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ORIGINAL PAPER

Rhinoplasty in the deviated nose: patterns of recurrence and role of facial asymmetry

Yves L. J. Goffart[1] · Sarah Remacle[1]

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Abstract

Background Various hypothesis concerning recurrence of nasal deviation have been proposed in the literature but are not clearly demonstrated.

Methods This retrospective study including 50 consecutive patients with a non-traumatic deviated was conducted to determine the pattern of nasal axis stabilization after rhinoplasty of the deviated nose on the basis of three anthropometric measurements: median face axis (MFA), interpupillary meridian axis (IMA), and scoliosis angle (SA). We studied possible mechanisms associated with progressive re-deviation occurring over time even to a very slight degree in many patients, and we reviewed the mechanisms associated with asymmetry of the face and nose. The hypothesis regarding recurrences and possible modification of surgical procedures are discussed. We retrospectively examined the pattern of recurrence of deviation over time in a consecutive series of non-traumatic patients undergoing primary esthetic or functional rhinoplasty. Patients were followed at 1 week, 2 weeks, 1 month, 3 months, and 1 year.

Results Of the patients, 92% (46/50) had an asymmetric face after comparing two anthropometric angles: MFA and IMA. Gradual re-deviation occurred in almost every patient, although very slightly, as MFA shifted from 4.1° ± 3.1 preoperatively to 1.0° ± 1.1 at 2 weeks, 1.1° ± 1.5 at 3 months, and 1.7° ± 2 at 1 year. IMA shifted from 4.7° ± 3.3 preoperatively to 0.9° ± 1.7 at 2 weeks, 1.5° ± 1.9 at 3 months, and 1.6° ± 2.8 at 1 year. SA shifted from 171.7° ± 6.2 preoperatively to 179.7° ± 1.4 at 2 weeks, 178.7° ± 3 at 3 months, and 177.8° ± 3 at 1 year. Stabilization was observed after 3 months to 1 year.

Conclusions Facial asymmetry is present in most patients with a deviated nose. Nasal deviation often recurs, even after adequate surgery. The re-deviation pattern is progressive over the first few months after surgery. Midfacial hypotrophy may play a role in the formation of bony foundation defects of the nose and dynamic and asymmetric soft tissue forces over time. For the "facial envelope theory," designing a surgical approach that would test this hypothesis is needed.

Level of Evidence: Level III, therapeutic study.

Keywords Crooked nose · Deviated nose · Facial asymmetry · Outcomes · Rhinoplasty

Key Points Question
What is the postoperative evolution of primary rhinoplasty in deviated nose? What are the factors that contribute to recurrences?
Findings
Some degree of re-deviation is often observed following rhinoplasty in crooked nose. The process is gradual over the first weeks and tends to stabilize after 3 months to 1 year postoperatively. Facial asymmetry is observed in most patients with deviated nose.
Meaning
The re-deviation pattern observed even slightly over time suggests the role of elastic forces. Besides cartilage resilience from the nasal septum, asymmetry in the facial soft is involved in nasal axis re-deviation.

The results of this study have been presented by Yves LJ Goffart at the 12th International Symposium of Facial Plastic Surgery on October 17, 2018, Dallas, TX.

✉ Yves L. J. Goffart
yves.goffart@chrcitadelle.be

[1] Department of ENT and Head Neck/MaxilloFacial Surgery, CHR Citadelle, B 4000 Liege, Belgium

Introduction

A deviated nose is a very common developmental feature in adult Caucasian populations. A crooked nose alters the perception of the symmetry of the face and may be perceived as unattractive [1]. Evolutionary biologists postulate that facial symmetry represents a sign of health and genetic quality and therefore is attractive [2, 3]. Moreover, midfacial asymmetry has been shown to be often associated with nasal axis (NA) deviation.

NA deviations are classified into three categories: linear or I-shaped, C-shaped, or S-shaped. Midfacial asymmetry may be present in the anteroposterior, vertical, or horizontal axis. Maxillary hypoplasia is defined as a decrease in all three planes, and an asymmetric maxilla develops when one or two planes are affected. As the anterior wall of the maxilla provides support to the nose, any asymmetry in the maxilla will affect the nasal superstructure and potentially alter its growth pattern.

Although authors since Cottle [4] have stressed the central role of septoplasty for adequate correction of the nose, rationales or patterns for recurrences after proper rhinoplasty remain unclear. Surgeons have theorized that recurrence over months depends entirely on the cartilaginous "memory"' structure of the nasal pyramid [3, 5, 6].

In our opinion, identifying the factors that may lead to recurrences, especially regarding facial asymmetry, and potentially their treatment or avoidance are major concerns for every surgery of a deviated nose.

Purpose of the study

We tried to demonstrate that the postoperative outcome in a deviated nose is not an on-off result, but that evolution occurs over time. For a better understanding of the re-deviation pattern, we tried to identify facial asymmetry by a simple method in our series. Possible factors explaining the recurrence of deviation are investigated. Ultimately, rationales are suggested for altering the recurrence rate.

Methods

We conducted a retrospective photographic analysis of 50 consecutive patients complaining of a significantly deviated or crooked nose. Patients who underwent esthetic or functional primary rhinoplasty, without a significant history of trauma, were included in this retrospective review. The senior author performed all operations with an open rhinoplasty approach. Although each surgery was individually tailored, general principles applied to all patients and may include septoplasty with a conservative approach to the cartilaginous structures, leaving at least 15 mm dorsal strip of cartilage, re-fixation to the nasal spine using a 4–0 Prolene° suture, conservative scoring, septal battens grafts along the septum when needed, asymmetric osteotomies when discrepancies between lengths of nasal bones were present, and clocking sutures between nasal septum and upper lateral cartilages.

High-resolution photographs were taken with a professional digital camera: Canon EOS 7D and 35–105 mm f/4 Canon lens. Baseline and postoperative photographs at 1 week, 2 weeks, 1 month, 3 months, and 1 year were analyzed. One patient who sustained trauma and required surgical reduction at 6 months was excluded.

Photographs were assessed using GIMP 2.8.22 (Gnome Foundation, USA) software by both authors. Three anthropometric measurements of the NA were obtained for each patient at each step:

- An imaginary sagittal line beginning from the central hairline point and crossing the glabella, the central point of Cupid's bow on the upper lip, and the bottom of the chin was drawn. The angle between this meridian and a line connecting the nasion (N) to the nasal tip (T) is defined as the median face axis (MFA).
- A horizontal interpupillary line was drawn, and a perpendicular line was drawn from the middle of this line. The angle between this meridian and a line connecting the nasion (N) to the nasal tip (T) is defined as the interpupillary meridian axis (IMA). NA is evaluated relative to IMA and MFA, and 0° indicated that no deviation was measurable. Given that the variable of interest was the degree and not the laterality of asymmetry, we will not distinguish left and/or right deviations.
- The deviation angles of the C-shaped crooked nose were measured as follows. First, a line was drawn from N to the apex of the convexity (A). From this point, a second line was drawn to the tip of the nose, and the scoliosis angle (SA) was measured; 180° indicated that the nose was perfectly straight and no scoliosis was measurable. Bony deviation of the nose until the apex of convexity was also assessed using MFA and IMA coordinates (Fig. 1).

Statistical analysis

Quantitative variables are expressed as median, mean, standard deviation, and interquartile rank. Angle distributions were assessed by t test (paired samples) or Wilcoxon test (non-parametric samples). Evolution of angles over time after surgery was analyzed using a generalized linear mixed model (GLMM model). The SAS 9.4 software was used for the analysis.

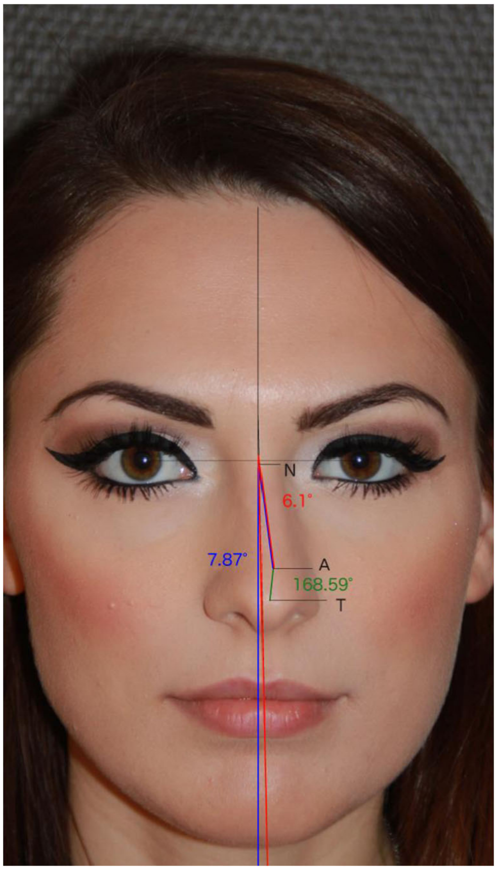

Fig. 1 Measurement of median face axis (MFA), interpupillary meridian axis (IMA), and scoliosis angle (SA). Blue line represents MFA angle, red line IMA angle, green line SA

Results

Table 1 presents statistical information for the analyzed data. IMA and MFA significantly differ ($p = 0.026$).

The relationship between MFA and SA is significantly increasing (RSpearman = 0.71, $p < 0.0001$) and between IMA and SA (RSpearman = − 0.56, $p < 0.0001$).

MFA and IMA angles both significantly decreased after surgery ($p < 0.0001$). MFA shifted from 4.1° ± 3.1 preoperatively to 1.2° ± 1.4 at 1 week, 1.0° ± 1.1 at 2 weeks, 1.1° ± 1.4 at 1 month, 1.1° ± 1.5 at 3 months, and 1.7° ± 2 at 1 year. Gradual augmentation did not reach significance because of the standard deviation ($p = 0.071$). The trend in the evolution of the MFA in weeks and months after surgery is shown in Fig. 2. A similar observation was found for IMA. The IMA shifted from 4.7° ± 3.3 preoperatively to 2.8° ± 1.4 at 1 week, 0.9° ± 1.1 at 2 weeks, 1.8° ± 2.3 at 1 month, 1.6° ± 1.9 at 3 months, and 1.6° ± 2.7 at 1 year. The trend in the evolution of the IMA in weeks and months after the surgery is shown in Fig. 4. SA also significantly evolved after surgery ($p < 0.0001$). SA shifted from 171.7° ± 6.2 preoperatively to 179.8° ± 1 at 1 week, 179.7° ± 1.4 at 2 weeks, 179.6° ± 1.4 at 1 month, 178.7° ± 3 at 3 months, and 177.8° ± 3 at 1 year. The trend to increase risk of scoliosis development months after surgery did not reach significance.

Table 1 Distribution of MFA, IMA, and SA

Variable	*N*	Median (p25–p75)	Min–max	*T* test *p* value
MFA	49	3.47° (2.25–5.36)	0.35–17°	
IMA	49	3.67° (2.61–6.54)	0.25–17°	
Scoliosis	49	173.2° (169.0–175.2)	148.35–180°	
MFA-IMA	49	− 0.5°(_1.5°–0.7°)	− 5.2–2.6°	0.026

Regarding clinical evolution, the trend to re-deviation was very slight (less than 2°) in the majority of patients and was not noticeable until precisely measured. Two patients presented with significant re-deviation, one patient who was however satisfied with the result, while the second one opted for a revision surgery (Fig.3). Two other patients needed minor touch up procedures for dorsal irregularities that were not related to the axis.

Discussion

Correction of the congenitally deviated nose requires thorough analysis toward a detailed surgical plan. A high proportion of these patients present with underlying asymmetry of the maxilla. This feature is not adequately assessed by visual evaluation. Hartman found in a random sample of computed tomography images that septal deviation was associated with localized asymmetry of the face [7].

Other studies were targeting patients seeking rhinoplasty and therefore more likely to exhibit a larger magnitude of deviation. The reported rates of associated facial asymmetry varied and ranged from 30 to 97% of patients seeking rhinoplasty [7].

A simple subjective assessment by a panel of viewers for a general rhinoplasty population showed that 38% of the population was perceived as having facial asymmetry [8]. However, if objective anthropometric measurements are made in that same population, almost all patients (97% of 234 patients) exhibit significant degrees of facial asymmetry [8].

Carvalho et al. [9] evaluated rhinoplasty candidates and volunteers (Caucasian-type nose) and found that 59% of patients were perceived as having asymmetric features, but 89% of them had notably asymmetric measurements.

Yi et al. found lower facial asymmetry rates after anthropometric measurements (55% of patients seeking rhinoplasty for a deviated nose vs. 32% in septoplasty patients) concerning an Asian population [10]. Hafezi suggested a significant facial growth delay on the concave side of the deviated nose [11]. Kim found that nasal septal deviation was highly correlated with lateral facial asymmetries in candidates for rhinoplasty [12]. A study by Munroe of over 125 patients revealed five broad categories of facial asymmetries, namely,

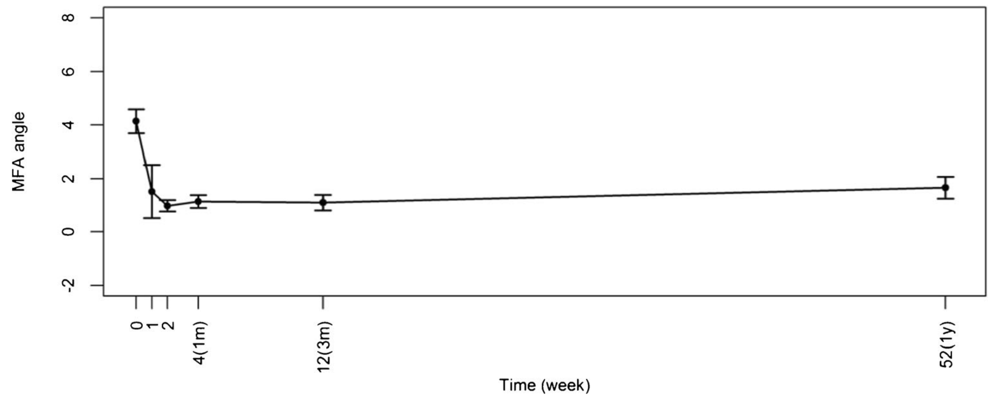

Fig. 2 Evolution of nasal deviation relative to the median face axis (MFA: mean ± SD)

difference in facial width, difference in orbital level (vertical orbital dystopia), rotation displacement of piriform aperture, tilted alar base, and facial hypotrophy [13].

Facial morphological changes during development are a complex process in which intrinsic and extrinsic factors interact with the facial skeleton. Considerable evidence suggests that nasal septal cartilage acts as a key facial growth center, representing the so-called "nasal septal traction" model. [14–16]

However, the growth of the nasal septum and other components of the facial skeleton are not isomorphic. When there is a disconnection between the facial skeleton and nasal septum growth, a deformation of the nasal septum will occur. Secondary constraints placed on the nasal septum by the facial skeleton are supported by pan-mammalian comparative studies [17] and experimental research [18]. Modifications of facial morphology and reduction of facial size—comparable to long snout species—occurred during human evolution. Comparative and experimental taxonomic studies suggest that this reduction imposed spatial constraints on the nasal septum, resulting in altered septal growth. Furthermore, the rate of septal growth is not equal in various human populations. The rate of septal growth is greater in the population of Caucasian descent. The high frequency of septal deviation in Europeans contrasts starkly with that in other groups, such as Native Americans or African-descent populations, who are characterized by low levels of septal deviation and low levels of facial asymmetries [19].

The nasal septal traction model postulates that the nasal septum exerts a morphogenetic influence on the surrounding skeletal tissue. As such, it also determines the growth of facial soft tissues including fascia, muscles, skin envelope, and fat. This relationship has been assessed using morphometric methods from pictures and dental casts [12].

Data on facial soft tissues have also been collected both in vivo and from cadavers and have been translated into a database used for forensic facial imaging. Facial soft tissue depth/thickness asymmetries have been reported at a high frequency, affecting around 50% of landmarks acquired from a contemporary adult general population from Germany by CT and 3D analysis [20].

Conversely, soft tissues will also influence the developmental pattern of the face. The most startling example of soft tissue interaction is encountered with nasal growth in cleft lip patients. The consistent pattern of deformities is likely a result of both the asymmetric bony base and the unbalanced biomechanical forces acting in the nose. Extrinsic muscular action on facial development is also demonstrated in patients with untreated congenital torticollis who present marked asymmetry of the face and nose [21].

To assess possible facial asymmetry in our patients, we compare MFA and IMA values. Although these measures

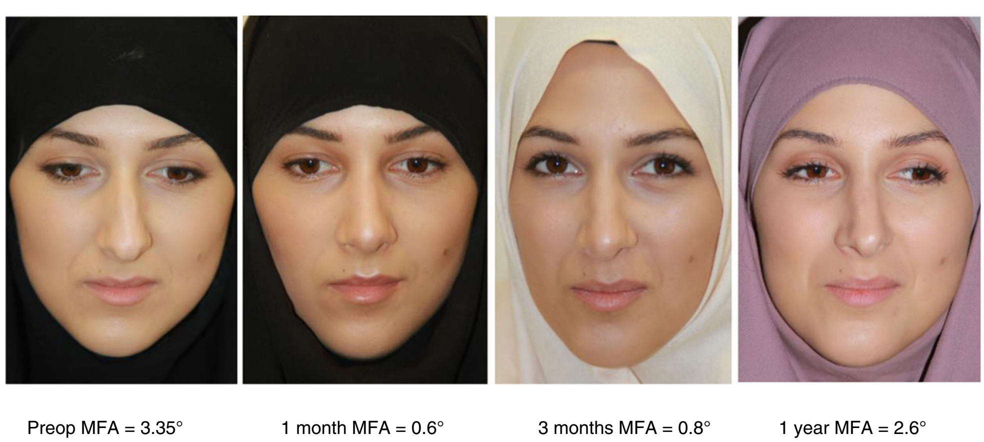

Fig. 3 Recurrence of NA deviation over a 1 year period necessitating revision surgery

address only two variables in the face, it is a very simple method of establishing vertical facial asymmetry. These two angles should be equal if the face is strictly symmetric. In contrast, any differences between IMA and MFA mean that the face is asymmetric to some extent in the vertical dimension. In our study, the comparison between MFA and IMA significantly differs in 92% of patients ($p = 0.026$). We suggest that the angle between MFA and IMA could be used to quickly establish the degree of facial asymmetry in vertical dimension, although this basic measurement will not assess asymmetries in the horizontal dimension of the face.

The relationship between subjective perception and objective measurements is complex. As many patients with deviated nose have asymmetric faces, the use of IMA is questionable because midfacial hypoplasia may cause orbital dystopia. Therefore, we analyzed two axes of reference, namely, MFA and IMA.

To what extent the correction of nasal deviation is achievable depends on the objective measurements. Precise photographic measurements, facial analysis, and preoperative morphing are helpful to assess the advisable amount of correction [22].

Despite the adequacy of the technique used, the nose may not maintain its correct position during the early postoperative stage, and it may deviate to its previous position to some extent [23]. Only few authors have reported their own experiences and success rates quantitatively. Okur found angles of 7.6° and 147° preoperatively and 1.9° and 167° postoperatively in 27 patients with I- and C-shaped crooked noses, respectively [24]. Erdem reported angles of 6.8° and 152° preoperatively and 2.0° and 173° postoperatively in 120 patients with I- and C-shaped crooked noses, respectively [23]. Ellis reported that the correction rates were 75% for rhinion deformities without any detail. [25] Certain assumptions have been made based on the etiology of nasal shift recurrence:

Inadequate surgical technique

Deviation of the nasal septum, discrepancies in nasal bone lengths, asymmetries in upper lateral cartilages (ULC), and asymmetries of the nasal tip are present in various extents and must be dealt with to obtain results. Inadequate surgery is a major cause of immediate imperfect corrections. However, as the surgeon gains experience and uses advanced techniques, this drawback should be resolved.

Bone memory

“Bone memory” or “cartilage memory” are cited as possible factors but appear to proceed more from a historical preamble than an established theory. Indeed, bone memory has no scientific evidence and is not supported by orthopedic and maxillofacial literature. Should an inadequate correction of nasal bones have been realized, the malposition of the nasal pyramid would still exist at completion of surgery and should be straightforward after cast removal. If length discrepancies of the nasal bones are addressed, bone should adequately be repositioned. Additional techniques such as one-piece nasal osteotomy have also been described [26]. Nasal bones would stay in place as long support mechanisms [3], that is, periosteum, maxillary bone, septum, and spreaders, have been maintained or reconstructed and disrupting forces, such as postoperative edema, have been contained by postoperative splinting.

Insufficient splinting

Postoperative splinting will prevent postoperative edema. In essence, the pressure exerted by the cast is symmetric and cannot prevent, even during the first days, the nose from possibly shifting sideward. Asymmetrically pressing nasal splints have been reported by Tugrul in the crooked nose [27]. However, if variants of this technique have long been used by many rhinoplasty surgeons, with the apposition of additional medical tape layers on one side, this technique will help maintain one nasal bone or the middle third area to be adequately closer to the midline, and relatively to it. However, it is impossible to affect the NA, as there is no point of support provided by the facial or cranial skeleton.

Cartilage memory

Cartilage memory is a misleading term as it supposes a malicious power of the cartilage where there is residual springiness. The main goal of septal surgery is to release all sideway spring mechanisms from the septum by re-fixation to the nasal spine and K area, through minimal excision, chondrotomy, suturing technique, and batten grafts [28]. Other techniques such as fixated spreaders grafts or free spreaders [29], clocking sutures, cross-bar technique [3], cartilaginous mattress sutures [30], and extracorporeal septoplasty [31] may be used to obtain both supporting straight septum and adequate median positioning.

Scar contraction

Scar contraction is a long-lasting process. If scarring could cause re-deviation of the nose, it should be a slow and progressive effect over months and years, as we can observe in tip modification or alar retraction. However, there is insufficient reason to hypothesize that scar retraction would occur since the first weeks or would be asymmetric, as the surgical exposure and dissection were done on the midline.

Insufficient nasal foundation

Equalizing nose foundation in hypoplastic maxilla definitely plays a role as suggested by Westreich RW and Rorhich R [32–34]. Subcutaneous alar filler grafts, initially described by Norman Pastorek, will stabilize the nasal base, correct the side of maxillary deficiency, and help support the foundation of the nose. However, if insufficient support over the bony foundation is obtained, it will affect mostly the tip rather than the entire pyramid, and the outcome would be immediate after surgery.

Facial envelope effect

As we have noted above, most authors describe long-term stability of the nose as derived from rigid or semi-rigid structures. Among authors recognizing the importance of the soft tissues, Rohrich et al. [35] recognize that nasal deviation is closely related to facial asymmetry. He underlined that the nose tends to deviate from the wide side of the face. 3D imaging showed that asymmetry in the maxilla is also reflected in the facial tissue volumes [35].

Most authors agree that during development, asymmetry of the muscle action or skin abnormalities will cause deformities, e.g., cleft lip nose, Parry-Romberg syndrome, torticollis, etc. The paradox is that little attention is paid to the same tissues and their changes after rhinoplasty in a congenitally deviated nose. It is, however, possible to observe important changes in the facial soft tissue when looking closely at pre- and postoperative images. For example, the repositioning of the facial envelope is obvious in the postoperative medialization of the philtrum, in the position of the nostrils, or on nasolabial folds (Fig. 4).

As a result, when the nose is set in the midline after rhinoplasty, additional tension is created on the short side of the face, while the wide side of the face loosens (Fig. 5). The short

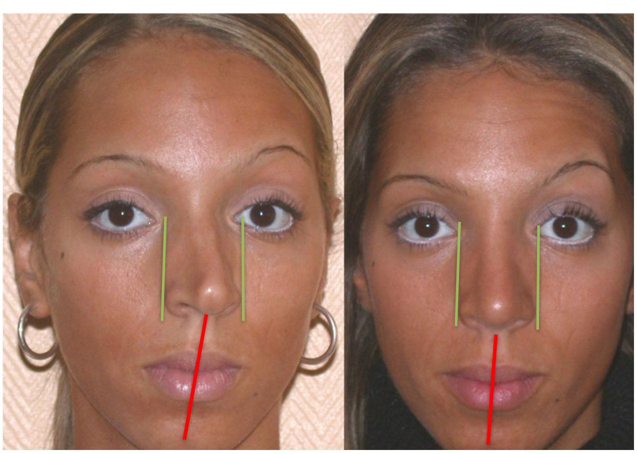

Fig. 4 Effect of median repositioning on soft tissues. The red lines represent the axis of philtrum and the green line represents the position of the nostrils relatively to the orbits

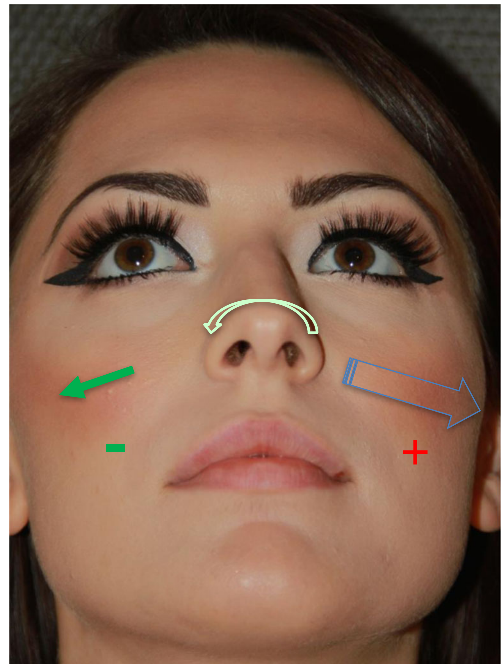

Fig. 5 Effect of median nose repositioning on facial soft tissues. Tension will increase on the hypoplastic side (red arrow) while tensile strength loosens on the wide side (green arrow)

side tension will even increase with facial expressions and smiling. Over time, these tissues gradually stretch and accommodate, but this process of relaxation is not immediate. This soft tissue constraint explains why, to our opinion, a nose that is perfectly straight after surgery may re-deviate progressively toward the hypoplastic side over a relatively short period.

We hypothesize that these tensile forces in facial soft tissues, fascia, and muscles will cause a progressive re-deviation process over a period of months until healing of bony and cartilaginous structures is complete and definitive stretching of soft tissues is obtained.

To test this facial envelope hypothesis, we designed and conducted an ongoing study with a personal surgical modification where the dorsal aspect of the nose is anchored deeply in the muscular and subcutaneous tissues contralateral to the deviated nose. We suggest that rigging the nose during the healing phase may counteract the unbalanced tension of the soft tissue. A possible slowing down of the re-shifting process of the nose, earlier stabilization in the postoperative period, or even overcorrection will be investigated to support our theory.

Conclusion

Postoperative recurrence of nasal deviation is observed in a high number of patients and gradually evolves during the first months before definitive stabilization. We suspect that preexisting asymmetry of the face plays a major role in the etiology of recurrence. We measured asymmetry in the midface of the deviated nose in almost every patient. We propose a simple method of assessing vertical facial asymmetry by comparing two anthropometric angles, namely MFA and IMA. Vertical asymmetry is present when these two angles significantly differ.

After reviewing different possible factors, we conclude that asymmetric soft tissue interaction—by tensioning muscular, fascial, and ligamentous insertions and by stretching the soft tissue on the hypoplastic side of the face—creates uneven forces on the NA until reasonable relaxation of the soft tissues and complete bone healing are achieved.

To test this "facial envelope theory," we are conducting additional studies with a new surgical technique. Anchoring the nose on the midline to counteract these facial elastic forces is being tested. The phase II pilot study results using absorbable sutures to rig the nose are presented in the second article of this study.

Compliance with ethical standards

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Ethical approval retrospective studies Accepted by Belgian ethical committee.

Conflict of interest Goffart Y., Remacle S. declare that they have no conflict of interest.

Informed consent Informed consent was obtained from all individual participants included in the study.

Additional informed consent was obtained from all individual participants for whom identifying information is included in this article.

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