European Journal of Plastic Surgery (2019) 42:125–134
https://doi.org/10.1007/s00238-018-1453-9

ORIGINAL PAPER

Dermal subcision of Nemoto's ligaments as a long-lasting treatment for forehead and glabellar wrinkles

Nader Gomaa Elmelegy[1] · Ahmed M. Hegazy[1]

Received: 17 May 2018 / Accepted: 9 August 2018 / Published online: 12 September 2018

Abstract

Background Ever since the beginning of recorded history, beauty has played a major social role. A youthful look, symmetry, and a soft, smooth skin texture, as well as an even colour, are the main characteristics and parameters of attractive and beautiful faces. The forehead is the first location in the face that shows wrinkles. Facial wrinkles show an increase in depth and severity with age in all faces, in both sexes, but usually, forehead wrinkles develop earlier in men than they do in women. The work published by Nemoto et al. in 2002 revolutionised the concepts about the aetiology and anatomy of forehead wrinkles, thus inspiring the authors to develop a new surgical technique for treatment.

Methods Sixty-five patients participated in this study (50 females and 15 males). The age range in this series ranged from 26 to 59 years. Through stab incisions at the hairline level, a standard ENT myringotomy knife was used to cut the fibrous septae connecting between the superficial layer of the galea apponeurotica (that covers the frontalis and glabellar muscles) and the dermis.

Results The results showed a high level of satisfaction among both patients and an objective assessor with no negative comments. Patients rated the operative results excellent in 52.3% of this series, while the operative results were rated excellent in 47.7% of patients by an independent, objective assessment. Kappa analysis showed perfect agreement between the objective and subjective assessments (K = 0.839). The mean Lamperle classification was 3.1 before surgery and 0.7 3 years after surgery. There was a significant reduction in the mean Lamperle classification 3 years after surgery.

Conclusions The cutting (dermal subcision) of fasciocutaneous ligaments of the forehead described by Nemoto et al. is a safe, economical and effective technique for forehead and glabella rejuvenation with long-lasting results.
Level of Evidence: Level IV, therapeutic study.

Keywords Dermal subcision · Nemoto's ligaments · Forehead rejuvenation · Glabellar rejuvenation

Introduction

Ever since the beginning of recorded history, beauty has played a major social role. A youthful look, symmetry and a soft, smooth skin texture, as well as an even colour, are the main characteristics and parameters of attractive and beautiful faces [1, 2]. These parameters are affected mainly by the process of ageing, which is destined for all humans. The development of facial wrinkles is the most characteristic and obvious among features of ageing [3]. Facial wrinkles are thus the target of a large and increasing number of treatment modalities in cosmetology science and its research [4, 5].

The forehead is the first location on the face that shows wrinkles, and the glabella is the last. Forehead wrinkles show an increase in depth and severity with age in both sexes and tend to appear earlier in males [6].

Some theories regarding wrinkles and skin ageing appeared in the past few decades. Overactivity of mimetic muscles, gene alteration by UV exposure, telomere shortening, exposure to free radicals, genetics, substance abuse, smoking and general diseases such as diabetes mellitus contribute to ageing [3, 7].

Electronic supplementary material The online version of this article (https://doi.org/10.1007/s00238-018-1453-9) contains supplementary material, which is available to authorized users.

✉ Ahmed M. Hegazy
ahmedmostafahegazy1973@yahoo.com

Nader Gomaa Elmelegy
naderelmelegy@gmail.com

[1] Tanta University, Tanta, Egypt

Overactivity in the frontalis muscle and glabellar muscles is a major cause of forehead wrinkles. As the frontalis muscle is the only brow elevator, it is classically assumed that its overactivity is a compensatory mechanism to counteract the ptosis of the soft tissues of the forehead and brow that leads to a reduction in the field of vision [8]. The frontalis and glabellar muscle contractions pull on the fibrous septa connecting between the superficial layer of the galea apponeurotica (that covers the frontalis and corrugator supercilii muscles) and the dermis, leading to these wrinkles. Additionally, the dermis becomes thinner at the sites of these wrinkles if compared to the dermis of the other parts of the forehead, and this thinning becomes more progressive with age [9, 10]. There are studies suggesting that forehead wrinkles are personally unique and can thus have significance in a forensic medicine for age assessment and identification, such as via fingerprints [11]. The work published by Nemoto et al. in 2002 [9] revolutionised the concepts about the aetiology and anatomy of forehead and glabellar wrinkles. The work of Nemoto et al. inspired the authors of this work to develop a new surgical technique for the treatment of forehead and glabellar wrinkles.

In this work, the authors are presenting and assessing this new surgical technique for the management of forehead and glabellar wrinkles.

Patients and methods

This study took place in the period from January 2011 to April 2018. Each patient who participated in this study should have been free from coagulopathies, any chronic dermatological diseases and uncontrolled hypertension. Patients should have been psychologically stable and had realistic expectations; in addition, a negative history of dermal filler injections in the forehead and glabella and the stopping of botulinum toxin treatments, if any existed, for at least 6 months before surgery were mandatory.

All patients included in this study signed an informed consent form. The consent form included information regarding the operation, participation in this study and the potential use of their medical data, including medical photography and videos in scientific publications; the patients further had to agree not to use botulinum toxin, dermal fillers and any form of skin resurfacing treatments for a minimum of 3 years (the follow-up period in the study design). All patients were subjected to a full medical history assessment, participating in full general clinical examinations and routine preoperative investigations. The patients' Fitzpatrick skin types were recorded [12]. The patients' forehead wrinkles were photographed (front close view). The photographs were used to classify forehead and glabellar wrinkles following Lemperle footsteps [13] by an independent assessor (plastic surgeon) as follows:

0: no wrinkles
1: perceptible wrinkles only
2: shallow wrinkles
3: moderately deep wrinkles
4: deep wrinkles with well-defined edges
5: very deep wrinkles with redundant folds

Patients with ptotic eyebrows and those with forehead skin redundant folds, i.e. Lemperle type 5, were excluded from this study.

Preoperative marking

The wrinkles were marked with a fine marker. The facial danger zone (facial danger zones II and V) was marked [14]. Facial danger zone II (for frontal nerve) is the triangular area localised by drawing a line from a point 0.5 cm below the tragus to a point 2 cm above the lateral eyebrow, so a line was drawn along the zygoma to the lateral orbital rim; a line was also dropped from the point above the eyebrow through the lateral end of the eyebrow to the zygoma [14–16]. Facial danger zone V (supratrochlear and supraorbital nerves) is defined by a circle with a radius of l.5 cm drawn around the supraorbital foramen [14]. Any visible superficial vein in the forehead area was marked.

Operative steps (Fig. 1)

Operations were done under general anaesthesia or local anaesthesia (supratrochlear and supraorbital nerve block using xylocaine 2%) according to patient preference, with the patient in a supine position and a doughnut head support. Using Klein formula [17] as an infiltration solution to decrease anticipated post-operative contusions and to provide some degree of analgesia post-operatively (usually approximately 10-cc solution), the surgeon pinched the skin of the forehead and pulled it off the galea, and thus, the subcutaneous space was identified and infiltrated by an ordinary syringe. Three 0.5 cm stab incisions were made by a number 11 blade, just one at midline and two medial to each superior temporal line. All the incisions were just above the hairline, vertically oriented and tangential to avoid injury to the hair follicles as much as possible. Again, the surgeon pinched and pulled the skin off the galea, and a standard bi-bladed myringotomy knife (arrowhead-shaped) was passed through the wounds. The knife was used to cut the fibrous septae (Nemoto's ligaments) between the dermis and the superficial galeal layer in the tissue plane just superficial to the galea. Any marked vein should be avoided. In cases of wrinkles in

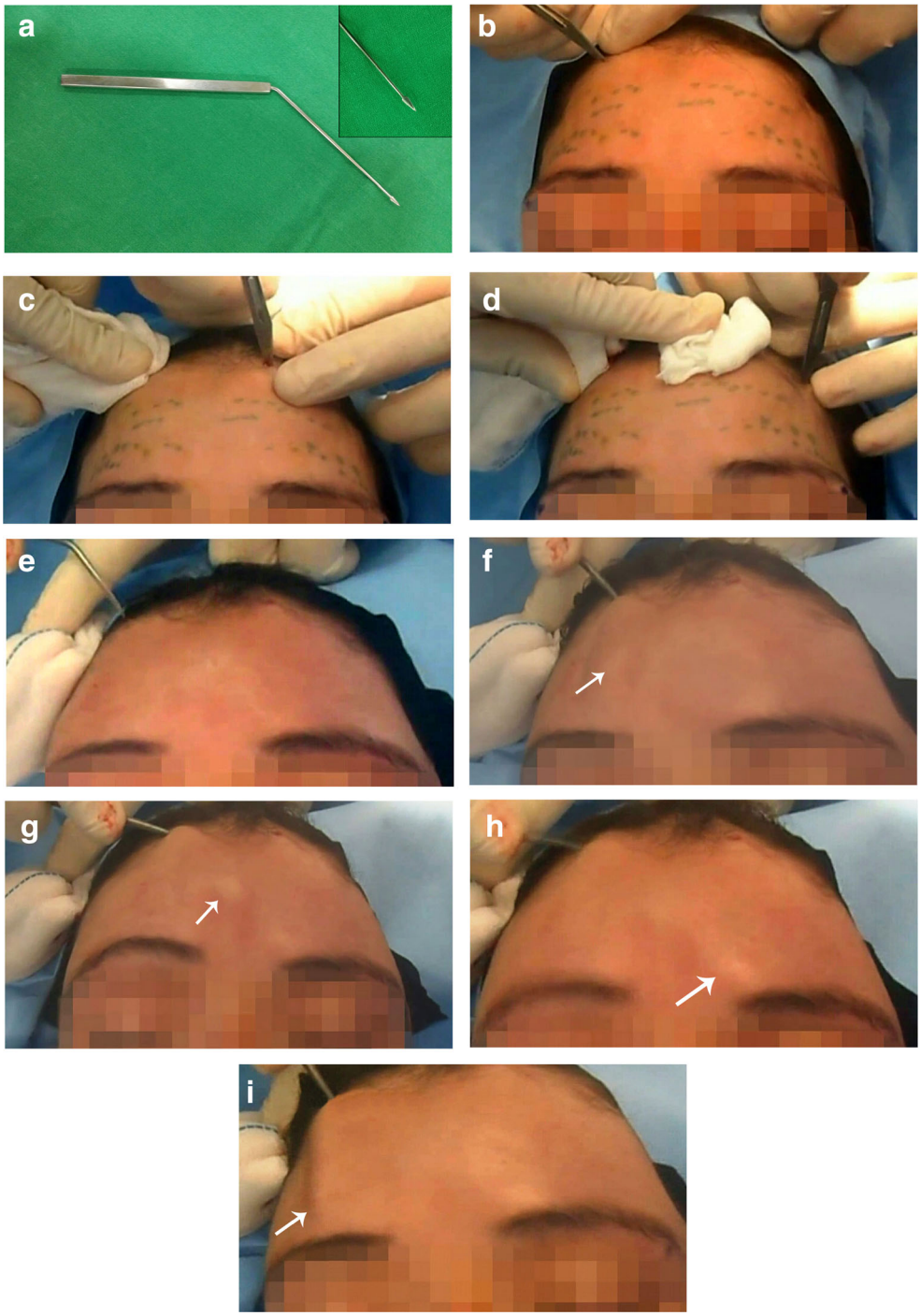

Fig. 1 **a** The myringotomy knife and a magnified view of its cutting tip. **b**, **c**, and **d** The three number 11 blade stab incisions. **e** Passing the knife into the incision. **f** The knife is cutting Nemoto's ligaments in the subcutaneous plane (deeper to the branches of the sensory nerves). **g** The cutting tip is shifted to the subdermal level (superficial to the main sensory nerves' trunks). **h** Cutting Nemoto's ligaments of the glabella in the subdermal plane. **i** Cutting Nemoto's over nerves' danger zone in the subdermal plane (frontal nerve is in the subgaleal plane while supratrochlear and supraorbital nerve trunks are in the deep subcutaneous space)

the glabella and over nerve-related danger zones, the knife was passed superficially, even in a subdermal level to cut the fibrous septa in these areas in the subdermal plane. Each wound was approximated by a single 6/0 prolene[R] simple stitch. The surgeon compressed the forehead for a few minutes by hand. A surgical dressing was applied to the wounds, and a compression bandage was used for 1 day. It is important to note that the number and sites of the hairline stabs were modified if needed according to wrinkle distribution and shape. (A demonstrative video clip is available.)

Post-operative follow-up protocol

The patients had their first follow-up visits on the 5th day after surgery (stitches removed) and then weekly for 1 month, every 3 months for 1 year and every 6 months afterwards. The post-operative photo session was done at any time to

Table 1 Statistical analysis of the demographic data of the patients

Variable	Number	Approximate percentage	Mean±SD	Range
Age	Not applicable	Not applicable	43.4 ± 8	26–59 years
Sex				
Male	15	23.07%	Not applicable	Not applicable
Female	50	76.9%		
Fitzpatrick skin types				
I	4	6.2%	Not applicable	Not applicable
II	7	10.8%		
III	27	41.5%		
IV	23	35.4%		
V	4	6.2%		

document complications, and there was an obligatory photography session 3 years after surgery. The patients' preoperative and post-operative photography took place without wearing any make-up. The patients' subjective opinions regarding results were recorded on a scale from 0 to 4 as follows:

0–1: poor results
2: fair results
3: good results
4: excellent results

The same independent assessor re-classified the patients' post-operative photography according to Lemperle classification; the results of this post-operative Lamperle classification were translated to objective opinions according to the following scale:

Lemperle (3–4): poor results
Lemperle (2): fair results
Lemperle (1): good results
Lemperle (0): excellent results

The results were collected and tabulated for statistical analysis. The mean and the standard deviation parameters were calculated as applicable, and the *P* value was measured to detect the significance of the operative results. Kappa statistical analysis was used to measure the agreement between the objective and subjective assessments of the results (no agreement K = 0, slight agreement K = less than 0.2, fair agreement K = 0.21 to 0.4, moderate agreement K = 0.4 to 0.6, substantial agreement K = 0.6 to 0.8 and perfect agreement K = 0.8 to 1) [18].

Table 2 Statistical analysis of Lemperle classification of forehead wrinkles before surgery and 3 years after surgery

Lemperle classification	Before Mean ±SD	After Mean ±SD	*t* test	*P* value
	3.1 ± 0.8	0.7 ± 0.7	30.1	0.000

Results (Tables 1, 2, 3 and 4 and Figs. 2, 3, 4, 5, 6, 7, 8, 9 and 10)

Fifty females and 15 males shared in this study. The age range in this series ranged from 26 to 59 years. Thirty-three patients in this series reported previous suboptimal results to botulinum toxin treatment; nineteen patients reported a gradual decrease in the effective period of botulinum toxin treatment, 11 patients did not like their brows in a higher position, and two patients preferred surgery to injections. Fitzpatrick skin types of our patients were type I (6.2%), type II (10.8%), type III (41.5%), type IV (35.4%) and type V (6.2%). The mean Lamperle classification was 3.1 before surgery and 0.7 3 years after surgery.

The authors excluded patients who failed to follow the post-operative protocol from this series. The most common cause was the failure to complete the 3-year follow-up. However, some of the patients appeared later with good post-operative results maintained. One patient did not follow-up after 1 year but reappeared after 5 years maintaining good results and a negative history of botulinum toxin injections, dermal filler injections and resurfacing treatments to the forehead and glabella (Fig. 10). The authors excluded her from the statistical assessments of this series, but she was mentioned; her photography was added for documentation only (the longest follow-up period after the operation).

Temporary forehead bruising was the main complication met in this series in approximately 66.15% of our patients. Transient lid oedema and bruising occurred in 38.46% of our patients. Forehead bruising and eyelid oedema resolved within 2 weeks in all patients. No permanent nerve-related

Table 3 Results of the objective assessment

Objective assessment:	Number of patients	Approximate percentage (%)
Excellent	31	47.7
Good	25	38.5
Fair	9	13.8

Table 4 Results of the subjective assessment

Subjective assessment:	Number of patients	Approximate percentage (%)
Excellent	34	52.30
Good	20	30.76
Fair	11	16.92

complications were detected in this series. Transient numbness in the forehead occurred in approximately 26.15% of our patients (17 patients), and all resolved within the first 4 weeks after surgery. The authors did not observe any changes in the eyebrow position in this series (neither ptosis nor elevation).

According to the authors' clinical assessment (skin analysis) of the skin of the glabella and forehead before and 3 years after surgery, there were variable degrees of improvement in the forehead and glabellar wrinkles in all patients.

The patients' assessment of the operation results (subjective assessment) are shown in Table 4. The objective assessment of the operation results are shown in Table 3. Kappa analysis showed perfect agreement between the objective and subjective assessments of the results (K = 0.839).

Discussion

The new surgical techniques are assessed according to safety and efficacy. Safety is dependent on anatomical knowledge, particularly, the anatomy of the important neurovascular structures. An anatomically based approach to surgical rejuvenation of the face gives way to a 'natural' lasting result with minimal morbidity [19].

In this study, safer identification of the subcutaneous plane was enhanced by exploiting the anatomical fact that the galea is fixed bilaterally to superior temporal lines by pinching the free forehead skin up so that the subcutaneous plane is identified for infiltration. The subcutaneous plane just superficial to galea aponeurotica is where the myringotomy knife will be used to cut Nemoto's ligaments. For safety, the plane of cutting was changed to the subdermal plane over the nerves' danger zones also by avoiding visible veins as possible.

Regarding the objective assessment of our post-operative results (Table 3), the new subcision technique has long-lasting good results. The respect of nerve-related danger zones led to the absence of nerve injury in this series. The complications met in this series were forehead bruising (66.15%), transient oedema and bruising around the eyes (38.46%); both, in our opinion, are more sequelae than complications. Temporary forehead numbness occurred in 26.15% of patients, and all resolved spontaneously within 4 weeks. As the dermal subcision method in this series does not violate osteocutanous ligaments of the eyebrows, forehead muscles and glabellar muscles or motor nerves, brow ptosis, elevation and asymmetry were absent in this series. The combination of safety and long-lasting good results led to the even better subjective assessment if compared to objective assessment of the results (Tables 3, 4). There was no negative (poor) assessment in either subjective or objective assessments. The results of this work show a significant reduction in Lamperle classifications 3 years after surgery (Table 2).

The results of this study suggest that the studied dermal subcision technique is useful for men and women. However, the relatively small number of men in this series and the overall small number of patients do not allow us to confirm which gender receives more benefit or whether both receive equal benefits.

The results of this study suggest that the dermal subcision technique not only improves forehead wrinkles that persist while muscles of the forehead and glabella are relaxed but also improves dynamic wrinkles (Fig. 9). In our opinion, the mechanism of this improvement is by cutting Nemoto's ligaments and may be due to the subdermal and subcutaneous fibrosis caused by the passage of the myringotomy knife. This fibrosis will make superficial galea apponeurotica and skin firmly attached and move as a mass. The deformational forces that act on the skin will change from combined pulling forces on Nemoto's ligaments and folding forces to only folding forces to the skin. The fact that progressive ageing does cause gradual thinning of the dermis that is more overt at the sites of dermal attachments of Nemoto's ligaments [9, 10] will make one expect relatively poor results on active wrinkles in

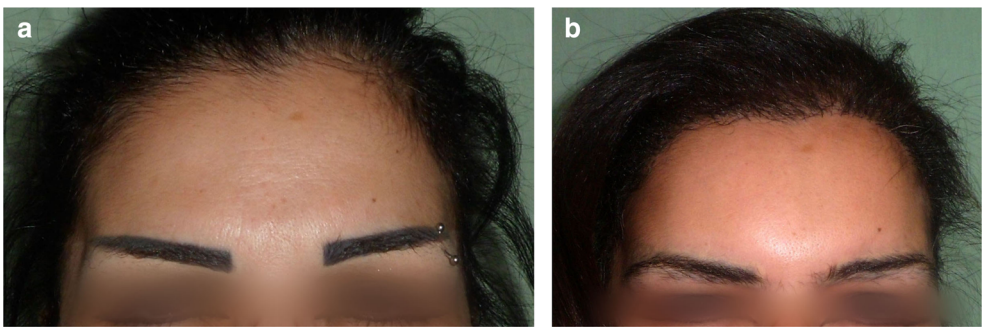

Fig. 2 43-year-old female patient. **a** Pre-operative picture is showing forehead and glabellar wrinkles. **b** Post-operative results after 3 years

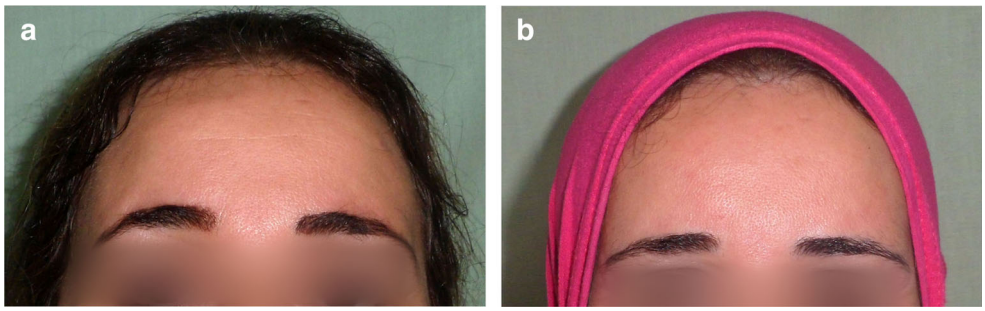

Fig. 3 38-year-old female patient. **a** Pre-operative picture is showing forehead and glabellar wrinkles. **b** Post-operative results after 3 years

older patients, but this statement needs further study for corroboration.

Thus far, most of the surgical procedures for forehead rejuvenation include a form of eyebrow lift and vice versa. In practice, on the other hand, there is a category of patients who have eyebrows in a good position and have wrinkles in the forehead and glabella only, as well as patients who ask only for eyebrow lifts, and their foreheads and glabellas bear no or very limited wrinkles.

Open (classic) forehead lifts often leave long and potentially visible scars, in addition to potential hazards to the supraorbital and supratrochlear nerves, and they can end with an excessively high hair line [20]. Open (classic) forehead lifts do not cut the fibrous communications between the dermis and the superficial layer of the galea apponeurotica described by Nemoto et al. [9]. Ablation of corrugator muscles and facial ligaments of the eyebrow area may lead to an abnormal rise in the medial eyebrow. The loss of function of any mimetic muscle leads to the loss of normal expression. The only advantage of a classic forehead lift is that it manages redundant skin and excessively low hairline if the latter is ever a problem [20].

The dermal subcision technique offers smaller hidden scars, as well as forehead and glabella with full motor function, and cuts the fasciocutaneous ligaments that contribute to forehead wrinkles; in addition, it offers its proven safety to supraorbital and supratrochlear nerves. Dermal subcision technique is not intended to treat forehead laxity or ptosis; this technique does not change the hairline level and does not lift eyebrows, as it does not manipulate the brows' facial ligaments.

A standard endoscopic forehead lift offers hidden smaller scars and does not affect the hairline, but it carries all the other disadvantages of a classic forehead lift. An endoscopic forehead lift cannot treat excess skin either [20] or ablate the traction of Nemoto's ligaments [9, 20]. In our opinion, the term, endoscopic forehead lift, is a misnomer, as it is actually a brow lift only.

Minimally invasive nonendoscopic forehead surgeries have the same limitations of endoscopic forehead procedures, but they do avoid wide forehead dissection [20], in addition to being less expensive compared to endoscopy.

In this work, the dermal subcision technique uses even smaller incisions than endoscopy. That is why there was no scar-related complication in this series. Dermal subcision technique ablates traction caused by Nemoto's ligaments, but it is not a brow-lifting procedure. The derma subcision technique is less expensive than the endoscopic technique and does not affect the function of the muscles of facial expression, and it was proven safe for the motor and sensory nerves of the forehead.

It is worth mentioning that the authors of this study focused on assessing the efficacy and safety of dermal subcision. Thus, it was not tried in combination with any other forehead rejuvenation technique, whether surgical or non-surgical. The authors of this work selected patients who had never had dermal filler injections in the forehead and glabella. Patients should

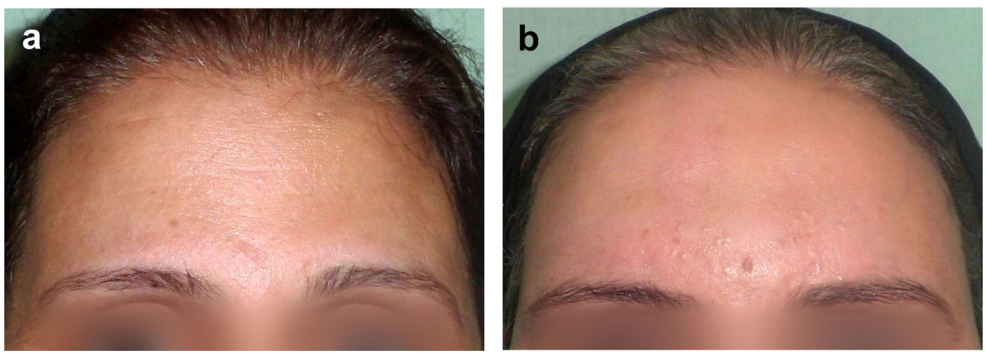

Fig. 4 52-year-old female patient. **a** Pre-operative picture is showing forehead and glabellar wrinkles. **b** Post-operative results after 3 years

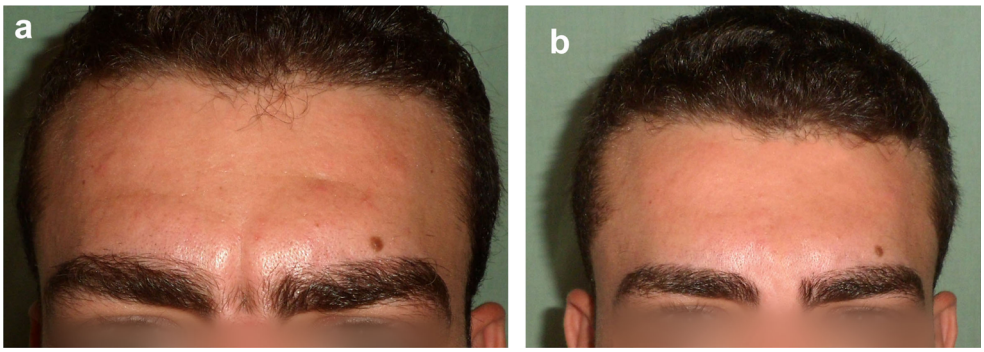

Fig. 5 27-year-old male patient. **a** Pre-operative picture showing forehead wrinkle and a deep frown line in glabella. **b** Post-operative results after 3 years

stop botulinum toxin injections 6 months before surgery. Patients agreed not to receive any forehead/glabella rejuvenation procedures of any kind during the follow-up period. The idea of using this procedure in combination with other rejuvenation procedures can be the subject of future study.

Dermal subsicion was tried before using special surgical wires (e.g. Aptos Wire Scalpel^{R}). In this technique, the wire is passed in the subdermal plane under each wrinkle. Each wrinkle needs at least two puncture holes. The wire is used for dermal subcision of the forehead and glabellar ligaments in the same way as a Gigli saw [21]. This method can cause widening of the puncture holes during sawing leaving scars that are difficult to hide in the forehead. Also using a disposable special instrument will increase the overall cost of the procedure. The limited subcisions under each wrinkle will not allow re-draping of the skin over the deeper tissues and theoretically will make little changes to the deformational forces that act on scalp skin during the action of frontalis and glabellar muscles. The fibrosis between the galea and skin will be theoretically at the same site of Nemoto's ligaments. The study on Aptos Wire Scalpel^{R} was biased by significant variability in the follow-up period (2 months to 4 years) [21]. The new method for dermal subcision in this work is more economical, as it uses classic and reusable instruments. The surgical wounds in our techniques are tiny (approximately 5 mm or less) and well hidden. We believe that the technique assessed in this series abolishes the pulling on Nemoto's ligaments and induces broad and firm attachment between the skin and the superficial galea apponeurotica by the post-operative fibrosis. This attachment will make both the galea and skin move as a mass, which will decrease skin folding, is why wrinkles improve even in motion and may be the secret of the longevity of the results. It is worth noting that we standardised for 3 years as a follow-up period for all patients. Choosing the range as a statistical method for a study that includes long and short-term follow-up patients put together as one group does not prove the longevity of the results and is a bias in the Aptos Wire Scalpel^{R} study results [21]. In this situation, a single exceptional case of 4 years can give the same range of results as many cases. The results of this series are significantly more reliable in our opinion.

In this study, some patients appeared after longer periods, for example, the case in Fig. 10 who came back after 5 years for other aesthetic surgery and still had maintained nice results with a negative history of any other surgical or non-surgical procedures in the glabella and forehead after dermal subcision. This patient was mentioned and photographed for documentation only as the case with the longest follow-up period, but she was excluded from the results.

Botulinum toxin treatment for forehead wrinkles, although a simple clinic-based treatment, is not free from disadvantages. Botulinum toxin is not an ideal treatment for forehead wrinkles that persist at rest and are exaggerated by motion, i.e. in patients above 30 years old [22]. Botulinum toxin treatment

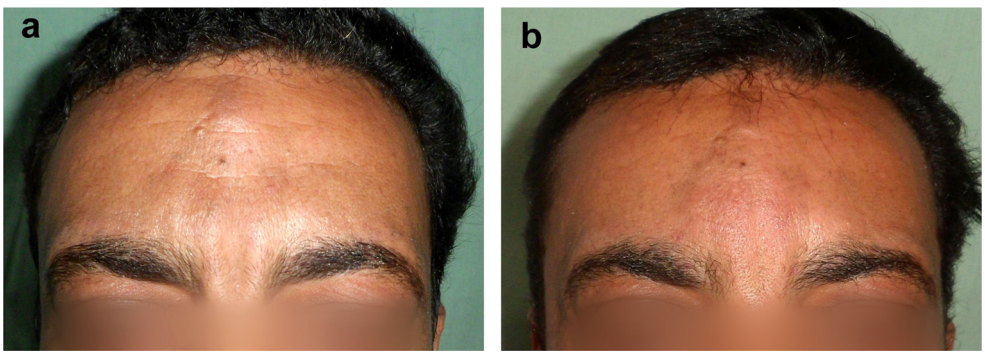

Fig. 6 49-year-old male patient. **a** Pre-operative picture is showing forehead and glabellar wrinkles. **b** Post-operative results after 3 years

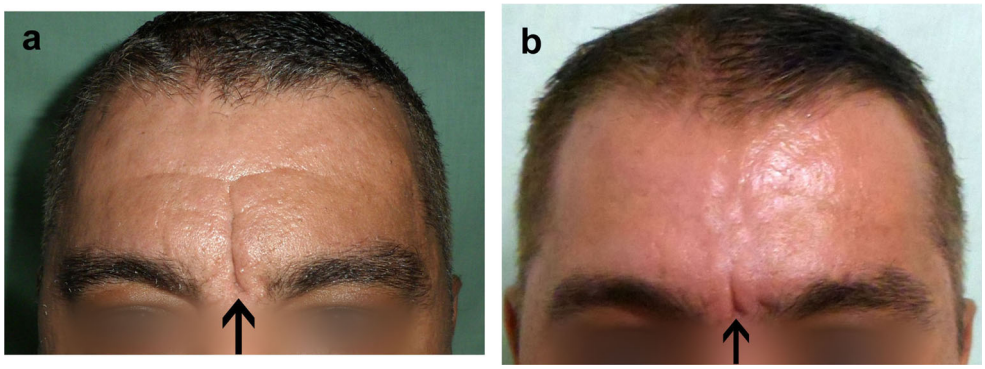

Fig. 7 55-year-old male patient (arrows are pointing to a deep scar that forms an extension to his frown line). **a** Pre-operative picture is showing forehead and glabellar wrinkles. **b** Post-operative results after 3 years showing improvement in the forehead and glabellar wrinkles and partial improvement in the scar area

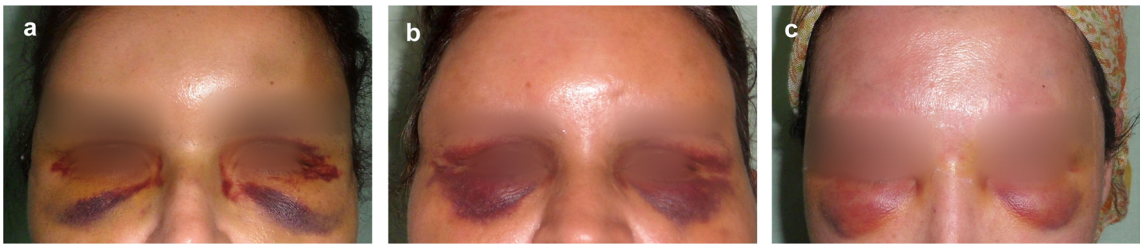

Fig. 8 Bruising and oedema of the forehead were the most common complications in our series. Sometimes oedema and bruising around the eyes occurred. All were resolved with warm compresses and anti-bruising creams. **a** The same patient in Fig. 1. **b** The same patient in Fig. 4. **c** The same female patient in Fig. 8

area in the forehead is limited to between the mid-pupillary lines to avoid brow ptosis and cannot thus treat lateral forehead wrinkles [8]. In hyperkinetic subjects, forehead treatment with botulinum toxin may lead to the appearance or exaggeration of lateral forehead wrinkles and elevated lateral brow ends, giving the patient a devilish look (the so-called Mephisto sign) [8]. Botulinum toxin temporarily paralyses the frontalis, and repeated botulinum toxin treatment to the forehead may lead to a permanent middle third of frontalis muscle atrophy [22]. The temporary or permanent loss of the

Fig. 9 A sample of the patients in our series showing a post-operative reduction of dynamic wrinkles with full preservation of forehead and glabella facial expression. a. Pre-operative. b. Post-operative after 3 years (frowning). c. Post-operative after 3 years (eyebrow elevation)

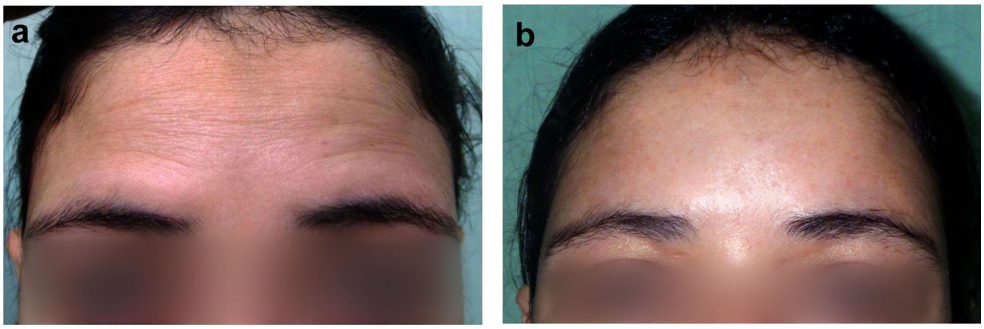

Fig. 10 33-year-old female patient. **a** Pre-operative picture is showing forehead and glabellar wrinkles. **b** Post-operative results after 5 years

function of a muscle of expression means the loss of normal facial expression. The cost of botulinum toxin treatment can be significant, especially if the patient needs many units (mostly among male patients) and also as treatment must be repeated. The botulinum toxin treatment-induced high arch of the brow is not aesthetically pleasing in males, and even many female patients still prefer to keep their natural brow arches preserved [8]. Although uncommon, some cases develop botulinum toxin treatment resistance after repeated injection due to antibody formation, in both aesthetic and therapeutic cases [8, 23]. Nineteen patients in this series reported a history of a gradual reduction in the effective period of botulinum toxin treatments. However, the subject of botulinum toxin resistance is not within the scope of this study, and no serology was done to these cases; thus, we cannot state that we had botulinum toxin resistance cases in this study.

Dermal subcision technique avoids most of botulinum toxin's limitations, can treat lateral forehead wrinkles, respects the function of the forehead and glabella muscle functions and, according to our results, is effective against forehead wrinkles that persist at rest and are exaggerated by motion. The cost of the studied dermal subcision technique is cheaper if compared to the cumulative cost of botulinum toxin treatments. However, it is fair to state that the simplicity of botulinum toxin treatment and the reversible nature of almost all of its potential complications are still strong advantages that made it the first option tried by almost all patients who seek forehead and glabellar rejuvenation. The dermal subcision technique evaluated in this series has its candidates, which in our opinion are different from the candidates for botulinum toxin treatment and all other methods discussed above.

Adding a control group or comparative group will give this study a greater impact but is unfortunately not possible, as the targets and impacts of other surgical options (discussed above) are different. Botulinum toxin therapy results, even if ideal, will last a few months and are known to have poorer results in patients with persistent wrinkles at rest. Finally, a no-treatment group will have unimproved forehead wrinkles in 100% of its patients. Thus, keeping this study at level (IV) was a significantly sound option in our opinion.

Conclusion

The cutting (dermal subcision) of fasciocutaneous ligaments of the forehead (described by Nemoto et al. [9]) is a safe, economical, effective technique with long-lasting results. This approach should be considered in patients with forehead wrinkles and non-ptotic eyebrows, patients with forehead and glabellar wrinkles that are persistent after botulinum toxin treatment, patients who are botulinum toxin treatment-resistant, patients who ask to improve forehead and glabellar wrinkles, patients who do not want to have higher eyebrows, patients who ask for long-lasting results and patients who are not willing to have treatments that need to be repeated. Dermal subcision is not an alternative for any of the other known options for forehead and glabellar rejuvenation but certainly is a newly added option.

Acknowledgements The authors would like to acknowledge the efforts of professor Doctor Ahmed Bhaa El-Din of the Faculty of Medicine—Elmansura University for giving his valuable objective opinion in the assessment of the results of this work.

Compliance with ethical standards

Conflict of interest Nader Gomaa Elmelegy and Ahmed M. Hegazy declare that they have no conflict of interest.

Ethical commitments All the procedures performed in this study that involved human participants were in accordance with the institutional, national research committee and compliant with the 1964 Helsinki Declaration and its later amendments and any comparable ethical standards.

Patient consent Informed consent was obtained from all patients who participated in this study, including the use of their clinical data, photography, videos, etc. in scientific publications.

References

1. Fink B, Grammer K, Thornhill R (2001) Human (Homo sapiens) facial attractiveness in relation to skin texture and color. J Comp Psychol 115(1):92–99
2. Fink B, Neave N (2005) The biology of facial beauty. Int J Cosmet Sci 27(6):317–325

3. Kligman AM, Zheng P, Lavker RM (1985) The anatomy and pathogenesis of wrinkles. Br J Dermatol 113(1):37–42
4. Robert L, Labat-Robert J, Robert AM (2012) Physiology of skin aging. Clin Plast Surg 39(1):1–8
5. Dulguerov N, D'Souza A (2011) Update on treatment rationale and options for the aging face. Curr Opin Otolaryngol Head Neck Surg 19(4):269–275
6. Luebberding S, Krugeer N, Kerscher M (2014) Quantification of age-related facial wrinkles in men and women using a three-dimensional fringe projection method and validated assessment scales. Dermatol Surg 40(1):22–32
7. Callaghan TM, Wilhelm KP (2008) A review of ageing and an examination of clinical methods in the assessment of aging skin. Part I: cellular and molecular perspectives of skin aging. Int J Cosmet Sci 30(5):313–322
8. De Maio M, Rzany B (2007) Chap.5: the most common indications. In: De Maio M, Rzany B (eds) Botulinum toxin in aesthetic medicine. Springer Verlag, Berlin, pp 27–92
9. Nemoto M, Uchinuma E, Yamashina S (2002) Three-dimensional analysis of forehead wrinkles. Aesthetic Plast Surg 26(1):10–16
10. Tsukahara K, Tamatsu Y, Sugawara Y, Shimada K (2011) The relationship between wrinkle depth and dermal thickness in the forehead and lateral canthal region. Arch Dermatol 147(7):822–828
11. Kaur M, Garg RK, Singla S (2015) Analysis of facial soft tissue changes with aging and their effects on facial morphology: a forensic perspective. Egypt J Forensic Sci 5:46–56
12. Fitzpatrick TB (1988) The validity and practicality of sun-reactive skin types I through VI. Arch Dermatol 124(6):869–871
13. Lemperle G, Holmes RE, Cohen SR, Lemperle SM (2001) A classification of facial wrinkles. Plast Reconstr Surg 108(6):1735–1750
14. Seckel BR (2010) Ch.12: facial danger zone 2. Ch.34: facial danger zone 5. In: Seckel BR (ed) Facial danger zones, avoiding nerve injury in facial plastic surgery. Thieme, New York, pp 12–34
15. Pitanguy I, Ramos AS (1966) The frontal branch of the facial nerve: the importance of its variations in face lifting. Plast Reconstr Surg 38(4):352–356
16. Bernstein L, Nelson RH (1984) Surgical anatomy of the extraparotid distribution of the facial nerve. Arch Otolaryngol 110(3):177–183
17. Klein JA (1993) Tumescent technique for local anesthesia improves safety in large-volume liposuction. Plast Reconstr Surg 95(3): 1085–1098
18. Viera AJ, Garrett JM (2005) Understanding interobserver agreement: the kappa statistic. Fam Med 37:360–363
19. Wong CH, Mendelson BC (2015) Ch.65: facial anatomy and aging. In: Farhadieh RD, Bulstrode NW, Cugno S (eds) Plastic and reconstructive surgery approaches and techniques. Wiley, Chichester, pp 923–947
20. Timothy J, Marten TJ, Marten DE (2015) Chap.67: forehead lift. In: Farhadieh RD, Bulstrode NW, Cugno S (eds) Plastic and reconstructive surgery approaches and techniques. Wiley, Chichester, pp 948–966
21. Sulamanidze MA, Salti G, Mascetti M, Sulamanidze GM (2000) Wire scalpel for surgical correction of soft tissue contour defects by subcutaneous dissection. Dermatol Surg 26(2):146–150
22. Moriarty KC (2004) Chap.8: treatment of forehead wrinkles. In: Moriarty KC (ed) Botulinum toxin in facial rejuvenation. Mosby, Elsevier, London, pp 65–84
23. Torres S, Hamilton M, Sanches E, Starovatova P, Gubanova E, Reshetnikova T (2014) Neutralizing antibodies to botulinum toxin type A in aesthetic medicine: five case reports. Clin Cosmet Investig Dermatol 7:11–17