FACIAL PLASTIC SURGERY CLINICS OF NORTH AMERICA

Facial Plast Surg Clin N Am 11 (2003) 477-482

Adjunctive applications for botulinum toxin in facial aesthetic surgery

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On a cold Sunday in March of 2003, the New York Times ran a front-page article entitled "Wrinkles Gone? New Uses Studied for Botox". In that article Dr. Jean Carruthers compared Botulinum toxin (Botox) with penicillin for its versatility against a wide range of ills, and also because it too is an organic product derived from a common bacterium. Although it is probably premature to declare Botox the penicillin of the twenty-first century, in the last several years it has been put to some startling new uses. Botox is well-established in the treatment of migraine headaches, vocal dysphonia, and axillary hyperhydrosis. However, in medical institutions around the country, botulinum toxin is being used to treat everything from clubfoot to back pain to carpal tunnel syndrome. Moreover, scientific studies are underway to examine its use in treating gastric ulcers, urinary incontinence, and morbid obesity.

In facial aesthetics, botulinum toxin has firmly established itself as one of the premier nonsurgical therapies. Botox use for treating rhytids on the upper face is unparalleled, whereas more recently it is being used for treating lower facial rhytids. Botox is now being used as an adjuvant to many surgical and nonsurgical aesthetic procedures. This article examines these uses and reviews the current medical literature. Specifically Botox is reviewed regarding its adjunctive uses in laser resurfacing, endoscopic forehead lifting, scar revision, eyelid reconstruction, and with filler materials.

Laser Therapy

In 1983, Anderson and Parish [1] described the theory of selective photothermolysis which revolutionized cutaneous laser therapy by producing a method of localized thermal damage. Carbon dioxide lasers were now able to deliver char-free ablation with site specific target injury. In the late 1990s the long-pulsed Erbium:YAG laser gained popularity as a method of skin resurfacing. The Erbium's wavelength at 2940 nm is 10 times more selectively absorbed by water, which results in less residual thermal damage, and, consequently, decreased postoperative erythema. Later developments in Erbium laser technology led to the combination of ablative and coagulative pulses, which allowed for deeper vaporization and hemostasis with controlled tissue coagulation. More recently, short-pulsed Erbium technology has been used in a "nonablative" manner in which the laser beam penetrates through the epidermis and results in dermal collagen remodeling. Another form of nonablative therapy is the intense pulsed light (IPL) systems, which are high intensity light sources that emit polychromatic light. These new, nonablative technologies result in minimal to no down time, and can be used on patients who have darker skin types. Although nonablative technology is encouraging, initial results have shown modest improvement; however, in the future nonablative lasers may play a larger role in photorejuvenative therapy.

The etiology of facial rhytids is multifactorial. Static rhytids are caused by environmental factors, genetics, and skin type, whereas dynamic rhytids are caused by the repetitive action of facial muscle expression. A target directed approach toward complete facial rejuvenation is to use laser resurfacing for the static component and botulinum toxin to soften the dynamic component. The cosurgical use of Botox in laser resurfacing procedures reduces dynamic muscle activity which prevents disturbances of the newly-deposited lamellar dermal collagen. This combined therapeutic approach may not only create an added benefit toward facial rejuvenation but may create a synergistic one as well [2,3].

The areas that have been shown to be most amenable to laser resurfacing include the cheek and periorbital regions [4]. Many patients who undergo laser resurfacing experience premature recurrence of rhytids at specific anatomic subsites [5]. Such subsites, crow's feet, horizontal forehead furrows, and glabellar frown lines, are areas of long-term muscle animation and produce hyperdynamic facial lines. Although histologic studies have confirmed that neocollagen formation is associated with laser resurfacing, it seems that fibroplasia cannot overcome the forces of chronic animation of these movement-associated rhytids [6,7]. Immediately following laser resurfacing, hyper-dynamic rhytids, as well as static rhytids, often resolve. Studies showed clinical improvement of nonmovement-associated rhytids to be as high as 94%, whereas hyperdynamic facial lines improved an average of 45% to 85% and generally recurred within 6 to 12 months [4,8].

Initial anecdotal clinical experience suggested that skin pretreated with Botox before laser resurfacing healed in a smoother, wrinkle-free fashion [2,3]. Fagien [9] reported "enhanced" laser results, especially in the crow's feet region, in patients who were treated with Botox before resurfacing. He suggested that pretreatment with Botox may improve the smoothing of newly resurfaced skin long enough to effect "more permanent eradication of wrinkles." Carruthers and Carruthers [10,11] treated four female patients asymmetrically with Botox before CO_2 laser resurfacing. They reported patient "satisfaction" was higher in the Botox-pretreated side. Furthermore the recurrent crow's feet were "coarser, thicker, and more obvious" on the nonpretreated side. They noted deterioration of the Botox-pretreated side at approximately 10 months. However, West and Alster [12] reported on the effects of Botox on movement-associated rhytids after CO, laser resurfacing. They reviewed 20 patients who underwent Botox therapy 1 to 3 months after resurfacing was complete. They found prolonged correction of rhytids if Botox was instituted during the postoperative period. Without such treatment, they claimed return of most movement-associated rhytids within 6 to 12 months. Zimbler et al [13] performed the first prospective, randomized, blinded trial in which Botox was shown to significantly improve laser resurfacing results. In this study, 10 patients had one side of the face treated with Botox before laser resurfacing. Results showed statistically significant improvement in the side that was pretreated with Botox compared with the non-treated side (Fig. 1). The crow's feet region showed the area of greatest improvement. For optimum results, the investigators recommended continued Botox maintenance postoperatively. Currently, Carruthers [14] is examining the use of Botox in combination with nonablative technology. In a recent study, two randomly selected groups of 15 patients each were given either a full face IPL treatment or a full face IPL treatment in conjunction with Botox to the crow's feet region. After five IPL treatments all subjects showed dramatic clearing of lentiges and telangiectasia with marked improvement in skin

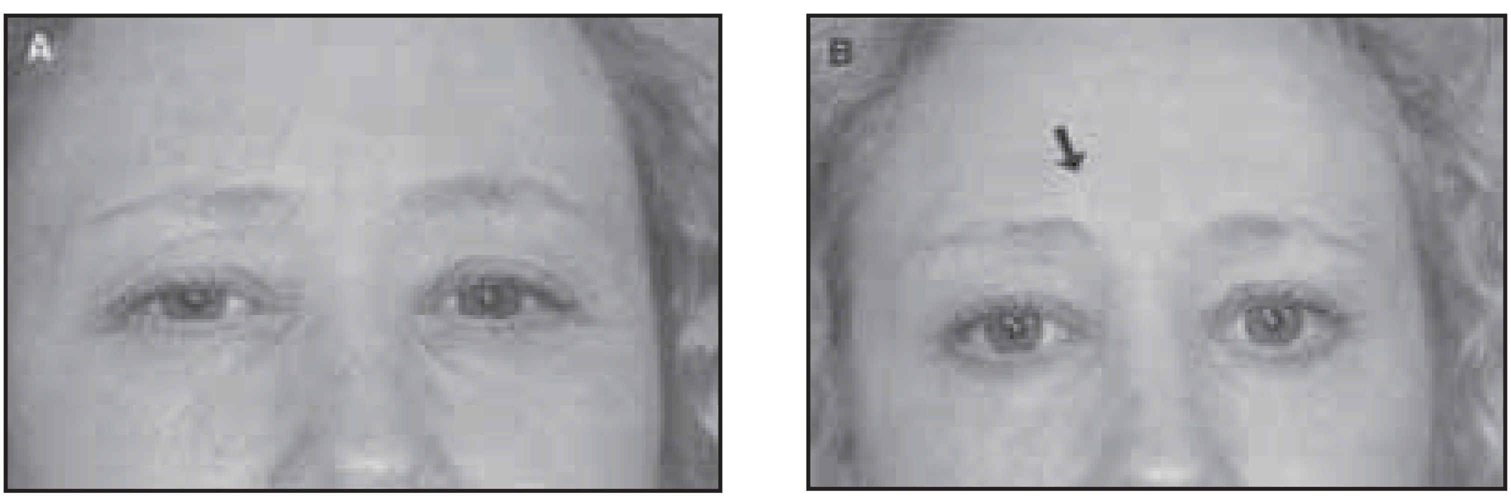

Fig. 1. (A) Glabellar frown lines before laser treatment. (B) Six-month postlaser results. Patients right glabellar lines were treated with Botox before laser resurfacing. (See also Color Plates 6 and 7).

tone and diminution of skin pores. The group that received IPL and Botox showed enhanced improvement in the resting and dynamic crow's feet.

Endoscopic forehead surgery

For years, surgeons have been amazed at the tenacity of the forehead musculature, and, in turn, their rhytids. Well before endoscopic procedures, surgeons complained of postoperative return of muscle activity. Even with open techniques, and despite aggressive and meticulous myotomies and myectomies, surgeons found return of muscle function. Botulinum toxin, despite its transient affects, has clearly established itself at the forefront of correcting forehead rhytids. Recent increased understanding of forehead muscular anatomy and physiology led to expanded uses for Botox. By chemically paralyzing forehead depressor muscle activity (corrugator, procerus, depressor supercilli, and supraorbital orbicularis oculi) one can achieve brow elevation, which has been termed a "chemical brow lift" [15,16].

Over the past decade, endoscopic forehead surgery has become the preferred operative technique. Although minor modifications in the basic principles have occurred since its first description, the only ongoing source of controversy is the method of brow fixation. Accepted methods widely vary and range in level of complexity. Proposed techniques include titanium screws, suspension sutures, bone tunnels, resorbable plates, fibrin glue, or no fixation at all. At the heart of this debate is the time that is required for periosteal fixation to occur. Scientific studies demonstrated that periosteal reattachment takes between 6 and 12 weeks to occur [17,18]. Botox is now being used in conjunction with endoscopic forehead surgery to weaken the brow depressors and promote maintenance of the postsurgical brow position. By paralyzing the inferior vector forces for 3 months postoperatively, the entire debate regarding periosteal reattachment and fixation becomes minimized.

In 2000, Dyer and Yung [19] were the first to describe botulinum toxin-assisted surgical brow lifting. Two weeks before surgery all patients were injected with Botox to block the depressor function of the suprabrow musculature (Fig. 2). Lateral brow fixation is accomplished with galea to temporalis sutures, whereas no central fixation is used. They followed 20 patients who underwent this procedure and monitored the postoperative results for up to 2 years. They concluded maintenance of lateral brow position with improvement of the medial brow.

Similar to Dyer and Yung we have shown, in 70 patients with more than a 2-year follow-up, that brow elevation may be achieved and maintained without central fixation [20]. Combining targeted Botox treatment with temporal fixation and complete periosteal release has resulted in long term brow correction (Fig. 3). Two weeks before surgery, the brow depressor musculature is chemodenervated with Botox. Each supraorbital orbicularis oculi is treated with 4 units (8 units total) (Fig. 4). The glabellar musculature, consisting of corrugator, procerus, and depressor supercili muscles, are treated with 20 units of Botox. Complete periosteal release from lateral orbital rim to lateral orbital rim, thorough depressor musculature myotomies, followed by temporal fixation, are the primary steps of the endoscopic-assisted browlift. The key to obtain a natural-looking brow is to create a temporal incision parallel to the tail of the brow with its medial extent at the temporal conjoint tendon border. The temporal incision orientation will help elevate the lateral half of

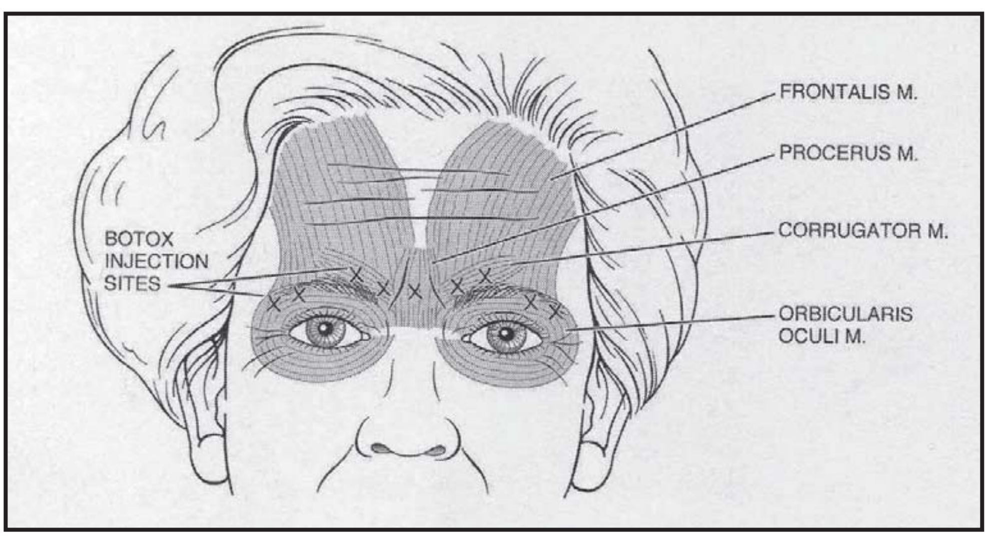

Fig. 2. Hyperdynamic forehead lines with underlying musculature. Endoscopic browlift Botox pretreatment sites (X) are in the corrugator, procerus, and supraorbital orbicularis oculi. Injections block depressor function of suprabrow musculature only.

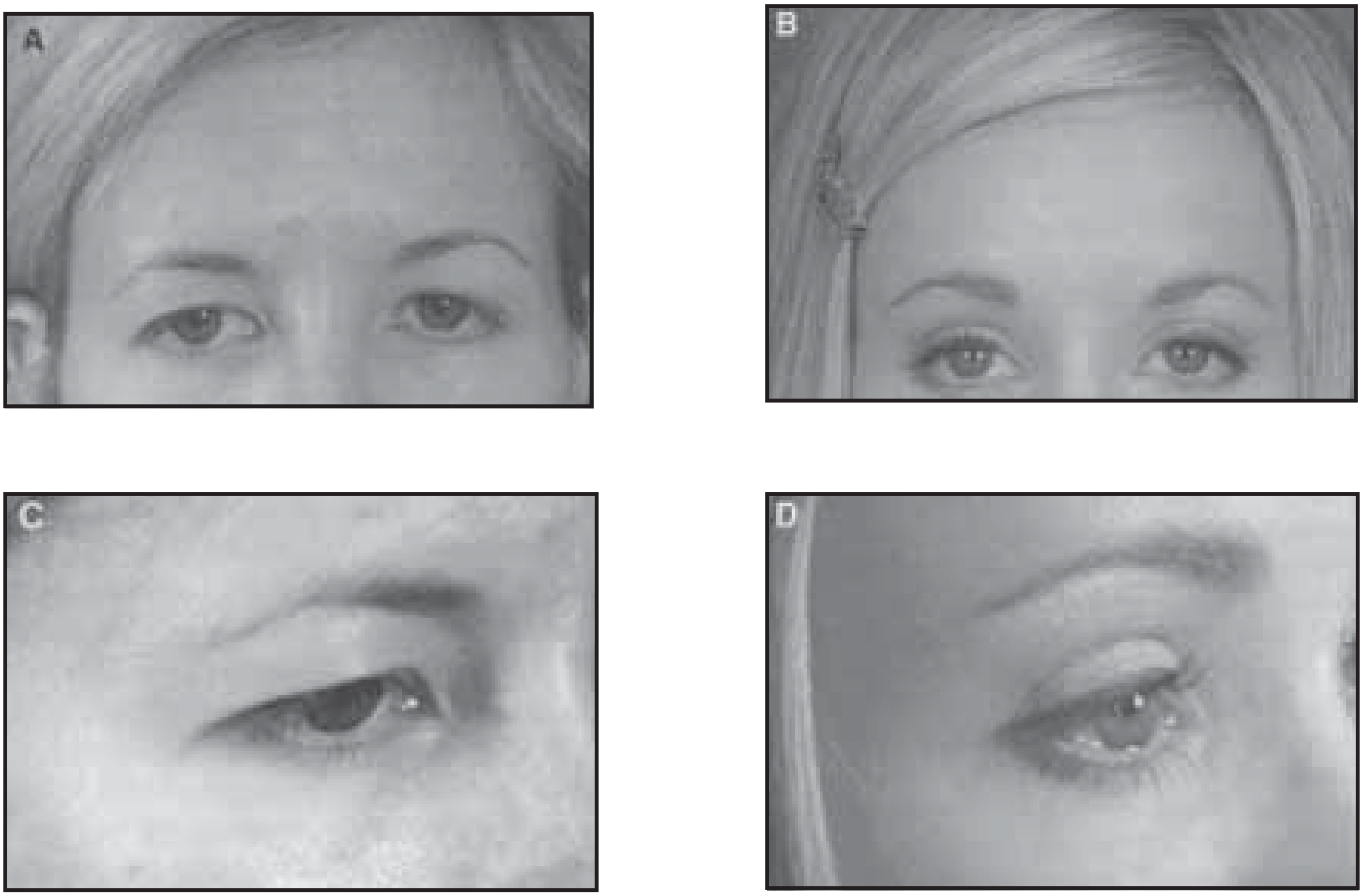

Fig. 3. (A) Thirty-two-year-old woman before surgery with ptotic brow position. (B) One year postendoscopic browlift and upper eyelid skin pinch blepharoplasty. No central fixation was used, just preoperative Botox treatment combined with temporal fixation and complete periosteal release. (C) Preoperative close-up. (D) Postoperative close-up. (See also Color Plates 8-11.)

the brow in a superolateral vector. Additionally, the medial brow will automatically elevate approximately 4 to 10 mm by performing the periosteal release alone. Pretreatment with Botox allows the periosteum to readhere without downward pull because the brow musculature has been chemodenervated. Because there are anec dotal reports of glabellar musculature reanastomos¬ing following myotomies, Botox may prevent this from occurring following the procedure because the depressors have been chemically denervated.

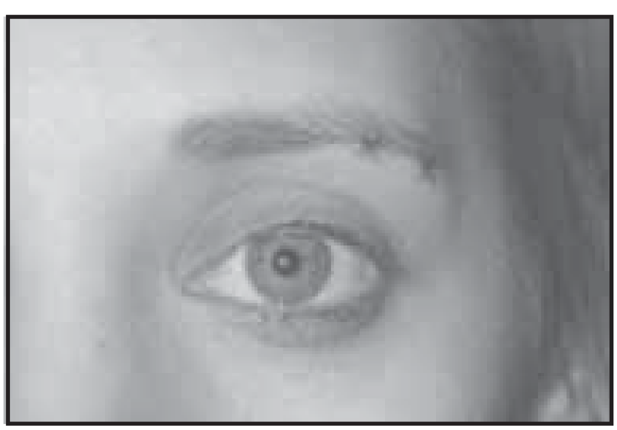

Fig. 4. Supraorbital orbicularis oculi Botox injection sites (X). Two injections totaled 4 units. (See also Color plate 12.)

Paralleling the gained popularity of endoscopic surgery over the past decade, is the use of fibrin glue sealants and platelet-rich plasma. These biologic products mimic the pathway of the coagulation cascade and stimulate key features of wound healing. Recently, several investigators reported good results using fibrin glue as the sole method of central fixation for endoscopic forehead surgery, providing adequate periosteal release [21,22]. Recently, Dyer [23] incorporated fibrin glue in his Botox-assisted surgical brow lift by placing it centrally to enhance early periosteal fixation [23].

Scar revision and eyelid reconstruction

Early works by Cloquet and Dupuytren laid the foundation for improved scar formation. In 1861, Karl

Langer, a Viennese professor of anatomy, created a map of cutaneous lines in cadavers that are known as Langer's lines. The modern concept of relaxed skin tension lines (RSTL) was derived from Borges [24] who based his work on that of Langer. One of the greatest factors that determines the final cosmetic appearance of a cutaneous scar is the tension that acts on the wound edges during healing. Critical to this is the alignment of the incision on the skin so that tension along the wound is diminished.

Carefully planned surgical incisions frequently achieve the best cosmetic result. Various techniques, such as placing scars parallel to RSTLs, using local flaps, or undermining wound edges, are applied to reduce excessive tension on incisions. Wound immobilization is a basic principle for proper wound healing and suture materials minimize the negative effect of muscle tension on healing tissue. The dynamic musculature of the face is in constant movement and can impede healing following facial surgery. Various techniques minimize, rather than eliminate, the tension acting on the healing wound. Repeated microtrauma that is caused by the continuous displacement of injured tissue induces a prolonged inflammatory response, which may lead to increased extracellular deposition of collagen and hypertrophic scarring. One way to eliminate some of the forces that work against wound healing is to decrease tension that is caused by local muscle contraction. Botox-induced temporary paralysis of the muscles that underlie a wound may be used to minimize tension across wound edges.

Gassner et al [25] examined the cosmetic results of facial wounds in primates who were treated with botulinum toxin. They found that the cosmetic appearance of unfavorably-oriented cutaneous scars was improved by pharmacologic chemodenervation of the surrounding tissue. Later, these same investigators applied this principle to human studies [26], which resulted in similar conclusions. They found that Botox improved scar formation, particularly during scar revision surgery or during the repair of traumatic lacerations with unfavorable cutaneous orientations.

In 1997, Choi et al [27] reported on 11 high-risk patients who underwent Botox therapy to promote wound immobilization while undergoing complex eyelid reconstruction. They found improved wound healing in the Botox-treated wounds than with simple tarsorrhaphy alone. Fagien and Brandt [28] recommend Botox injections when performing lateral canthal suspension procedures, such as the lateral tarsal strip or lateral retinacular suspension. Botox reinforcement around the lateral canthus, similar to the treatment for crow's feet, reduced local orbicularis function, which may compromise the position and security of the lateral canthus with repeated muscle contraction.

Filler materials

Another useful adjunctive application of Botox is for patients who are undergoing soft tissue augmentation, specifically, when planning lip augmentation procedures and the treatment of glabellar furrows. Botox is administered approximately 1 week before augmentation therapy and seems to have a synergistic affect [28]. Injection of the dermal filler, subdermal fat, or surgical implant is placed into the paralyzed or muscularly weakened area. The muscle denervation serves several purposes, which may explain this synergism. Firstly, it eliminates or reduces the dynamic muscular component of rhytid formation. Secondly, it may reduce microextrusion at the injection site by repetitive muscle action. There is also some theoretic suggestion that denervation may increase the longevity of the injected material by reducing the mechanical influence on the implant. This can be seen by weakening the medial brow depressors before administering collagen or fat to the glabellar region. This enhancing affect can also be demonstrated by weakening the lip elevators before soft tissue augmentation of the nasolabial fold. Regarding upper and lower lip rejuvenation, fine perioral wrinkles can be effaced with the careful administration of Botox to the vermilion border. Lower dosages (1.25 units/0. I mL in four separate injections) of Botox must be applied to avoid complications of lip dysfunction. After treatment to the upper lip, softening of rhytids can cause slight eversion or pseudoaugmentation at the vermilion border. This affect, coupled with intradermal lip augmentation, can result in a dramatic and enhanced result.

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