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The effect of a Le Fort I incision on nose and upper lip dynamics: Unraveling the mystery of the "Le Fort I lip"

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ABSTRACT

Introduction: Postoperative flattening of the upper lip with loss of lip pout and down turning of the corners of the mouth is often seen after Le Fort I surgery. We aim to determine which facial muscles are involved in this phenomenon to update the literature on this subject.

Methods: In 6 cadavers, a unilateral Le Fort I incision was executed. After removal of the skin, all individual facial muscles were identified and submitted to bilateral tactile traction, comparing incised sides with non-incised sides.

Conclusion: All the components of the deep layer of the modiolus alae nasi (transverse part of the nasalis muscle and the myrtiformis muscle) and the deep layer of the midface musculature (levator anguli oris muscle) were transected by the Le Fort I incision. After performing the incision, the majority of the depressor septi nasi is intact. Further, the superficial layer of the midface musculature is intact but it loses tension because of its connection to the deep layer. This study suggests the importance of correctly suturing the deep muscular layers to maintain the 3-dimensional facial contour. Moreover, in this cadaver study, we attempt to predict the functional consequences on the impairment of facial mimics related to the Le Fort I incision.

1. Introduction

Gaining surgical access to an osseous structure, mainly for maxillary osteotomies and genioplasties, requires careful soft tissue dissection and therefore careful reconstruction of the transected structures at the end of the surgery to maintain soft tissue function. The functional aspects of facial soft tissue components can be both static and dynamic. Static aspects include maintaining facial contour and nasal width, whereas dynamic aspects can be described as facial expression or correct pronunciation. Modern concepts of orthognathic surgery are oriented towards a predicted static soft tissue outcome. The effect of adequate soft tissue reconstruction during orthognathic surgery on dynamic soft tissue functionality, however, remains unclear.

Descriptions of the muscular structures encountered during soft tissue dissection of a Le Fort I osteotomy vary significantly among authors. The design and localization of the mucosal incision, the submucosal, trans- or para-muscular dissection, and the extent of subperiostal dissection are the main determinants for the encountered muscular structures. Ancient masters promoted extensive subperiostal dissection with detachment of the insertions of the transverse part of the nasalis muscle, levator labii superioris (LLS), levator alaeque nasi muscle (LLSAN), zygomaticus muscles, oblique fibres of the orbicularis oris, myrtiformis muscle (MM), and incisal muscle (Schendel and Delaire, 1985). Modern authors limit subperiostal dissection and detachment of muscular anchorings as "overzealous dissection [that] could lead to sag of the soft tissue envelope and a plumper aspect of the midface" (Mommaerts, 2013).

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The impairment of a facial muscle, whether transected or detached from its origin, has an effect on facial contour and facial dynamics. The influences on facial contour, the static changes, are well described. In case of exclusively mucosal suturing without muscular closure after Le Fort I surgery, three typical issues in soft tissue redraping can be encountered. Changes in the width of the alar base of the nose in relation to the maxillary movement have been documented by many authors (Mansour et al., 1983; Schendel and Carlotti, 1991). Changes in nasal tip projection and vertical axis of the nasal valve must also be considered, but are probably more related to hard tissue management and nasal septum positioning. A second issue is upper lip flattening, with an apparently decreased thickness of the lip, loss of normal lip pout, and a decrease in the amount of visible vermilion (Schendel and Delaire, 1985). Dropping of the corners of the mouth is the third characteristic that can be present after Le Fort I surgery without muscular closure.

Only a few teams have reported on the dynamic changes in postoperative facial mimics (Johns et al., 1997; Nooreyazdan et al., 2004; Sforza et al., 2008; Muradin et al., 2009; Popat et al., 2012). Surgeons with experience in Le Fort I osteotomies will agree that the mobility of the central upper lip decreases significantly for a variable postoperative period, the so-called "Le Fort I lip." To set up a research project on the effect of soft tissue management after Le Fort I surgery on the dynamics of the midface, a discussion arose about the fundamental question of which facial muscles are involved. With the modern tendency to limit subperiosteal dissection, the current muscle involvement cannot be as extensive as previously described. This cadaver study determines the encountered components of facial musculature of a modern Le Fort I incision, combining recent concepts in soft tissue management (e.g., subspinal osteotomy; Mommaerts et al., 1996) and a limitation in subperiosteal dissection. Furthermore, we attempt to predict the hypothetical static (three-dimensional) and functional (four-dimensional) consequences, secondary to the injury of a specific facial muscle.

2. Materials and methods

2.1. Cadaver population

Six fresh-frozen heads were obtained from the department of Human Anatomy & Embryology of the University of Antwerp. Before dissection, demographic data were obtained for each cadaver (age and sex). Specimens were excluded if there was evidence of previous surgical intervention involving the soft or osseous facial tissues.

2.2. Procedure

In all cadavers, a unilateral Le Fort I incision was executed. Fig. 1A shows an intraoperative image of the Le Fort I incision. The incision varies slightly from the incision described by other authors (Bell and Condit, 1970; Ellis and Zide, 1995; Miloro et al., 2004; Ueki et al., 2006), but the department of Maxillofacial Surgery of the AZ Monica Hospital in Antwerp has 33 years of experience with this incision, with only minor modifications over time. It is a rectilinear incision in the intraoral mucosa, 1.5 cm cranial of the mucogingival border. Once the mucosa is incised, the edge of the no. 15 blade is pushed on the bone. Bony contact is acquired in the most lateral part of the incision. The no. 15 blade is then inclined to a 60° angle to complete the submucosal and periosteal dissection. The incision was checked on transection of muscle bundles, which were marked with methylene blue (Methylthioninium Chloride Proveblue, Cenexi, Fontenay-sous-Bois, France). Fig. 1B shows a unilateral Le Fort I incision in a cadaver. Subsequently, skin and subcutaneous fat were carefully removed. 2.5× extended field magnifying loupes (Designs for Vision, Ronkonkoma, New York, USA) were used for the methylene marking, the skin and fat removal and the identification of the different facial muscles (pars alaris and pars transversa of the nasalis, MM, depressor septi nasalis, LLSAN, LLS, zygomaticus minor, zygomaticus major, risorius, orbicularis oris, levator anguli oris (LAO) and buccinator). Single-lens reflex macrophotographs were taken using a Nikon camera (model D300, Nikon Inc, Melville, New York, United States). A 1080p HD video recording was obtained using the iSight Camera of an iPhone 5S (Apple Inc., Cupertino, California, USA). Direct inspection and bilateral comparative tactile traction testing was used to examine whether a mimic muscle was transected, released from its origin or left intact.

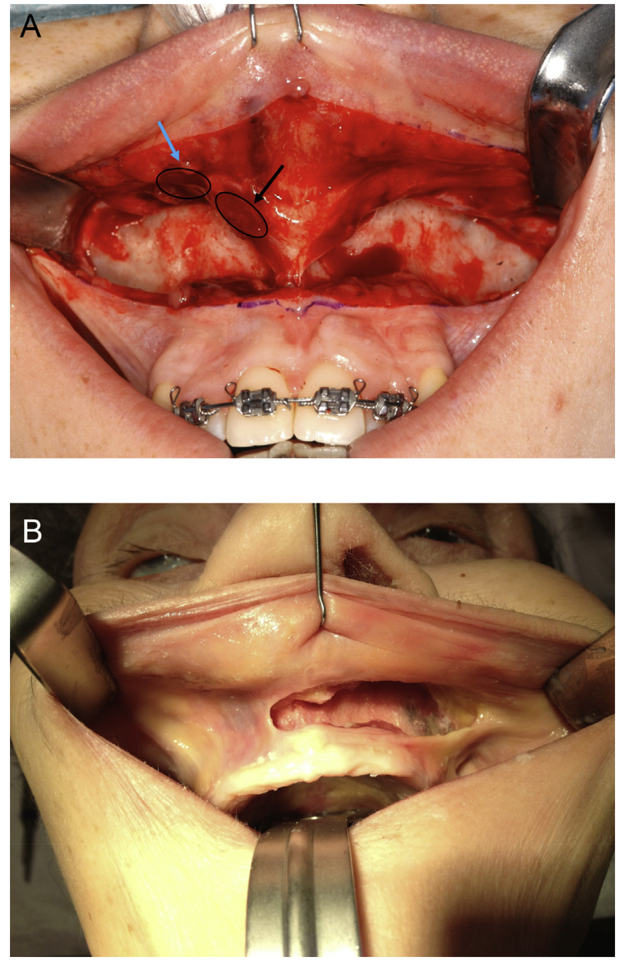

Fig. 1. (A) Intraoperative view (cephalic); black arrow, transected myrtiform; blue arrow, muscle transected nasalis muscle. (B) Unilateral Le Fort I incision in a cadaver before methylene blue marking. Rectilinear incision in the alveolar mucosa at a 1.5-cm distance of the mucogingival border. Once the mucosa is incised, the point of the blade is pushed until bone contact is acquired in the most lateral part of the incision. The blade is then inclined to a 60° angle to the bony surface to complete the submucosal and periosteal dissection.

3. Results

Six cadaver heads were dissected. The mean age of the cadavers (five females and one male) was 72 years, with all cadavers older than 60 years.

4. Discussion

Despite differences in the types of Pessa midfacial muscle pattern (Pessa et al., 1998), there was no influence on the anatomical findings related to the encountered muscles in the Le

Fort I incision. The lateral paranasal, central nasal musculature, and the lateral facial mimic musculature will be discussed separately.

4.1. Lateral paranasal region

To predict the static (3D) and dynamic (4D) consequences of the impairment of a facial muscle, we will use a theoretical model by Delaire (1978) that describes the facial musculature as three interconnecting muscular rings, which support each other and have medial and lateral anchorage points. The superior ring is suspended from the infraorbital rim, the nasal bridge, and the frontal process of the maxilla, and it encircles the nose to maintain its static dimensions and mobilizes the tip and alar part (Schendel and Delaire, 1985). Interruption of the upper loop will therefore widen the nasal base (3D) and impair tip and alar mobility. In the lower paranasal region, the superior loop is connected to the middle loop, consisting mainly of the orbicularis oris muscle. Figallo and Acosta (2001) named the hither chiasma of paranasal musculature of the superior ring with the middle ring the *modiolus alae nasi*.

Daniel et al. (2013) refined this concept by defining the existence of a superficial and a deep layer, connected by intertwined muscle fibres. The superficial layer has a transverse course and comprises the LLS, LLSAN, and the superficial part of the orbicularis oris. The superficial layer was intact in all dissected cadaver heads, as shown in Video 1 and Fig. 2. The deeper layer, however, was transected in all cadavers because of its more vertical aspect (Fig. 3). According to Daniel et al. (2013), the deeper layer includes the MM, the transverse nasalis and the "dilator naris," a muscle variously described by different authors, which they see as a distinct entity. In our limited series of six dissections, however, we could not identify this muscle as distinct from the nasalis muscle, as was the case for other authors (Figallo, 1995).

Supplementary video related to this article can be found at http://dx.doi.org/10.1016/j.jcms.2016.08.022.

4.2. Myrtiformis muscle (MM)

Aiach (1993) describes the vertical course of the MM from its juxta-alveolar origin above the lateral incisor (myrtiform fossa) towards the lip, the base of the columella and the nostril. According to Daniel et al. (2013), the origin is broad (10–15 mm) and it counteracts the action of the LLSAN. The electromyographic tests of Delaire (1977) show that the MM is responsible for the anterior projection of the central part of the upper lip, resulting in down movement of the nasal tip and contraction of the nasal orifice. Because of its vertical course, the muscle belly of the MM was transected in all cases with intact origins.

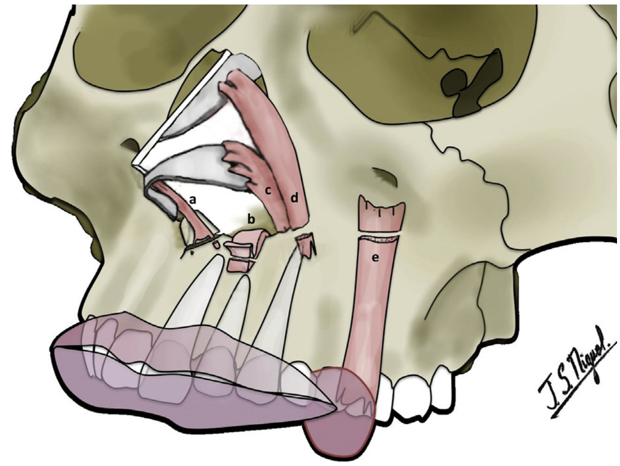

Fig. 3. (a) The depressor septi nasi in mainly unaffected by the Le Fort I incision, because we routinely perform a subspinal osteotomy and leave the periosteal insertions of the anterior nasal spine intact. However, function will be impaired because the subspinal osteotomy fragment of the maxilla can be considered as acting like an avulsion fracture. (b) The MM is transected above its inferior origin. Some of the fibres of the MM connect to the muscular components of the superficial layer. The loss of tension of the intact superficial layer can be explained by these connections between the deep and superficial layer. (c) Alar part of the nasalis muscle. (d) The pars transversalis of the nasalis muscle is cut a few millimetres above its inferior anchorage point. (e) The LAO muscle is transected just below its superior anchorage point.

Fig. 2. Skin and subcutaneous tissue have been removed. The forceps holds part of the superficial layer of the facial musculature (LLS, LLSAN and zygomaticus minor) after they have been surgically detached from their insertion on the orbicularis oris muscle. Note that the superficial layer was intact before this manoeuvre. The black arrow indicates the transection of the deep layer of the modiolus alae nasi (nasalis muscle, MM), the blue arrow indicates the transected LAO.

4.3. Nasalis muscle

As classically described, the nasalis muscle has two components: the pars transversalis and the pars alaris. The transverse part compresses and elongates the nose by contracting the nostrils and narrowing the vestibules, and is therefore called the compressor nasi (Guyuron, 2006). The pars transversalis is transected in all cadavers a few millimetres above his inferior anchorage point, as shown in Figs. 1A and 2.

Regarding our theoretical model, interruption of the upper loop could result in widening of the nasal base (3D). Functionally (4D), an impairment of the contraction of the nasal orifice could theoretically be expected, together with less anterior active projection of the central part of the lip (Delaire, 1977).

4.4. Central nasal region: depressor septi nasi (DSN)

Reintroduced by Pinto et al. (1998) after a period of academic omission, the presence of the DSN as a distinct muscle could be confirmed in all cases, although sometimes it was very atrophic. Although described by Daniel et al. (2013) as arising from the maxilla directly above the central incisor, our dissections show a more prominent origin, just below the nasal spine, with only a minor part arising from the midline between the central incisor and the nasal spine. The majority of the muscle, therefore, was unaffected by the Le Fort I incision because we routinely perform a subspinal osteotomy (Mommaerts et al., 1996) and leave the periosteal insertions of the anterior nasal spine intact. However, function will be impaired because the subspinal osteotomy fragment of

Table 1
Summary of the results of the cadaver study.

		Transection?	Loss of function to be expected[a]?	Possible theoretical consequences of transection and/or loss of function[b]	
				Static effect	Dynamic effect
Modiolus alae nasi	Superficial layer	No	No	–	–
	Deep layer (MM, Nasalis muscle)	Yes	Yes	Widening of the nasal base	• Weakened contraction of nasal orifice • Impaired anterior projection of central part of the lip
Depressor septi nasi		No	Yes (avulsion fracture)	Upwards rotation of the nasal tip	Less depression of the nasal tip on animation
Lateral midface musculature	Superficial layer (LLS, LLSAN, Zygomaticus major and minor)	No	Yes (loss of tension)	Flattening of the upper lip	
	Deep layer (LAO)	Yes	Yes	Down turning of the corners of the mouth	

MM, myrtiformis muscle; LLSAN, levator labii superioris alaeque nasalis; LLS, levator labii superioris; LAO, levator anguli oris.
[a] Loss of function could hypothetically be expected if the muscle is transected or one of the origins is released.
[b] Assumptions are based on the impairment of the function of each muscle. Herefore, we make use of the description of the function of each muscle as stated in Delaire (1977), Schendel and Delaire (1985), and Guyuron (2006).

the maxilla can be considered as acting like an avulsion fracture. Except for an upwards rotation of the nasal tip (3D effect), impairment of the DSN could result in a subsequent deficiency of the depression of the nasal tip on animation (4D) (Guyuron, 2006).

4.5. *Lateral facial midface musculature*

The midface musculature can be divided into a deep and a superficial layer. They arise either directly from the periosteum or from adjacent muscles and insert into other facial muscles or directly into the connective tissue of the skin (Schünke et al., 2007).

4.5.1. *Deep layer*

Fig. 2 clearly shows a transected LAO muscle in the lateral extent of the incision. Limiting the extent of the incision (Raffaini, 2013) would equally lead to a loss of function as the infraorbital origin of the LAO is released by subperiostal dissection. The down turning of the angles of the mouth at rest in the postoperative phase could therefore be explained by the unopposed depressor activity of the triangularis muscle after section and/or detachment of the LAO.

4.5.2. *Superficial layer*

Schendel and Delaire (1985) reported the insertions of all muscular components of the superficial layer (LLS, LLSAN, and the zygomaticus muscle) to be damaged by the Le Fort incision. As a detached muscle tends to reattach at a shortened length, Schendel and Delaire hold the lateral vector resulting from the muscular retraction of the muscles responsible for flattening the upper lip and apparently decreasing the thickness of the upper lip. We found the superficial layer to be intact, as clearly can be appreciated on Video 1 and Fig. 2: the intact LLS, LLSAN, zygomaticus major and minor muscles are released to better visualize the deep layer. On bilateral comparative tactile traction testing, however, all components of the superficial layer showed a clear loss of tension in relation to the nondissected side. Superficial and deep layers are mainly at the level of the oral and nasal modiolus and attached by interconnecting fibres. Section or release of a muscle of the deep layer of the modiolus alae nasi or the midface musculature will therefore reflect on the tension of the muscles of the superficial layer, although these muscles are stricto sensu intact. Loss of tension of the muscles of the superficial layer could result in flattening of the upper lip, due to a lateral vector and a volume shift away from the midline if the deep muscular layers are not properly addressed during wound closure.

5. Conclusion

The results of this cadaver study are summarised in Table 1. All of the components of the deep layer of the modiolus alae nasi (transverse part of the nasalis muscle and MM) and the deep layer of the midface musculature (LAO) were transected by the Le Fort I incision (Fig. 3). Sectioning of the deep layer of the modiolus alae nasi could lead to widening of the nasal base if the transected muscle endings were not reattached and repositioned. Moreover, weakening of the contraction of the nasal orifice could be expected, as well as the impairment of the anterior projection of the central part of the lip. Sectioning or releasing the LAO could be held responsible for the down turning of the angles of the mouth. The superficial layer of the midface musculature is intact, but it loses tension because of its connection to the deep layer. This finding could explain the flattening of the upper lip after improper closure of the deep layers. Because of the subspinal osteotomy, the majority of the DSN is intact; however, its function will be impaired because the bone fragment of the subspinal osteotomy acts as an avulsion fracture.

This study suggests the importance of correctly suturing the deep muscular layers to maintain static facial contours. Moreover, this cadaver study attempted to predict the functional consequences of the Le Fort I incision on the impairment of facial mimics. Although it is impossible to deduce dynamic findings from a cadaver study, these findings form a theoretical base for a clinical study that will try to confirm the functional assumptions made in this article and focus on recovery of facial mimics after Le Fort I surgery.

Conflict of interest

The authors have no financial interest to declare in relation to the content of this article.

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