

Patterns of contraction of the frontalis muscle: a pilot study

Estudo piloto dos padrões de contração do músculo frontal

ABSTRACT

Introduction: Diverse anatomical characteristics and varied kinetic spectra determine the specific contraction patterns of individuals' frontal facial musculature.

Objective: To identify and classify the frontal facial musculature contraction patterns in patients who sought care for treating frontal facial wrinkles.

Methods: Retrospective analysis of pictures taken from 83 patients. The muscular contraction pattern was classified according to the predominant hyperkinetic area that was observed in the picture in the frontal muscle's maximum contraction.

Results: Three contraction patterns were identified: total, medial and lateral. In 50.6% of cases, the total pattern was observed: the horizontal rhytids present in the center of the forehead extend laterally beyond the mediopupillary line, up to the end of the brows. The medial pattern was observed in 25.3% of cases: the horizontal rhytids are concentrated in the central region of the forehead, predominantly contained between the mediopupillary lines. The lateral pattern was observed in 24% of the cases: the horizontal rhytids prevail on the sides of the forehead, mainly occurring laterally to the mediopupillary line.

Conclusions: The identification and classification of Frontalis muscle contraction patterns provides an individualized approach for each patient, which is one of the most important pillars of a successful treatment plan.

Keywords: botulinum toxin type A; muscle contraction; classification

RESUMO

Introdução: Características anatômicas distintas e espectros cinéticos variados determinam padrões de contração da musculatura frontal peculiares a cada pessoa.

Objetivo: Identificar e classificar os padrões de contração da musculatura frontal de pacientes que procuraram atendimento para tratamento de rugas frontais.

Métodos: Análise retrospectiva de fotografias de 83 pacientes. O padrão de contração muscular foi classificado de acordo com a área hiperkinética predominante, observada na fotografia em contração máxima do músculo frontal.

Resultados: Foram identificados três padrões de contração: total, medial e lateral. O padrão total foi observado em 50,6% dos casos. As rítmicas horizontais presentes no centro da fronte avançam lateralmente além da linha mediopupilar, até o final da cauda das sobrancelhas. O padrão medial foi observado em 25,3% dos casos. As rítmicas horizontais concentram-se na região central da fronte, contidas predominantemente entre as linhas mediopupilares. O padrão lateral foi observado em 24% dos casos. As rítmicas horizontais

predominam nas laterais da fronte, a maioria ocorrendo após a linha mediopupilar.

Conclusões: A identificação e classificação dos padrões de contração do músculo frontal permitem avaliação mais individualizada de cada paciente, o que é um dos pilares mais importantes para um plano terapêutico bem-sucedido.

Palavras-chave: toxina botulínica tipo A; contração muscular; classificação

Original Article

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INTRODUCTION

The face is an important element in inter-human communication, and its features convey personal characteristics, impressions, and information, such as health condition, emotions, and age.¹

Located in the upper third of the face, the frontalis muscle originates in the galea aponeurotica, below the coronal suture. Its insertion into the skin occurs in the superciliar region, and interlaces with the fibers of the procerus, corrugator, and orbicularis oculi muscles.² Being positioned vertically, it lifts the eyebrows, and is thus responsible for facial movements involving surprise, interest, or concern.^{1,3} However, with time, repeated contractions lead to the formation of horizontal wrinkles in the overlying skin. When such wrinkles persist – even in a resting state – or occur markedly during facial expression, they are known as hyperfunctional facial lines, and are usually seen as a sign of aging.^{1,4}

In 1990, Carruthers and Carruthers⁵ described for the first time the use of botulinum toxin type A for the correction of hyperfunctional glabellar lines for aesthetic purposes.

Ensuing scientific publications reported on the efficacy and safety of the botulinum toxin when treating frontal hyperfunctional lines.^{3,6}

According to Carruthers et al.,³ the use of botulinum toxin type A for the relaxation of the frontalis muscle poses a challenge – especially to less experienced physicians – due to variations in the structural and functional anatomy of that muscle. Diverse anatomical features and kinetic spectra determine frontal musculature contraction patterns that are unique to each person. The understanding of such individual patterns is instrumental when choosing the most appropriate application points, thereby providing patients with individualized approaches.

Nevertheless, descriptions found in the literature suggest a more classical application model^{3,7–10} that does not take into account interpersonal differences in contraction patterns, approaching the issue as if one technique could be applied to all patients.

With this in mind, the objective of the present analysis was to identify and classify the contraction patterns of the frontalis muscle according to the predominant hyperkinetic areas of patients who sought treatment for horizontal forehead wrinkles, suggesting the most appropriate application points for each pattern.

METHODS

This retrospective analysis of case studies was accomplished at the private clinic of one of the authors (AVB). The photographs of 83 randomly selected patients (72 women and 11 men; age 31–80, mean = 48) who sought treatment for horizontal forehead rhytids were evaluated. Clinic patients with a previous history of ablative (laser, peel, or dermabrasion), surgical, or filling treatments were excluded. There was no restriction regarding gender, age, or phototype. Two photographs of each patient (one with the forehead in a resting state and the other during maximum contraction of the forehead) were simultaneously analyzed.

Contraction patterns were subsequently identified and classified according to the predominant direction of the frontal region's hyperfunctional lines: hyperfunctional lines extending beyond the midpupillary lines, up to the end of the tail of the eyebrows, were classified as having a total pattern; those predominantly contained between the midpupillary lines were classified as having a medial pattern; and those predominantly occurring outside the midpupillary lines were classified as having a lateral pattern. Before the second photograph was taken, the patient was asked to repeat the maximum contraction movement three times, to make sure that such movements had been made in a standardized and most intense way. Camera adjustments, such as illumination and distance, were kept constant in the two photographs. The study complied with the Declaration of Helsinki, 2000 revision.

RESULTS

Three different patterns of frontal contraction were identified and classified as total, medial, and lateral, according to the predominant direction of the hyperkinetic lines observed in the 83 cases studied.

CLASSIFICATION OF FRONTAL CONTRACTION PATTERNS

Below are the descriptions of each pattern, their observed frequency, and suggestion of application sites for botulinum toxin type A.

Total pattern: The total pattern was observed in 42 cases (50.6%) and it is the most frequent contraction pattern. The horizontal rhytids presented in the center of the forehead and extended sideways beyond the midpupillary lines, up to the tails of the eyebrows. In this group there was no predominant pattern regarding the positioning of the brows. For patients showing this contraction pattern we suggest application points along the whole musculature, with higher doses of the toxin in the central area and smaller doses in the lateral areas (Figure 1). As the frontalis muscle is the only elevator muscle in the upper third of the face and is instrumental for the positioning of the eyebrows, we suggest that it should always be treated in conjunction with the glabella, whose muscles are depressors and antagonists to the frontalis muscle. Furthermore, we recommend that the application is administered 1.5 cm above the eyebrow, on the midpupillary lines, to avoid drooping (ptosis) of the upper eyelid the botulinum toxin should not reach the eyelid levator muscle.

Medial pattern: The medial pattern was observed in 21 cases (25.3%) and it is the second most frequent contraction pattern. The horizontal rhytids concentrate in the central region of the forehead, and are usually contained between the midpupillary lines. Due to this configuration, this is also known as the horizontal forehead wrinkles or 'Venetian blind' pattern. The rectified positioning of the eyebrows prevailed in this group, with eyebrow ptosis in some cases. For these patients we suggest one to three application points in the medial region of the forehead. When three points are used, the configuration of the



Figure 1 - Frontalis muscle total pattern of contraction. (A) Anatomy; (B) Patient in maximum contraction; and (C) Suggested distribution of points for toxin application



Figure 2 - Frontalis muscle lateral pattern of contraction. (A) Anatomy; (B) Patient in maximum contraction; and (C) Suggested distribution of points for toxin application



Figure 3 - Frontalis muscle medial pattern of contraction. (A) Anatomy; (B) Patient in maximum contraction; and (C) Suggested distribution of points for toxin application

markings should resemble an inverted triangle (Figure 2). We suggest avoiding applications outside the described area, due to the risk of either causing or accentuating eyebrow ptosis.

Lateral pattern: The lateral pattern was observed in 20 cases (24%). It is the contraction pattern which occurs less frequently. The horizontal rhytids are predominant in the lateral areas of the forehead, mainly outside the midpupillary lines. They occur in smaller numbers and with lower intensity, to the extent of not being present in the frontal medial region in some cases.

In this group, we observed the prevalence of the arched positioning of the eyebrows. For these patients we suggest appli-

cation points in the lateral areas, using low doses of toxin in order to avoid interfering with eyebrow movement. Usually, application points in the central area are not necessary (Figure 3).

We noticed asymmetry in 7.1% of cases of total pattern contraction, with this pattern showing prevalence of superior and inferior wrinkles, or of wrinkles in the left or right hemifrontal areas. Such variations should be taken into account when marking the points.

Asymmetry also occurred in 4.7% of cases of medial pattern contraction and in 5% of cases of lateral pattern contraction, with rhytids being predominant in either the left or the



Figure 4 - Suggested distribution of points for toxin application for asymmetrical patterns of contraction of the frontalis muscle. (A) Total pattern with the predominance of rhytids in the upper part of the forehead and in the right hemiface; (B) Medial pattern with the predominance of rhytids in the left hemiface; and (C) Lateral pattern with the predominance of rhytids in the right hemiface

right hemifrontal areas. Figure 4 shows the suggested application points for several types of asymmetry.

DISCUSSION

After nearly two decades from when botulinum toxin type A was first used for rejuvenation purposes, techniques for the relaxation of frontal musculature described in the literature still suggest classical models, suitable, however, only for patients who present uniform muscular activity in the whole forehead.

In 1974, while aiming to improve the results of surgeries used to repair facial paralysis, Rubin¹¹ described three modalities of smile, each being under the control of a muscle group. In 2003, Kane¹² classified women's periorbital rhytids into four groups, considering this classification key for individualized treatment. In 2010, Almeida et al.¹³ classified the patterns of glabellar wrinkles into five types, identifying the most important muscles in each of these patterns.

Using the experience acquired over the years, the authors observed that his patients presented different frontal musculature contraction patterns, each with specific application points that, in turn, led to improved aesthetic results. Therefore, the different contraction patterns recorded in his daily practice were organized and named in the present study as total, medial, and lateral patterns.

As facial hyperfunctional lines are formed on the muscle's hyperkinetic areas, a different application technique was suggested for each group. In addition, we observed that contraction pattern also correlates with eyebrow positioning. In patients showing the medial pattern there was prevalence of the rectified eyebrow type, while the arched type prevailed in patients with the lateral pattern of contraction. This appears to support the notion that a single technique cannot meet the different characteristics presented in all groups, and that an individualized approach is fundamental for a satisfactory result. For instance, in

the medial pattern, the application of botulinum toxin type A beyond the midpupillary lines should be avoided, due to the hypokinesia of this area. Likewise, in patients showing the lateral pattern, the hypokinetic area occurs in the middle of the forehead, which means that application of the toxin in this area would be ineffective.

The results described in the present article are further supported by the anatomical studies published in 2005 by Kushima et al.,¹⁴ which analyzed the characteristics of the frontal musculature of 14 cadavers. The authors described two types of muscles. One type showed the absence of fibers in the central region and had lateral portions more developed than medial ones, thus corresponding to the lateral pattern of contraction. The other type of muscle was continuous and equally developed, thus corresponding to the total pattern of contraction. We believe that the medial pattern of contraction results from a laterally narrower muscle configuration, however, no anatomical studies in cadavers are available to support this hypothesis.

CONCLUSION

Unsatisfactory results in the treatment of the frontalis muscle are usually linked to: the total paralysis of the muscle, with the loss of eyebrow movement; asymmetric muscular relaxation with the alteration of facial expression; or yet to the failure in attaining the desired wrinkle correction. For the effective treatment of frontal hyperfunctional lines with botulinum toxin type A, it is necessary to be able to recognize the different patterns of contraction of the frontalis muscle. Ready-to-use formulas are not available, so it falls to each professional to evaluate and understand each patient's specific needs. Notwithstanding, we believed that the identification and classification of frontal contraction patterns, combined with the application points described in this study, can enhance the precision of the treatment administered to each individual patient. ●

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