Botulinum Toxin and Smile Design

Mario Polo, DMD, MS, FICD[a,b,*]

KEYWORDS

• Gummy smile • Smile esthetics • Excessive gingival display • Asymmetric smiles • Smile design • Neuromodulators • BOTOX COSMETIC

KEY POINTS

- Smiles with excessive gingival display exceeding 3 mm are considered unattractive.
- Excessive muscular contraction of lip elevator muscles is the etiology in most of these cases.
- Botulinum toxin type A (BTX-A) blocks muscular contraction.
- BTX-A has been proven to be an effective treatment alternative to correct these conditions affecting smile esthetics.

INTRODUCTION

Botulinum toxin type A (BTX-A) was first reported to be used in the face for cosmetic purposes in the early 1990s after being therapeutically used for the treatment of blepharospasm **Table 1**[1] In well-trained hands, injecting this powerful neurotoxin is a simple, effective, and safe procedure. My experience with neuromodulators dates to 2002 when a pilot study using BTX-A for the correction of excessive gingival display (EGD) in subjects with gummy smiles (GS) was performed.[2] On this pioneer evaluation in the use of neuromodulators for the cosmetic improvement of GS, a remarkably beneficial effect was observed and reported. Another clinical trial using a larger sample consisting of 30 subjects with varying degrees of severity in their GS was then conducted: results obtained were quite positive and encouraging, consistently reducing excessive gingival displays to esthetically acceptable levels.[3] The author's clinical experience with OnabotulinumtoxinA for the treatment of GS has primarily been with BOTOX and BOTOX COSMETIC (Allergan, Madison, NJ). All references in this article to BTX-A specifically refer to BOTOX and BOTOX COSMETIC.

[a] Private Practice, Orthodontics and Facial Esthetics, San Juan, PR, USA; [b] Department of Orthodontics, University of Puerto Rico School of Dental Medicine, San Juan, PR, USA
* 702 La Torre De Plaza, 525 F.D. Roosevelt Avenue, San Juan, PR 00918.
E-mail address: drmariopolo@mariopolo.com

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Table 1
Polo's injection protocol for gummy smiles

Gingival Exposure (mm)	Injection Sites: Number (Location)	Dose (per Side)	Total Units
4.0–5.0	1 (LLSAN/LLS)	2.0 U/side	4.0 U
5.0–7.0	1 (LLSAN/LLS)	2.5 U/side	5.0 U
7.0–8.5	2 (LLSAN/LLS; LLS/Zm)	2.0 U/side	8.0 U
> 8.5	2 (LLSAN/LLS; LLS/Zm)	2.5 U/side	10.0 U

Dose and sites determined according to amount of gingival exposure presented.
Abbreviations: LLS, levator lavii superioris; LLSAN, levator lavii superioris alaeque nasi; Zm, zygomaticus minor.

BRIEF HISTORY

Produced by the bacterium *Clostridium botulinum*, the initial use of botulinum toxin in medicine was reported in the 1950s by Dr Vernon Brooks, and later in the 1970s, by Dr Alan Scott for the correction of strabismus. It was eventually used for the treatment of blepharospasms, a neuromuscular condition affecting the eyelids, and then used to treat subjects with hemifacial spasms and cervical dystonia.[4] As previously mentioned, the first systematic study of BTX-A in facial rejuvenation was performed in the early 1990s by Jean and Alastair Carruthers, and Botox was then approved for the correction of facial lines in the glabellar region by the US Food and Drug Administration in 2002. This cosmetic effect was attained by means of neuromodulation of the procerus and corrugator supercillii muscles in this facial region. Since then, several other therapeutic and cosmetic applications have been developed and are currently used.

ETIOLOGY OF GUMMY SMILES

Gingival displays of more than 3 mm are considered excessive and unattractive.[5] The etiology of the EGD is multifactorial, and skeletal, periodontal, muscular, and combined factors have been described,[6,7] and treatment should always be determined according to the underlying etiologic factor. When an excessive vertical bony growth of the maxilla is present, a skeletal etiology, the treatment of choice for the correction of the EGD is a Le Fort I osteotomy.[8] When the EGD is secondary to altered passive dental eruption or short clinical crowns, periodontal etiologic factors, gingival reduction by excision (gingivectomy or a surgical crown lengthening) is indicated.[9] Those cases presenting EGD with an underlying muscular etiology and some cases with a combination of etiologic factors that include a muscular component are those in which the use of BTX-A is best indicated. A muscular etiology is present when the upper lip elevator muscles are in a state of hypercontractility when smiling without restriction. At times called lip hypermobility, an excessive elevation of the lip is produced by some of the mimetic muscles responsible to produce a smile.

PREVALENCE

Sexual dimorphism is present in subjects with GS. The prevalence of gingival smiles in female individuals is much higher than in male individuals, with a 96% prevalence in female individuals, as reported by Peck and colleagues.[5]

ANATOMY

Lips are the main facial structures involved in the production of a smile, although other structures, such as the eyes, also interact when conveying a smile, a facial expression of happiness. This happens because the muscles of facial expression are closely interleaved one with another, either at their origin or at their insertion. Knowledge of the underlying anatomy, as related to the location of muscles, arteries, accompanying veins and nerve endings, their relation to the skin and facial bones, and their actions in producing facial expressions, is essential when injecting BTX-A. The muscles involved in the production of a smile are the levator labii superioris alaeque nasi (LLSAN), levator labii superioris (LLS), zygomaticus minor (Zm), zygomaticus major (ZM), levator anguli oris (LAO), risorius (R), depressor anguli oris (DAO), depressor labii inferioris (DLI), mentalis (M), depressor septii nasi (DSN), and the orbicularis oris (OO) muscles (**Fig. 1**). It has been previously established that the muscles primarily associated with lip elevation in the production of a smile are the LLSAN, the LLS, the Zm, and the ZM.[10,11]

The LLSAN, LLS, Zm, and the ZM muscles receive their blood supply from the terminal branches of the facial artery and the infraorbital branch of the maxillary artery. Blood supply to the LAO comes from various small branches of the labial, infraorbital, and facial arteries, whereas R receives its arterial blood supply via the facial artery and the transverse facial artery at its origin. DAO receives its blood supply from the superior labial branch of the facial artery and the infraorbital branch of the maxillary artery. DLI receives arterial blood supply from the inferior labial branch of the facial artery and the mental branch of the maxillary artery, while the inferior labial branch of the facial artery supplies the M muscle. The DSN is supplied by the superior labial branch of

Fig. 1. Facial muscles involved in the production of a smile. 1. LLSAN, 2. LLS, 3. Zm, 4. ZM, 5. R, 6. DAO, 7. M, 8. DLI, 9. LAO, 10. DSN, 11. OO.

the facial artery, whereas the OO has vascular supply mainly from the superior labial and the inferior labial arteries. The nerve supply to all these muscles is provided by the terminal buccal and zygomatic branches of the facial nerve.

PHYSIOLOGY AND MODE OF ACTION

Botulinum neurotoxins are known to have 7 serotypes (A, B, C1, D, E, F, and G). The BTX molecule is a 150-kDa structure composed of a 100-kDa heavy chain, together with a 50-kDa light chain held together by a disulfide bond and an associated zinc metalloprotease. Although the 7 different types of BTX bind at different areas of the nerve membrane and cleave different proteins at the presynaptic nerve terminal, all of them have the same mode of action. All serotypes act by preventing the release of acetylcholine at the neuromuscular junction of striated muscle fibers, thus producing a flaccid paralysis of the muscle.[12]

RECONSTITUTION AND DILUTION

BTX-A is supplied as a vacuum-dried powder in 50-, 100-, and 200-Unit vials that need to be reconstituted with 0.9% normal saline solution without preservatives before being injected. Dilution volumes with saline vary according to the muscle mass to be injected, and the injector's choice of concentration. The BTX-A vial, which is mostly used for cosmetic purposes, is the 100-U vial. The most common dilution protocol used consists of adding 2.5 mL of a 0.9% normal saline solution to a 100-U vial. This dilution will result in a 4.0-U/0.1-mL concentration. For the 50-U vial, using half of these volumes will result in the same concentration, whereas for the 200-U vials, 2x the saline volume will produce the same concentration.[13]

PATIENT EXAMINATION, SELECTION, AND INTERVIEW

The most important factor contributing to a successful treatment outcome, regardless of which, is patient selection. When evaluating a person with a chief complaint of "showing too much gum tissue when smiling," the clinician should first assess the reason why an EGD is present. The etiology needs to be accurately established, for treatment options should be based on the existing etiologic factor because these options should not be used indiscriminately.[14]

The use of BTX-A for GS with a muscular etiology, excessive contraction resulting in extreme upper lip elevation or hypermobility, is the treatment of choice.

Besides an EGD, these subjects also present with a short vertical dimension at the mid-portion of the upper lip at the philtrum, and a thin upper lip vermillion border. In those presenting a "canine smile" type of smile, the gingival exposure extends even more posteriorly, into the premolar and even the molar area.

Quantification of the amount of EGD present is essential because all GS are not the same. EGDs exceeding 4 mm, even up to 15 mm, may be clinically observed. On examination, the clinician should determine and record the amount of EGD present, together with the patient's smile type. Care should be used when considering its use in individuals presenting GS together with a hypotonic or flaccid upper lip. If asymmetry is present, further assessment and planning are essential, and patients should be clearly informed of this and other existing conditions (eg, asymmetric lip elevation, canting of the maxilla, facial asymmetry, mandibular laterognathia). The presence of these and other factors might influence results and interfere with the patient's expectations.

Clinicians should carefully evaluate the patient's expectations regarding this procedure and learn about their degree of satisfaction with results attained with previous

cosmetic procedures. Dealing with patients expressing high levels of dissatisfaction with the results of a previous procedure or unrealistic expectations, is a situation that needs to be closely evaluated during this initial session. Thorough written documentation of facial findings and conversation details addressed during the patient's interview must be performed. Photographic documentation, both before and after the injection procedure, is also essential.

DOSE

It is highly advisable to inject varying doses according to the severity of the GS, as learned from the clinical trials initially performed,[2,3] and throughout my clinical experience during the past 20 years successfully injecting BTX-A for GS correction.

During the 2 phases of the first trial, it was established that smaller BTX-A doses of 1.5 U/injection site could not effectively treat subjects with more severe degrees of EGDs. After the second trial, it was observed that higher doses of 2.5 U in subjects with milder degrees of EGD were not as esthetically pleasing as those obtained in more severe cases.

Varying doses according to the severity of the gingival display were then established, and my injection protocol was accordingly modified and clinically used for more than 4 years. This first revision of the initial injection protocol was reported in 2013 in the journal *Plastic Reconstructive Surgery*.[15] In 2016, a second revision with a subtle dose modification was published in the journal *Aesthetic Surgery*.[16] This injection protocol remains the one currently used. It is based on a classification of GS based on the degree of severity and is summarized in the accompanying table (**Table 1**). Pleasing results have been obtained by using these doses. The injection sites remain the same as those originally used with the LLSAN, the LLS, and the Zm muscles being the target muscles. The injection sites for the correction of GS by means of BTX-A injection, the Polo Injection Points,[17] are shown in **Fig. 2**.

INJECTION TECHNIQUE

Upper lip elevator muscles originating in the zygomatic bone present a triangular and inferiorly converging pattern, eventually inserting mostly into the superiorly located fibers of the OO muscle, whereas some of their fibers also insert into the skin of the

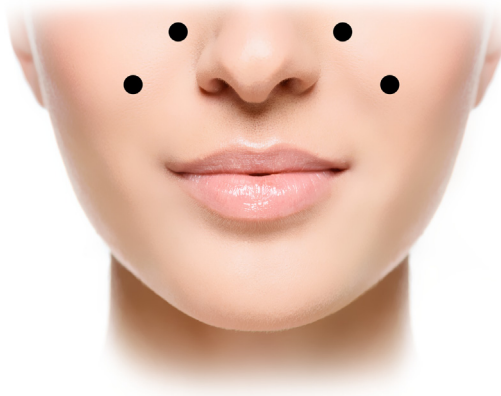

Fig. 2. Polo Injection Points. These points demonstrate the approximate injection location. Exact injection points should be individually determined by means of palpation and animation, as described in the text.

upper lip. The more medially located muscles, the LLSAN, LLS, and Zm pull the upper lip upward (elevation), whereas others more laterally located tend to pull the upper lip laterally and horizontally. These laterally positioned muscles (ZM, LAO, and R) should be avoided to prevent undesired, unesthetic results in the patient's smile. The LLSAN, LLS, and Zm determine the amount of elevation of the upper lip. At their utmost inferior portion near their insertion at the OO, these muscles tend to present proximity, overlapping, and even interleaving of their fibers. For this reason, these were the target muscles selected for injection during my 2005 preliminary study and continue being so. Because undesired esthetic results could arise by injecting muscles located too far laterally, near the ZM area, the author recommends avoiding such injections.

All in all, in the technique here presented, the target injection sites are the convergence area of the LLSAN and the LLS, and the convergence area of the LLS and the ZMi, at the Polo Injection Points[17] (see **Fig. 2**). They are clinically determined on an individual basis for each patient by means of palpation and facial animation and are subject to variation from one individual to another. Factors such as facial dimensions, facial type, and ethnicity, determine this variability, as reported by L.G. Farkas and colleagues.[18] The most superior set of the Polo Injection Points, corresponding to the area where the LLSAN and the LLS approximate each other, is determined by deep digital palpation with the index finger to locate the canine fossa, and further corroborated by muscle animation while still maintaining finger pressure at this area. They usually are located 0.5 cm lateral to the mid-portion of the lateral aspect of the nose. The second set of points, the crossover area of the LLS and the Zm, is located approximately 1.0 cm inferiorly and laterally, and always above the level of the OO muscle, is determined mostly by animation (smiling), followed by superficial palpation detecting contraction of these muscles. Again, individualization according to facial type and dimension is critical to attain pleasing esthetic results.

The area is anesthetized with a 5% lidocaine cream for 15 minutes. After removing the anesthetizing cream, the area is thoroughly sanitized with 70% isopropyl alcohol swabs, and the injection preselected points are marked. The use of ice pads before and after injection is recommended because of their additional numbing of the skin and production of localized vasoconstriction, thus reducing discomfort, and reducing the risk of bruising. The BTX-A vial is reconstituted and diluted with a preservative-free 0.9% normal saline solution, as previously explained. The author's dilution choice is 2.5 mL for the 100-U vial, and 1.25 mL for the 50-U vial, both dilutions producing a 4.0 U/0.1 mL injected; 1.0 mL tuberculin syringes with 32G one-half inch needles are used. The desired number of units are then injected at each of these sites. Results attained by this off-label minimally invasive modality for the correction of EGD (GS) are observed within 2 to 5 days postinjection. There is minimal discomfort associated with the procedure and results are highly predictable.

OTHER USES FOR ESTHETIC SMILE ENHANCEMENT

BTX-A has successfully been used by the author for the correction of asymmetric smiles in patients with GS in whom upper lip elevation is greater on one side, as compared with the other side. Also, it has been used in some individuals presenting unilateral upper lip elevation and in persons presenting excessive unilateral lower lip depression secondary to excessive contraction of the DLI muscle.

Careful selection of the injection site(s) and treatment dose is needed when injecting these individuals, and it should be attempted only by experienced injectors because unesthetic results may happen.

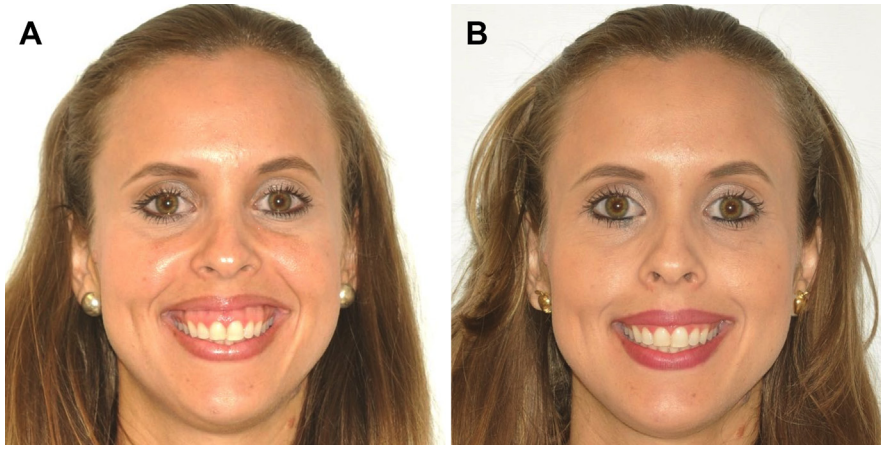

Fig. 3. Full-face smiling photographs of a 30-year-old female patient with a Grade 4 GS of 8.6 mm. (*A*) Before BTX-A injection with 2.5 U/site at 4 sites. (*B*) Two weeks after injection: 8.5-mm reduction in gingival display was attained.

CONTRAINDICATIONS

BTX-A is contraindicated in individuals with hypersensitivity to any botulinum toxin preparation or to any of the components in the formulation. Infection at the injection site is another contraindication. The presence of certain neurologic conditions and other medical conditions may contraindicate treatment with BTX-A. Some prescription and over-the-counter medicines may cause serious side effects. Its use during pregnancy may affect fetus formation. It is unknown if botulinum toxin passes into breast milk during lactation. Adequate evaluation of the medical history is essential before its use.

COMPLICATIONS

Complications arising when using BTX-A usually are site-specific, although there is always the possibility of a distant spread of toxin effect. Some side effects may be serious and even life-threatening. Injectors should familiarize themselves with pertinent medical information provided in the package insert before using BTX-A. When using low doses for the correction of GS, complications are usually few. The most

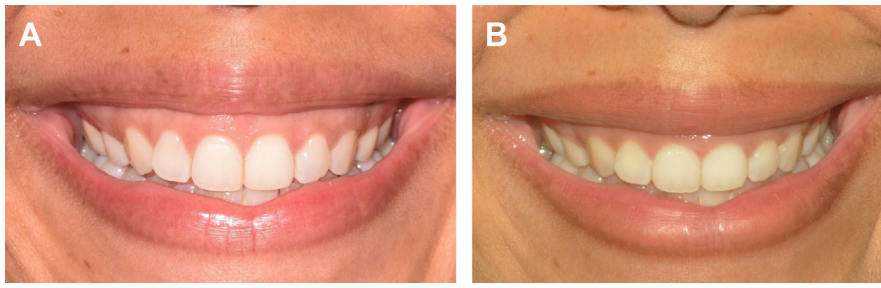

Fig. 4. Close-up smiling photographs of a 32-year-old female patient with a Grade 1 GS of 4.7 mm. (*A*) Before BTX-A injection with 2.0 U/site at 2 sites. (*B*) Two weeks after injection: 3.2-mm reduction in gingival display was attained.

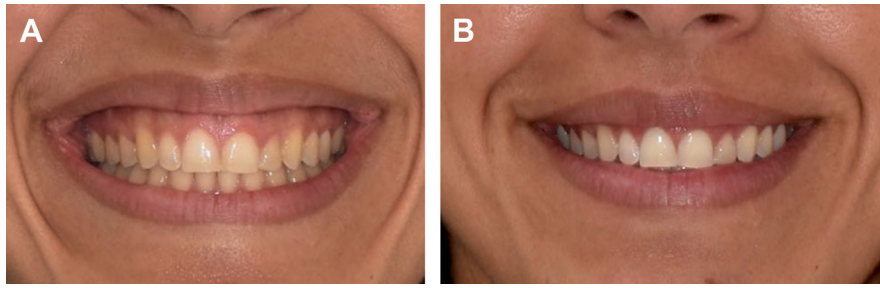

Fig. 5. Close-up smiling photographs of a 37-year-old female patient with a Grade 2 GS of 5.4 mm. (*A*) Before BTX-A injection with 2.5 U/site at 2 sites. (*B*) Two weeks after injection: 5.4-mm reduction in gingival display was attained.

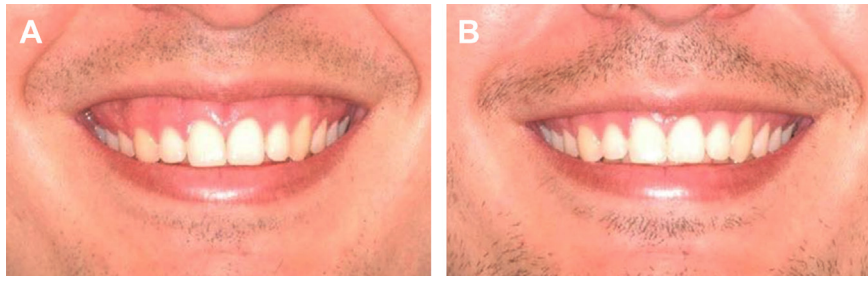

Fig. 6. Close-up smiling photographs of a 30-year-old male patient with a Grade 3 GS of 7.3 mm. (*A*) Before BTX-A injection with 2.0 U/site at 4 sites. (*B*) Two weeks after injection: 6.3-mm reduction in gingival display was attained.

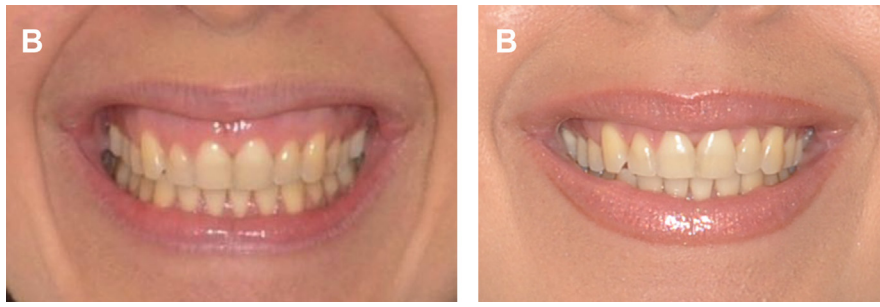

Fig. 7. Close-up smiling photographs of a 31-year-old female patient with a Grade 4 GS of 8.5 mm. (*A*) Before BTX-A injection with 2.5 U/site at 4 sites. (*B*) Two weeks after injection: 8.5-mm reduction in gingival display was attained.

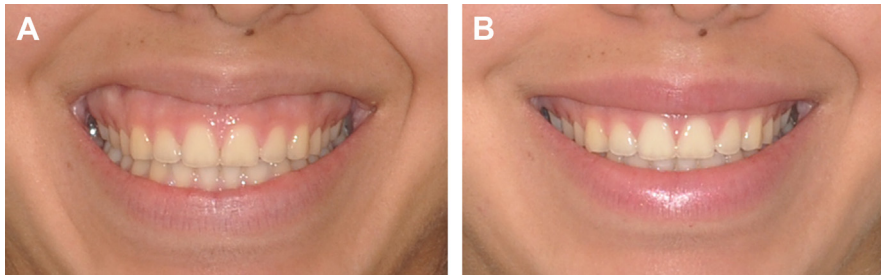

Fig. 8. Close-up smiling photographs of a 21-year-old female patient with an asymmetric bilateral GS, Grade 4 (8.5 mm) right, Grade 3 (7.0 mm) left. (*A*) Before BTX-A injection with 2.5 U/site on the right side and 2.0 U/site on the left side. (*B*) Two weeks after injection: approximately 8.5-mm reduction in gingival display was attained on the right side and 7.0 mm on the left side.

common complications, although infrequently observed, are bruising and tenderness at the injection sites. Smile asymmetry or excessive ptosis or drooping of the upper lip could take place if injection sites are not adequately selected or if dose guidelines are not followed. Injection of BTX-A is a relatively safe procedure when used for the correction of GS with underlying excessive muscle activity. A sound understanding of facial anatomy and adequate training in using neurotoxins is essential.

IMMUNORESISTANCE

For the past 20 years during which I have been injecting BTX-A for the correction of GS, and of thousands of injection sessions for this purpose, only one patient has not had BTX-A correct her EGD condition. This 30-year-old woman had the procedure done on 3 occasions, at a 4-month interval from each other, and using a higher dose on each consecutive session. No change in the upper lip's vertical position was observed in any of these 3 injection sessions. Immunologic resistance to BTX-A is suspected.

CLINICAL CASES

Before and after photographs illustrating the results attained by the author using the technique herein described are enclosed. Fig. 3 presents before and after full-face photographs of a 30-year-old female patient with canine smile and a severe degree

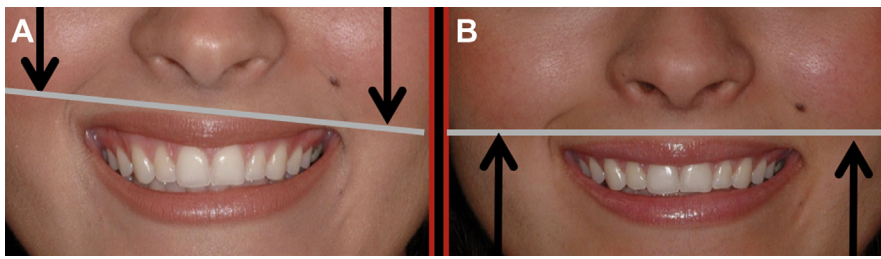

Fig. 9. Close-up smiling photographs of a 22-year-old female patient with an asymmetric unilateral GS on the right side. (*A*) Before BTX-A injection with 1.5 U on the right LLSAN/LLS site. (*B*) Two weeks after: a significant improvement of the asymmetric smile can be observed.

of gingival display. Figs. 4–7 present before and after photos of patients with varying degrees of GS. Two patients with asymmetric smiles are presented in Figs. 8 and 9: one with a bilateral anterior and posterior GS (see Fig. 8), and another patient presenting an asymmetric excessive unilateral anterior GS resulting from excessive contraction of the right-side upper lip elevator muscles (see Fig. 9).

CLINICS CARE POINTS

Pearls
- Injection of BTX-A at specific target sites is a minimally invasive treatment alternative for the correction of GS
- This procedure is cost-effective
- Outcomes are effective and predictable

Pitfalls
- Esthetic results could be compromised when incorrectly injected or inadequate doses used
- Results are temporary

DISCLOSURE

Author has nothing to disclose.

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