Modifications of Eyebrow Position With Botulinum Exotoxin A

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Objective: To determine if clinically used botulinum exotoxin A (Botox) injections to the forehead and glabellar and crow’s-feet regions result in modifications of eyebrow position.

Design: Prospective study.

Setting: Academic medical center in St Louis, Mo.

Subjects: Twenty-nine adult patients treated with botulinum exotoxin A injections for rhytids.

Intervention: The eyebrow position at 13 different sites was measured before injection and 2 weeks after treatment. The areas injected were based on patient preference and physician assessment. Of the 29 patients, 14 received injections into the glabella only and 15 received injections into the glabella and forehead, with or without treatment of the crow’s-feet.

Results: In 29 patients at rest, we found no significant (P value range: .17 to .97) change in eyebrow position, except for a point depression at the right lateral eyebrow. The 15 patients who received injections into the forehead and glabella, with or without treatment of the crow’s-feet, had no significant (P value range: .11 to .84) change in eyebrow position, except for a point depression at the left medial eyebrow. Both groups exhibited eyebrow depression in the active state (eyebrow maximally elevated).

Conclusions: Botulinum exotoxin A injections into the forehead and glabellar, and crow’s-feet regions did not significantly change the resting eyebrow position. However, forehead injections contributed to eyebrow depression in the active state.

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Botulinum exotoxin A injection doses and sites were selected based on the typical injections used for treatment of the upper third of the face in our practice (Figure 2). For treatment of the forehead, 5 injection sites were used, with 4 U per injection, for a total of 20 U. Three 5-U injections were used to treat the glabella, for a total of 15 U. Each lateral orbital region was injected at 2 sites, with 4 U each, for a total of 16 U to treat the bilateral crow’s-feet regions.

Statistical analyses were performed using SAS statistical software, version 6.12 (SAS Institute Inc, Cary, NC). Observations were paired measurements of the distance before and after treatment with botulinum exotoxin A; therefore, we used a paired t test in our statistical analysis. Posttreatment measurements were subtracted from pretreatment measurements, and the average difference was tested using a null hypothesis that the average difference was 0. We performed one statistical test for each of the 13 sites for the entire sample and for the subsample of 15 patients who received injections into the forehead and the glabella. Results were considered significant if \( P < .05 \).

RESULTS

We first tested whether modifications in eyebrow position could be detected for resting positions. In all 29 patients at rest, only the right lateral eyebrow elevation (position AR in Figure 1) was significant (mean, \(-1.34 \text{ mm}; P = .006\) (Figure 3). There was no significant (\( P \) value range, .17 to .97) change in intereyebrow or other eyebrow distances. In the subsample of 15 patients who received injections into the forehead and glabella, with or without treatment of the crow’s-feet, the left medial eyebrow (position FL in Figure 1) was significantly depressed (mean, \(-1.87 \text{ mm}; P = .03\) (Figure 4). No other significant (\( P \) value range, .11 to .84) changes were found in other eyebrow positions or in the intereyebrow distance. A separate analysis of the 14 patients who received glabellar injections without forehead injections produced no significant (\( P \) value range, .18 to .73) changes in eyebrow position.

We did find significant (\( P \) value range, <.001 to .01) changes in eyebrow position for the active state, with the
This results in an improved cosmetic appearance. The primary functional upper facial rhytids include the glabellar frown lines, the horizontal forehead furrows, and the crow’s-feet. The medial frontalis, the procerus, the corrugator supercilii, and the medial orbicularis oculi muscles contribute to the glabellar frown lines. Contraction of the frontalis muscle causes the horizontal forehead furrows, and contraction of the lateral orbital portion of the orbicularis oculi muscles results in the crow’s-feet rhytids.

Eyebrow position is determined by underlying skeletal shape, resting muscular tone, and overlying skin tone. It is generally accepted that the eyebrow is elevated by the frontalis muscle and depressed by the procerus, the corrugator supercilii, and the orbicularis oculi muscles.1

In their retrospective study of 29 patients injected with 20 U of botulinum exotoxin A into the procerus and corrugator supercilii muscles, Frankel and Kamer3 found that 8 (32%) of 25 patients had an elevation of the medial eyebrow, 12 (48%) of 25 patients had an elevation at the mid pupillary eyebrow, and 17 (59%) of the 29 patients had an increase in intereyebrow distance with measurements from standardized photographs. A subjective comparison of the photographs by blinded observers found that 18 (62%) of the 29 patients have a higher medial eyebrow. Although this is not stated in their article, further interpretation of their results suggests that 17 (68%) of their 25 patients had either a depression or no change in medial eyebrow position, 13 (52%) of the 25 patients had either a depression or no change in mid pupillary eyebrow position, and 12 (41%) of the 29 patients had either a depression or no change in intereyebrow distance. Huilgol et al4 reported that 5 of 7 women patients had either a depression or no change in intereyebrow distance, and 12 (41%) of the 29 patients had either a depression or no change in medial eyebrow. Although this is not stated in their article, further interpretation of their results suggests that 17 (68%) of their 25 patients had either a depression or no change in medial eyebrow position, 13 (52%) of the 25 patients had either a depression or no change in mid pupillary eyebrow position, and 12 (41%) of the 29 patients had either a depression or no change in intereyebrow distance. They injected a total of 10 to 14 U into the glabellar region and the supralateral eyebrow, and measured from the mid pupillary line to the lowest portion of the eyebrow to make this determination. One difference from the present study is that the subjects in the study by Huilgol et al received lateral eyebrow injections. No statistical analysis was performed in either of these studies; therefore, the results should be interpreted with this in mind.

Ahn et al6 examined subjects with only injections to the supralateral eyebrow. The purpose of the injections was to produce an eyebrow-lift, not to treat rhytids. No injections were performed in the crow’s-feet area inferior to the lateral canthus. There was significant lateral and mid eyebrow elevation after supralateral eyebrow injection. The injection sites differ significantly from those in the present study; therefore, no direct comparisons can be made.

In our study, eyebrow position was assessed after injections of botulinum exotoxin A for cosmetic treatment of hyperfunctional facial rhytids on the upper third of the face. The 29 patients at rest had no statistically significant change in eyebrow position after injection, except in the right lateral eyebrow measurement. These same patients had a depression of the medial two thirds of the eyebrow in the active position. This change can be explained by the toxin’s effect on the frontalis muscle, the

eyebrow maximally elevated. For the 29 patients in the active position, the medial two thirds of the eyebrow (positions B, C, E, and F in Figure 1) were depressed (Figure 5). The numbers were bilaterally consistent, with absolute means ranging from 2.93 to 11.53 mm (P value range, <.001 to <.01). The subsample of 15 patients also had a depression of the entire eyebrow in the active position at all sites shown in Figure 1, except site A8 (Figure 6). Again, the effects were bilaterally consistent, with absolute means ranging from 2.93 to 11.53 mm (P value range, <.001 to <.01).

Functional facial rhytids result from tension of the underlying mimetic facial musculature on the overlying skin. Botulinum exotoxin A acts as a peripheral neuromuscular blockade and, thus, weakens the underlying muscles of facial expression, causing a flattening of the overlying skin.

Figure 5. All 29 patients with maximal elevation, showing a depression of the medial two thirds of the eyebrow (arrows).

Figure 6. The 15 patients who received injections into the forehead and glabella in the active position had a depression of the entire eyebrow (arrows), except at the right lateral eyebrow position.
only eyebrow elevator. In patients who received injections into the forehead and the glabella, with or without crow's-feet injections, there was significant change in eyebrow position at rest, except for the left medial eyebrow measurement. These patients also had a depression of the eyebrow in the active eyebrow-raising position 2 weeks after injection, also explained by the botulinum exotoxin A effect on the frontalis muscle.

These results can be correlated with facial anatomical features. The corrugator supercilii muscle is situated in a horizontal or diagonal plane. The procerus is a vertical muscle, and the orbicularis oculi is a circumferential muscle. These eyebrow depressors, however, are relatively smaller in muscle mass than the frontalis muscle and, therefore, in most patients, contribute less to eyebrow elevation or depression than the frontalis muscle. The frontalis muscle inserts into the skin of the eyebrows and the nasal root. Therefore, botulinum exotoxin A injections at the eyebrow level will likely affect the most inferior portion of the frontalis muscle, in addition to the corrugator supercilii muscles. This relationship may explain the lack of eyebrow elevation with injections into the medial eyebrow area. The horizontal or oblique orientation of the corrugator supercilii muscle explains its dominant role in eyebrow medialization and its more minor role as an eyebrow depressor, creating the vertical wrinkles at the glabella. The 2 sites that showed a statistically significant change at rest, the right lateral eyebrow and the left medial eyebrow, may change with a larger sample size.

We found that it was more difficult to measure from the eyebrow to the hairline than from the eyebrow to the closed eyelid margin. The exact margin of the hairline was sometimes ambiguous and more difficult to reproduce at the 2-week follow-up. Despite this, the eyebrow-to-hairline measurements were generally confirmatory with respect to eyebrow position.

A subpopulation of subjects in this study (n=10) who were classified as hypertonic (defined in the pretreatment consultation as having clinically constant corrugator and/or frontalis muscle contraction) were not significantly different from the general population. This may be secondary to the small numbers in the subpopulation in our study. Another possible explanation is that the subjects were asked to purposely relax the upper third of their face for the resting measurements, which may have reduced their baseline muscular hypertonicity. Two of us (M.S.K. and D.A.G.) have clinically observed subjects who are hypertonic who have more exaggerated eyebrow position changes after botulinum exotoxin A injections. In other words, some patients who constantly raise their eyebrows, even at rest, have a dramatic depression in their resting eyebrow position after botulinum exotoxin A injection into the frontalis muscle. Further study of this subpopulation is warranted.

CONCLUSIONS

We present a prospective and statistically analyzed study of botulinum exotoxin A–induced effects on eyebrow position. We found that glabellar, including procerus, corrugator with or without depressor supercilii, and crow's-feet (lateral orbicularis oculi), injections did not significantly change resting eyebrow positions. Forehead injections resulted in depression of the eyebrow in the active state. This translates into a decreased ability for upward excursion of the eyebrow after injection into the forehead.

Our findings are important for patient counseling before injection with botulinum exotoxin A. While it may be possible to modify the eyebrow with botulinum exotoxin A injections, the resultant modification of the eyebrow position in the relaxed state is not consistently predictable. When treating the forehead for rhytids, the physician should modify the injections in a patient with a ptotic eyebrow to avoid further lowering of the eyebrow in the extended position. In other words, patients who constantly and actively raise their eyebrows will likely be perceived as having eyebrow ptosis after botulinum exotoxin A injections to the frontalis muscle, because their eyebrows will be relatively depressed. It is helpful in the pretreatment patient consultation to manually lift or depress the patient’s eyebrows to demonstrate the possible modification in eyebrow position and the varying degrees of resultant upper eyelid skin redundancy. This provides the patient with a better understanding of the possible aesthetic changes in the upper third of the face after botulinum exotoxin A injection.

This study suggests that botulinum exotoxin A injections to the upper third of the face do not universally lift the eyebrows. Based on this study and our review of the literature, botulinum exotoxin A may result in eyebrow depression, eyebrow elevation, or no change in eyebrow position. The resultant effect on the eyebrows is likely multifactorial, including the site(s) and dosage of injections, the extent of muscular paralysis, the state of muscle activity, and individual anatomical variations.

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REFERENCES