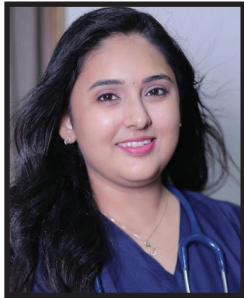


Botulinum Toxin Type A for Forehead Rejuvenation: Clinical Evaluation and Treatment Outcomes



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Abstract

Facial aging is a progressive and multifactorial process characterized by the development of folds, ridges, and wrinkles resulting from structural and functional decline within the skin. Forehead rhytides are among the earliest and most prominent manifestations of facial aging and are primarily caused by repetitive contraction of the frontalis muscle. Botulinum toxin type A is widely used for the management of dynamic facial rhytides through localized chemodenervation and reduction of excessive muscle activity. Appropriate patient selection, anatomical assessment, individualized treatment planning, and precise injection technique are essential for achieving balanced and satisfactory outcomes while minimizing complications. Clinical assessment includes evaluation of the forehead at rest and during active facial expression, standardized photography, wrinkle-severity grading, and assessment

of frontalis muscle activity. Treatment involves appropriate botulinum toxin formulation and preparation, precise injection-site selection, post-procedure care, and follow-up. Botulinum toxin provides a minimally invasive and predictable approach for the management of dynamic forehead rhytides, with rapid onset of action, low downtime, and high patient satisfaction.

Keywords: Botulinum toxin type A, forehead rhytides, facial rejuvenation, frontalis muscle, dynamic wrinkles

Introduction

Skin aging is a progressive and multifactorial process characterized by the development of folds, ridges, and wrinkles resulting from structural and functional decline within the skin. It occurs due to the interplay of intrinsic factors such as genetic influences, cellular metabolism, and hormonal changes and extrinsic factors

including ultraviolet radiation, environmental pollutants, and chemical exposure. With advancing age, reduced fibroblast activity, decreased collagen synthesis, and diminished dermal vascularity contribute to loss of elasticity and increased skin laxity. Intrinsic aging manifests as fine wrinkles, dryness, and reduced elasticity, whereas extrinsic aging, particularly photoaging, accelerates these changes through environmental damage. Hormonal alterations further impair collagen production, hydration, and barrier function, with progressive disorganization of collagen and elastin fibers playing a central role in wrinkle formation.¹

Botulinum toxin is a versatile agent widely used in both therapeutic and aesthetic practice. Clinically, it is indicated for conditions such as chronic migraine, spasticity, cervical dystonia, and detrusor overactivity, while in cosmetic dermatology it is extensively utilized for the management of facial lines and wrinkles. Derived from *Clostridium botulinum*, it exists in multiple serotypes A, B, C, D, E and G, of which types A and B are used clinically. Type A formulations are most commonly employed due to their well-established efficacy and safety profile.³

In addition to neuromuscular disorders, botulinum toxin has demonstrated benefit in conditions such as strabismus, hypersalivation, and certain chronic pain syndromes, particularly in patients who do not respond adequately to conventional therapies. Its therapeutic effect is primarily

attributed to localized muscle relaxation, resulting in reduction of excessive or abnormal muscle activity.⁴

Forehead rhytides represent one of the earliest and most prominent manifestations of facial aging, presenting as horizontal lines caused by repetitive contraction of the frontalis muscle. These lines initially appear during facial expression as dynamic wrinkles but may become static over time due to dermal matrix degradation, reduced collagen synthesis, and loss of skin elasticity.¹

Clinically, forehead lines vary in depth, length, and distribution, ranging from fine superficial creases to deeper, well-defined furrows. Their presentation is influenced by individual muscle activity patterns, skin characteristics, and facial morphology. These features are often associated with an appearance perceived as fatigued, aged, or stressed, thereby impacting aesthetic perception and self-image.¹

The development and progression of forehead rhytides are further influenced by intrinsic aging, genetic predisposition, and environmental factors such as chronic ultraviolet exposure. Lifestyle habits, including smoking and repetitive facial expressions, contribute to accelerated wrinkle formation. Additionally, the broad anatomical distribution of the frontalis muscle from the eyebrows to the hairline results in variability in muscle strength and function, leading to heterogeneity in clinical presentation.¹

Beyond physical changes, forehead rhytides can have a notable psychosocial impact. Visible lines are often subconsciously associated with negative emotional states such as fatigue or stress, which may not reflect the individual's actual condition. This misperception can affect social interactions, diminish self-confidence, and influence overall quality of life.¹

Mechanism of Action

At the molecular level, botulinum toxin acts through a multi-step mechanism involving binding to presynaptic cholinergic nerve terminals, internalization, and enzymatic cleavage of SNARE proteins, including SNAP-25, VAMP, and syntaxin. This process inhibits acetylcholine release at the neuromuscular junction, leading to temporary chemodenervation and decreased muscle contraction. Although its primary action is localized, emerging evidence suggests potential indirect effects on central neural pathways, further contributing to its therapeutic applications.²

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Diagnostic and Pre-Procedural Evaluation

The diagnosis of horizontal forehead rhytides is primarily clinical and is based on a comprehensive assessment of facial morphology and muscle activity. Clinical examination involves evaluation of the forehead both at rest and during active facial expressions, particularly eyebrow elevation, to differentiate dynamic

from static lines. This helps determine the contribution of the frontalis muscle and assess wrinkle depth, distribution, and symmetry, which are essential for confirming the diagnosis and guiding management.⁵

Standardized clinical photography using high-resolution two-dimensional imaging plays an important supportive role by documenting baseline findings and enabling objective comparison over time. In addition, validated photonumeric grading systems, such as the Allergan Forehead Lines Scale, assist in quantifying wrinkle severity and improving reproducibility of clinical assessment.⁵

Dermoscopy has a limited but supportive role in this condition. It may be used to evaluate superficial skin texture, fine lines, and early elastotic changes, particularly in cases where photoaging is a contributing factor. Although it is rarely used as a primary diagnostic tool for rhytides, it provides valuable complementary information and enhances the overall assessment of associated cutaneous changes.⁵

Imaging techniques, including three-dimensional skin imaging and optical profilometry, allow objective measurement of wrinkle depth and surface topography. These modalities are mainly used in research or advanced aesthetic settings to provide precise quantification of skin changes and to monitor treatment outcomes.⁶

Adjunctive functional assessment using electromyography (EMG) can evaluate the activity of

the frontalis muscle and its relationship with eyebrow movement. This method helps in understanding muscle dynamics and may support diagnosis in complex or research-based evaluations.⁷

Laboratory investigations are generally reserved for selected cases and may be considered when underlying systemic or hormonal contributors to premature aging are suspected, as forehead rhytides are primarily a clinical and structural condition.⁵

Treatment Protocol

Indications

Botulinum toxin injections represent the most frequently performed cosmetic procedure worldwide. It is commonly performed to chemically denervate certain muscles of facial expression for the purposes of facial rejuvenation and anti-aging. Facial rhytids, or “wrinkles,” result from repeated contracture of the muscle underlying the facial skin, which over time causes atrophy of the overlying dermis and pleating of the skin. Targeted chemodenervation of facial musculature enables precise management of dynamic rhytids, especially in the upper facial region.^{8,9}

Cosmetic botulinum toxin injections are indicated for upper facial rhytids, including frown lines, horizontal forehead lines, and crow's feet, as well as facial asymmetry and gender-specific facial modulation. It is preferred for dynamic rhytids with optimal response; static wrinkles show limited improvement and may require combination therapy. Target

muscles include orbicularis oculi, procerus, corrugator supercilii, and frontalis.^{8,9}

Contraindications

Botulinum toxin is contraindicated in neuromuscular disorders including amyotrophic lateral sclerosis, Lambert-Eaton syndrome, multiple sclerosis, and myasthenia gravis; hypersensitivity to constituents; active infection or dermatosis at the injection site; body dysmorphic disorder; and unrealistic expectations, with caution in pregnancy, breastfeeding, and keloidal scarring.^{8,9}

Patient Selection and Pre-Procedure Assessment

Pre-procedure assessment requires knowledge of facial musculature and rhytid formation, with rhytids and skin tension lines perpendicular to muscle fibers. Aesthetic consultation includes clinician–patient evaluation with a handheld mirror to identify concerns, assess asymmetry, and set treatment goals with discussion of outcomes and complications. Standardized photographic documentation is recommended. Patients should stop aspirin and other anticoagulants/supplements two weeks prior to reduce bruising risk; anesthesia is generally not required.^{8,9}

Botulinum Toxin Preparation

Selection of an appropriate botulinum toxin formulation requires consideration of factors such as molecular weight, presence of complexing proteins, excipients, and storage characteristics. Commonly used formulations

include onabotulinumtoxinA, abobotulinumtoxinA, incobotulinumtoxinA, and prabotulinumtoxinA.

Reconstitution is carried out using preservative-free 0.9% sodium chloride, typically in volumes ranging from 1 to 5 mL per 100 units of BoNTA, which may influence the degree of tissue diffusion. Syringes are prepared with the calculated dose, and injection sites are precisely marked under appropriate lighting conditions, with pre-procedure photographic documentation recommended.^{8,9}

Procedural Planning

The treatment objective is reduction of dynamic lines while preserving natural movement. Procedural planning should account for individual facial anatomy, frontalis activity, wrinkle distribution, and eyebrow position.

Injection Technique: Frontalis (Forehead Lines)

The frontalis muscle, the primary elevator of the upper face, originates from the galea aponeurotica and inserts into the subcutaneous tissue and deep dermis over the superciliary arch. Its contraction produces horizontal forehead rhytides, with patterns varying among individuals.

Injections are placed approximately 1–2 cm above the orbital rim and extended laterally up to 2 cm beyond the lateral brow tail to minimize the risk of brow ptosis and excessive lateral brow elevation. The lateral extent corresponds to approximately 1 cm lateral to the superior temporal crest, and medial injections alone may be

insufficient for lateral forehead lines due to limited diffusion.^{8,9}

Post-Procedure Care

The procedure is well tolerated. Patients should avoid rubbing, massaging, or applying pressure to treated areas and refrain from strenuous activity for 24 hours, while routine activities may be resumed immediately. Monitoring for adverse effects such as bruising, swelling, ptosis, or asymmetry is recommended.^{8,9}

Follow-Up

Follow-up evaluation guides the need for repeat treatment based on individual response and muscle activity. Clinical effects may become evident within 24–72 hours, followed by peak response and a limited duration of action.^{8,9}

Outcome Assessment

Outcomes are assessed using standardized photography, dynamic facial evaluation, and patient-reported measures. These assessments allow evaluation of treatment response and facilitate comparison during follow-up.^{8,9}

Clinical Outcome / Results

The clinical outcome was documented using standardized before-and-after clinical photography.



Before Treatment



After Treatment

Figure 1: Forehead Lines treated with Botulinum toxin Type A

Discussion

Botulinum toxin (BoNT) remains the most commonly performed aesthetic procedure globally and is widely utilized across adult populations. Its increasing demand is driven by aging demographics as well as a growing emphasis on preventive aesthetic interventions among younger individuals aimed at delaying the onset of dynamic rhytids. BoNT offers a precise, minimally invasive, and reliable approach to facial rejuvenation, thereby establishing itself as a fundamental modality in aesthetic practice.^{8,10}

A wide spectrum of alternative therapies is available for wrinkle management, each targeting different aspects of the aging process. Topical agents such as retinoids (e.g., tretinoin, adapalene) enhance collagen production and epidermal turnover, while antioxidants including vitamins C and E and coenzyme Q10 mitigate oxidative damage and photoaging. Peptides contribute

modestly to collagen and elastin synthesis, and alpha- and beta-hydroxy acids facilitate exfoliation and skin renewal. Hyaluronic acid-based moisturizers improve hydration and transiently enhance skin turgor.^{8,10}

Minimally invasive procedures serve as adjuncts or alternatives to BoNT. Dermal fillers, including hyaluronic acid, calcium hydroxylapatite, and poly-L-lactic acid, address volume loss, correct static wrinkles, and improve facial contours. Chemical peels promote epidermal regeneration and reduce fine lines, while microneedling, with or without platelet-rich plasma, stimulates neocollagenesis and enhances skin elasticity. Energy-based modalities such as ablative and non-ablative lasers, as well as intense pulsed light, facilitate dermal remodeling, improve pigmentation irregularities, and reduce superficial wrinkles. Radiofrequency and ultrasound-based devices, including Thermage and Ultherapy, induce collagen contraction and tissue tightening. Combination approaches often produce synergistic and more comprehensive outcomes. Surgical interventions, including rhytidectomy, blepharoplasty, and brow or forehead lifts, provide definitive correction for advanced aging changes but are invasive and associated with increased downtime and procedural risk. Lifestyle modifications—such as photoprotection, smoking cessation, adequate nutrition, hydration, and minimizing repetitive facial movements—support skin health but have

limited impact on established dynamic wrinkles.^{8,10}

In comparison, BoNT offers distinct advantages. It provides rapid onset of action, targeted reduction of muscle activity, minimal invasiveness, low downtime, and reversible effects. It is particularly effective for dynamic rhytids, as it directly addresses the underlying cause—muscle overactivity—unlike topical therapies and energy-based devices. Compared to dermal fillers, which correct volume deficits, BoNT specifically improves motion-related wrinkles. In contrast to surgical procedures, it allows a controlled, titratable approach with a significantly lower risk profile and quicker recovery.^{8,10}

Complications associated with cosmetic BoNT use are infrequent and typically mild and transient. These include injection-related reactions such as ecchymosis, erythema, edema, tenderness, pain, headache, vasovagal responses, and rarely infection or paresthesia, as well as toxin-specific effects including hypersensitivity or antibody formation. Appropriate patient selection, meticulous technique, and accurate dosing are essential to minimize untoward effects.

Overall, BoNT provides a targeted, minimally invasive, and predictable approach for the management of dynamic facial wrinkles, delivering consistent, natural-looking results with high patient satisfaction, particularly in the treatment of forehead lines and crow feet, and continues to serve as a cornerstone of

modern aesthetic practice.^{8,10}

Advantages

Botulinum toxin injection is a minimally invasive procedure with predictable outcomes, high patient satisfaction, and a favorable safety profile. It induces targeted chemodenervation, resulting in muscle relaxation and reduction of dynamic rhytids, with limited effect on static wrinkles. Clinical effects appear within days, and repeated treatments may prolong duration without loss of efficacy.^{8,9}

Limitations

The temporary nature of the treatment effect and the limited response of static wrinkles represent important limitations of botulinum toxin treatment. Static wrinkles may require combination therapy, while repeat treatment may be required according to individual response and muscle activity. These considerations should be discussed during treatment planning.

Complications and Risk Management

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Conclusion

Botulinum toxin type A remains a highly effective and reliable treatment for dynamic forehead rhytides, offering predictable aesthetic improvement with preservation of natural facial expression when administered appropriately. Detailed anatomical assessment, individualized dosing, and precise injection technique are essential to achieve balanced and satisfactory outcomes. Overall, a patient-centered approach integrating clinical expertise with aesthetic judgment is crucial for optimizing results and enhancing patient

satisfaction in cosmetic dermatology practice

Declarations

Patient Consent

Written informed consent was obtained from the patient for the procedure and for publication of the clinical photographs accompanying this article.

Conflict of Interest

The author declares no conflict of interest.

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Author Contributions

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Ethics Approval

Ethics approval was not required for this individual procedural case.

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