic impact of their gingival exposure during a habitual smile. Clinically, all patients exhibited at least 3 mm of gingival exposure between the highest gingival point of the anterior teeth and the lower border of the upper lip, which confirmed the diagnosis. Physical examination and two-finger palpation aided in identifying the involved muscles, in accordance with the established diagnostic criteria. Other potential diagnoses were excluded through clinical evaluation using a Williams periodontal probe to assess altered passive eruption and alveolar extrusion. All measurements were taken directly on the patient using a digital caliper.

Inclusion and Exclusion Criteria

To define the study population, the inclusion and exclusion criteria were established as follows:

Inclusion criteria

(a) patients over 18 years old; (b) patients diagnosed with GS due to muscle hypercontraction, as discussed by Hong (2023) in their methodology; (c) patients with no absolute contraindications to botulinum toxin application; (d) patients with no known allergies to the formula components and (e) patients with adequate gingival health.

Exclusion criteria

(a) patients under 18 years old; (b) patients diagnosed with GS of non-contractile origin; (c) patients with absolute contraindications to botulinum toxin application; (d) patients with known allergies to the formula components; (e) patients with inadequate gingival health and (f) patients previously treated with TXBA for GS.

TXBA Application

After diagnosis, all participants underwent the TXBA application protocol, targeting points one centimeter lateral to the nasal ala and the Yonsei point bilaterally. Initially, facial hygiene was performed to prevent microorganism transmission during needle puncture. Patients washed their faces with neutral soap and running water for 30 seconds, followed by the application of a gauze pad soaked in 70% alcohol to the peri-nasal region for another 10 seconds.

The injection sites were marked with a skin marker (one cm lateral to the nasal ala, Yonsei point, and one cm lateral to it) bilaterally to guide precise needle placement. After the skin dried, approximately 2 g of Pliaglis® anesthetic cream (lidocaine 70 mg/g and tetracaine 70 mg/g) was applied evenly with a 1 mm thickness using a spatula and left for 40 minutes.

While waiting for the anesthetic effect, TXBA was diluted according to the manufacturer's instructions for the commercial brand Botulifit® (Medytox, Inc., Ochang-eup, Cheongwon-gun, Chungcheonbul-do, South Korea). A 22G hypodermic needle (0.70 mm × 25 mm) and a 5 ml syringe were used to aspirate 4 ml of refrigerated sterile NaCl, which was slowly injected into a 200U TXBA vial. The diluted solution was then drawn into a 1 ml syringe (Solidor®) with a 30G needle (0.30 mm × 13 mm) (Terumo®) and applied at the predetermined sites (one centimeter lateral to the nasal ala and the Yonsei point), totaling 8U bilaterally, via slow, continuous, and perpendicular injections to the facial plane.

Post-procedure recommendations included: keeping the head elevated for 4 hours, avoiding compression of the area, refraining from physical activity for 24 hours, avoiding makeup for 24 hours, minimizing sun exposure, and using sunscreen for the first 15 days. Follow-up appointments for reassessment and final questionnaires were scheduled at T1 (15 days), T2 (60 days), and T3 (120 days).

Photographic Protocol

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Participants were photographed at four different time points: T0, T1, T2, and T3. All photographs were taken by the same researcher at the clinic where the procedure was performed.

A digital camera was mounted on a tripod with a 100 mm lens at an approximate distance of 215 cm from the subject's face. To standardize the protocol, a black guideline was marked on the floor. The camera lens was adjusted to be parallel to the vertical plane of the subject. A natural smile was maintained for all participants. This protocol was based on the studies of Cengiz, Goumen, and Akcali (2020).

Outcome Assessment

Outcome assessment was performed by comparing pre-treatment (T0) and post-treatment measurements at T1 (15 days), T2 (60 days), and T3 (120 days). Pain levels were evaluated using the Visual Analog Scale (VAS) at all study time points.

The quality of the results was also assessed qualitatively using the VAS. Durability and effectiveness were measured by assessing (a) the distance from the nasal spine to the inferior border of the upper lip and (b) the distance from the inferior border of the upper lip to the incisal edge of the upper right central incisor (tooth 11).

The VAS is a widely used tool for assessing subjective intensity perceptions in clinical, psychological, and pharmacological research. It consists of a straight line of fixed length, where one end represents the complete absence of the evaluated attribute and the other end denotes the maximum possible intensity. Participants are instructed to mark a point on the line that corresponds to their perception of the attribute's intensity, as discussed by Sung & Wu (2018).

The validation of the VAS in the literature is notable, with numerous studies demonstrating its reliability, sensitivity, and validity across various contexts. The VAS has been applied in multiple fields, such as pain assessment, anxiety, stress, quality of life, and treatment responses. Its simple yet effective nature, combined with the possibility of continuous quantification and statistical analysis, establishes its role as a fundamental tool for measuring subjective constructs.

For data analysis and result evaluation, Word® (Microsoft Office 365, San Diego, CA, USA) and Excel® (Microsoft Office 365, San Diego, CA, USA) were used. Descriptive statistics were performed, including absolute and percentage distribution calculations for each response obtained. A ring light with a tripod was used for photography, and all images were taken in a clinical setting using a Canon T5i® digital camera equipped with a 100 mm MACRO lens. The camera settings were adjusted to manual mode with the following specifications for facial photographs: f=11; ISO=100; Shutter Speed=1/125.

RESULTS

The results indicated that for the measurement of the distance from the anterior nasal spine to the inferior border of the upper lip at T3 (14.95 mm), the mean distance was greater compared to T0 (14.82 mm) but lower than at T1 (16.53 mm) and T2 (15.42 mm). Regarding the mean distance from the inferior border of the upper lip to the incisal edge of the upper right central incisor, T3 (11.23 mm) was lower than T0 (12.11 mm) but higher than T1 (08.94 mm) and T2 (08.52 mm). For the mean patient satisfaction score, the VAS scale at T3 (10) was higher than at T0 (4.5), T1 (8.5), and T2 (9).

The research findings revealed statistically significant differences, particularly concerning the VAS scale values. At the initial time point (T0), patients had lower scores, whereas in the three subsequent time points (T1, T2, and T3), the scores were statistically similar but significantly higher than at T0, as shown in Table 2. At T1, for both Measure A and Measure B, there was a strong correlation between them (Spearman's Rho, -0.632, $p<0.01$), indicating a high degree of association. The ANOVA/Games-Howell test was used for the VAS scale, while ANOVA/Tukey was applied to Measures A and B.

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Table 1. - Results found in the research. Legend: VAS - Visual Analog Scale. MED A - Measure A given by the distance from the nasal spine to the lower border of the upper lip. MED B - Measure B given by the distance from the lower border of the upper lip to the incisal of the right upper central incisor. T0 – Time 0 pre-treatment. T1 – Time 1, 15 days post-treatment. T2 – Time 2, 60 days post-treatment. T3 – Time 3, 120 days post-treatment.

PACIENTE	VAS				MED A				MED B			
	T0	T1	T2	T3	T0	T1	T2	T3	T0	T1	T2	T3
MÉDIA	4,5	8,5	9,0	10	14,82	16,53	15,42	14,925	12,11	08,94	08,52	11,23

Table 2. - Mean (SD) of VAS, MED A, and MED B values. Comparisons made within the same column. Values followed by the same letter represent statistical similarity (p>0.05). Legend: T0 – Time 0; T1 – Time 1; T2 – Time 2; T3 – Time 3; VAS – Visual Analog Scale; MED A – Measure A; MED B – Measure B; SD – Standard Deviation.

TEMPO	VAS	MED A	MED B
T0	4,5 (3,0) B	14,3 (2,2) A	12,2 (1,8) AB
T1	8,2 (2,1) A	16,2(4,0) A	9,17 (4,4) B
T2	8,9 (1,5) A	15,2 (2,0) A	8,71 (2,2) B
T3	8,4 (2,7) A	12,2 (1,9) A	10,8 (2,0) AB

Table 3. - Contingency table related to VAS/Time scale. Legend: T0 – Time 0; T1 – Time 1; T2 – Time 2; T3 – Time 3; VAS – Visual Analog Scale.

0	1	0	0	1	2
1	1	0	0	0	1
2	3	0	0	0	3
3	2	0	0	0	2
4	1	1	0	0	2
5	3	2	1	1	7
6	1	1	1	0	3
7	2	1	1	2	6
8	0	3	0	2	5
9	0	1	6	1	8
10	2	7	7	9	25
Total	16	16	16	16	64

Beyond the previously described statistical findings, the contingency analysis of the VAS scale indicated statistical significance and suggested that patients tend to assign higher scores at T3, as demonstrated in Table 3. Fisher's exact test showed a tendency for individuals to give higher VAS scores at T3 (p=0.015). Unlike the VAS scale analyses, Measure A, which varies considerably among individuals, showed no statistical differences across time points. Regarding Measure B, the results indicated higher scores at T0 compared to T1 and T2 (which were statistically similar), followed by a return to statistically equivalent values at T3. An additional hypothesis is that Measures A and B may be correlated at T1, possibly influenced by muscle response due to the recent administration of the dose, and may diverge later over time.

DISCUSSION

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Facial aesthetics depend on elements such as the habitual smile, which involves a slight exposure of the gingiva (1–3 mm) and the balance between the shape and color of facial structures (Matos et al., 2017). When a visual imbalance known as a gummy smile (GS) occurs, characterized by excessive gingival exposure (more than 3 mm) while smiling, negative aesthetic consequences arise, affecting patients' self-esteem (Chagas et al., 2018). This condition, recognized by the American Academy of Periodontology (AAP) as a mucogingival deformity, has a multifactorial etiology, including altered passive eruption, excessive vertical maxillary growth, hyperfunction of the labial musculature, and alveolar extrusion (Tjan & Miller, 1984; Zangrando et al., 2017). A precise diagnosis is essential for an individualized treatment plan (Robbins, 1999).

In cases of altered passive eruption, where the periodontal complex fails to migrate properly toward the cementoenamel junction, resulting in gingival exposure due to a shortened clinical crown, gingivectomy is the recommended treatment to expose part of the dental crown (Jananni et al., 2014; Zangrando et al., 2017). Hyperfunction of the labial musculature, frequently observed in clinical practice, can lead to excessive gingival exposure. In such cases, the application of botulinum toxin type A (BTXA) is an appropriate treatment (Nasr et al., 2016; Al-Fouzan et al., 2017). Proper identification of the specific muscle or corresponding area is crucial for achieving satisfactory outcomes, considering variations in dosage, BTXA type, training, and technique (Chagas et al., 2018). Muscle palpation and patient-induced facial expressions are effective methods for determining the muscles involved when GS is attributed to muscular hyperfunction (Fatani, 2023).

The levator labii superioris alaeque nasi muscle, originating from the frontal process of the maxilla and inserting into the nasal ala and upper lip, can be identified by asking the patient to unilaterally lift the upper lip. Meanwhile, the zygomaticus major muscle, originating from the lateral surface of the zygomatic bone and extending to the oral commissures, can be located when the patient smiles, raising the corners of the lips under the guidance of a dental surgeon (Hutto & Vattoth, 2015; Beltrão, 2017).

Several classifications of GS have been proposed, with the most accepted being based on the involved muscle groups: anterior, posterior, mixed, or asymmetric (Pedron, 2014; Zangrando et al., 2017). The anterior group includes muscles such as the levator labii superioris and/or levator labii superioris alaeque nasi, while the posterior group includes the zygomaticus major and/or minor muscles, both playing a significant role in GS. The mixed group involves musculature related to both the anterior and posterior groups (Rego et al., 2015; Fatani, 2023). When applying BTXA, it is crucial to target the anatomical region associated with each muscle. Generally, GS activity involves both anterior and posterior muscles, suggesting that a single application targeting all three muscles may be suitable (Pedron, 2014; Hong, 2023). According to Pedron's classification (2014), this study categorized the GS of the sampled patients based on the muscle groups involved, with all cases classified as mixed GS.

Another classification for GS diagnosis considers gingival exposure while smiling. A 2 mm exposure can already affect smile aesthetics, and GS is categorized into three severity levels: mild (2–4 mm of gingival exposure), moderate (4–6 mm), and severe (≥6 mm) (Martínez et al., 2011). This classification also guides the required BTXA dosage, with higher doses recommended for more severe cases. Additionally, different smile analyses contribute to GS diagnosis, including lip, gingival, and dental analyses. Lip analysis considers thickness, gingival analysis evaluates contour and zenith, and dental analysis examines tooth shape, size, and their relationship with gingival behavior in various situations (Van der Geld et al., 2007; Moskowitz & Nayyar, 1995; Ghasemani & Akbari, 2022; Magne & Belser, 2004; Fradeani, 2008; Ahmad, 2005).

This study on GS treatment with BTXA is highly relevant to the field of facial aesthetics, as demonstrated by Cengiz, Goymen, & Ackcali (2020). The smile is a key component of an individual's appearance, and the visual imbalance caused by excessive gingival exposure while smiling can negatively impact patients' self-esteem. This condition, known as GS, has a multifactorial origin, and precise diagnosis is essential for an individualized treatment plan. The application of botulinum toxin to the muscles responsible for hypercontraction is an effective therapeutic approach, as it reduces

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muscle contractions and decreases gingival exposure. The methodology described in this study includes identifying the involved muscles and precisely administering the toxin to the correct anatomical points. The research provides important insights into the efficacy and effects of botulinum toxin, highlighting its safety and reversibility as a controllable treatment for GS.

At the beginning of the study, an initial group of 21 patients (n=21) was recruited. However, during follow-up, five patients (n=5) discontinued participation for various reasons, resulting in a final sample of 16 patients (n=16). This reduction in sample size may be attributed to personal reasons, logistical difficulties, or other factors impacting continued participation.

Despite this, the study plays a fundamental role in the fields of dentistry and facial aesthetics. Excessive gingival exposure while smiling can have negative aesthetic consequences and impact patients' self-confidence. Based on the study's methodology, involving muscle identification and precise BTXA application, an individualized and effective treatment can be offered to each patient. BTXA functions by blocking muscle contractions responsible for GS, thereby reducing gingival exposure. This research provides valuable information on optimal dosage, injection sites, and the duration of BTXA effects, contributing to the refinement of this therapeutic approach. The application of BTXA for GS treatment is a controllable and reversible option, significantly improving facial aesthetics and self-esteem, as corroborated by previous studies (Polo, 2020; Cengiz, Goymen, & Ackcali, 2020; Rojo-Sanchis et al., 2023).

BTXA has been extensively studied in the literature (Hwang et al., 2009; Gracco & Tracey, 2010; Mazzuco & Hexsel, 2010; Patel et al., 2012; Mostafa, 2018; Pedron & Mangano, 2018; Gupta & Kohli, 2019; Moreira et al., 2019) and has demonstrated safety and efficacy in treating gingival exposure, with variations in effects depending on the application site and dosage (Nunes et al., 2015). Proper BTXA use requires a deep understanding of facial anatomy, muscle relationships, and anatomical planes, as well as correct drug dilution (Earp & Marmur, 2008; Gracco & Tracey, 2010). It is important to note that BTXA reaches peak efficacy between 7 and 14 days post-application, with effects lasting up to 6 months before gradually and reversibly diminishing (Jaspers et al., 2011). This therapeutic approach is fully controllable and reversible (Sandler et al., 2007; Pedron & Mangano, 2018).

Hexsel et al. (2021) conducted a double-blind randomized clinical trial to evaluate the effects of different BTXA doses for anterior GS treatment. Results showed that a 5 U dose significantly reduced gingival exposure compared to 2.5 U. All GS severity groups exhibited statistically significant reductions in gingival exposure at 4 and 12 weeks post-injection. Furthermore, at 12 weeks, over 80% of patients reported being satisfied or very satisfied, aligning with this study's findings, in which the mean satisfaction score on the Visual Analog Scale (VAS) improved from 4.5 at baseline (T0) to 10 at T3. These findings underscore the effectiveness of BTXA as a minimally invasive, safe, and reversible approach for GS treatment.

CONCLUSION

TXBA qualitatively increased the patient's satisfaction with their smile and demonstrated a durability of at least 4 months.

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