Macroscopic surgical anatomical examination of the external nose and innovative surgical techniques in the aesthetic and reconstructive operations of the nose and the treatment of the alveolar cleft

PhD thesis

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INTRODUCTION

Fundamental anatomy of the external nose

With the wide spread adoption of reconstructive and aesthetic rhinoplasty surgery following adoption of the open – transcolumellar / Rethi-type –technique, there appeared a need for understanding nasal anatomy in greater detail. With this work, our aim is to reveal morphological features that may be important to preserve or to recreate. This is also true for the rhinoplasty of the cleft patients, with the difference, that in those cases the structure must not only be modified but often require reconstruction of the tissue that failed to develop.

The bony base of the nose is created by the paired nasal bones and the frontal process of the maxilla and premaxilla. They create the pear-form opening anterior bony nasal opening - the pyriform aperture. The nasal cavity can be divided into meati by the upper, middle and lower turbinates and the bony and cartilaginous septum. Thus, we can distinguish upper, middle, lower and common nasal meatuses. Both in rhinoplasty and cleft surgery aspect, the lower and middle meatuses and turbinates are clinically significant. The triangular cartilages (cartilage nasi lateralis) are referred to as the upper lateral cartilages in the English literature, that are connected to the dorsal edge of the cartilaginous septum. We will refer to these cartilages hereinafter as upper lateral cartilages (ULC). The great alar cartilages are paired cartilages caudal to the upper lateral cartilages and we will refer to them hereinafter as lower lateral cartilages (LLC). The small alar cartilages (cartilage alaris minor) join to the lateral end of the lower lateral cartilages. We will refer to them hereinafter as accessory cartilages. The nasal muscles are composed of numerous small muscles whose topography and function is still not absolutely clear. The source of the confusion is probably the complicated course of the muscles, emergence of rare remnant muscles, the huge number of anatomical variations and the small size of the muscles. The blood supply of the external nose is insured by three main arteries: columellar, dorsal nasal and lateral nasal. The facial artery may terminate in the angular artery that courses towards the medial canthus. It gives a branch to the lateral nasal wall, called lateral nasal artery, that along with the marginal artery contributes to the creation of the alar arcade. The sensory innervation of the nose is from multiple sources. The radix is mostly supplied by the infratrochlear branches of the ophthalmic nerve. The majority of the nasal dorsum is supplied by the anterior ethmoidal nerve. The remaining areas are supplied by the infratrochlear nerve. The palatinal branches minimally also participate in the sensory innervation of the columellar skin. The facial nerve innervates the mimetic muscles of the face. The innervation of the nasal muscles is provided by the zygomatic terminal branches.

Nasal deformity associated with the cleft lip

Complete cleft lip is always associated with the deformity of the nose as well. It does not mean that the partial cleft lip cannot be associated with nasal deformity. The development of the lip and nose are firmly associated, since the cranial end of the upper lip continues into the nasal base. The premaxilla, maxilla and also the upper lip constitute the support of the nasal base. As the child growths the nasal deformity will become more significant with the end of nasal growth occurring at the end of puberty.

The unilateral cleft lip nasal deformity is characterized by the following: short columella; columellar base is deviated towards the unaffected side; tip is deprojected and deviated; tip defining points are asymmetrical; alars are broad and flat on the side of the defect; alar rim is more convex on the side of the defect; nostrils are asymmetric; the nasal cavity is located more caudal on the side of the defect than on the contralateral side; origin of the alars are more lateral than normally; the anterior nasal spine and the caudal septum is shifted to the unaffected side; the septum is deviated in every case, so more or less nasal obstruction is always present; most of the cases the lower turbinate is hypertrophic on the side of the defect; the maxilla is underdeveloped on the cleft side; the segments of the upper dental arch are in malposition.

Bilateral cleft lip is characterized by the following nasal deformity: columella is symmetrically shorter and its base is wider, that continues into the prolabium; the tip is severely deprojected; the origin of the alars are lateralized, so the alars are flat; the nostrils are almost symmetrical, however their long axis becomes not vertical but horizontal; the convexity of the alar rims is extreme, because of the symmetrical tip deprojection; the nostril sill does not develope; the nasal tip is broader and each crus of the lower lateral cartilage is distorted, because of the tip deprojection; the anterior nasal spine and the caudal septum is more caudal then normally.

The alveolar cleft that causes the sinking of the nasal base

The alveolar osteoplasty is done to reconstruct the maxillary cleft. The most accepted form of the alveolar osteoplasty is the early secondary alveolar osteoplasty which means that the operation is done around the 8-10th year of age before the cleft side permanent canine tooth would erupt. The bone graft utilized is most often an autologous graft, that are most often composed of particulated spongious bone grafts from the iliac crest. This graft incorporates very well into the alveolar cleft and locally contributes to the osteogenesis through surviving osteocytes and induction of the osteoblast activity. The precise preoperative morphology of the alveolar cleft is crucial. 3-dimensional evaluation of the cleft is not an easy task, even if CBCT (cone-beam computed tomography) imaging is available, because the individual differences are significant, and the anatomy of the alveolar cleft is complex. CT (computed tomography) based surgical simulations became available in surgery. There are 3-dimensional computer programs that allow the planning of bone grafts into the alveolar cleft. These programs allow valuable insight into a localized defect, but do not evaluate the impact on the associated nasal deformity. Looking at the cleft patients alveolar and nasal deformity, it becomes obvious that alveolar cleft effects the above located lower nasal base and indirectly effects the nasal tip projection. The nasal base sinks downward on the cleft side of the nose. Thus, the bony support is insufficient on the effected side, the pyriform aperture is deformed, and it is positioned posteriorly in an antero-posterior plane.

Dorsal preservation in rhinoplasty

In most of the aesthetic-reconstructive rhinoplasty, the reduction of the dorsal hump is an essential part of the operation, that results in disintegration of the osseocartilaginous vault. By lowering of the dorsal height, the dorsal keystone area is totally destroyed, that’s why it must be rebuilt for aesthetic and functional reasons. Thus, if we have any possibility for preserving the dorsum, then it would be possible to improve nasal function and preserve the natural dorsal aesthetic lines. Furthermore, it would be possible to avoid the secondary complications of the nasal dorsum. In case of reconstructive rhinoplasty, especially in cleft lip and palate patients, the width of their dorsum is frequently excellent, however the axis of their nasal dorsum is almost always deviated. If their dorsum is appropriate except the deviation, it would be worthy to correct the deviation and parallelly preserve the integrity of the osseocartilaginous vault. The answer is the "push down" technique, that has been popularized by Cottle, as an alternative solution for the dorsal reduction technique described by Joseph. The basic purpose of the technique is the preservation of the osseocartilaginous vault. Applying this conservative approach, the internal valve collapse can be avoided, that obviously negatively effects the nasal breathing and the dorsal aesthetic lines. Furthermore, the lowering of the intact osseocartilaginous vault results in cranial rotation of the lateral crus of the lower lateral cartilage through scroll area thus stabilizing the junction between the upper and lower lateral cartilages. The basic concept of dorsal preservation in nasal surgery was introduced by Lothrop in 1914. His technique was a *push in maneuver* of the nose composed of the three following steps: 1) septal strip removal from the bony and cartilaginous septum close to the dorsum, but not immediately under it, 2) triangular bony strip removal from the frontal process of the maxilla, 3) percutaneous osteotomy in the radix. Cottle and al. described another type of "push down" technique in 1954, that preserved the continuity of the dorsum, but achieved the lowering of the nasal septum in a different way. Gola refined and modified Cottle's technique in 1989 by resecting from the septum directly underneath the dorsum. The high septal resection results in a direct dorsal lowering, that has been further refined by Saban. Even if the results of dorsal preservation techniques were generally good, yet they gradually walked out from standard rhinoplasty. It has 3 main reasons: 1) the classical Cottle "push down" technique meant a complicated septal surgery; 2) the technique was not divergent enough to be applicable in a wide spectrum of rhinoplasties, i.e. the original hump had to be more or less normal; 3) the classical structural open rhinoplasty ensured better vision onto the osseocartilaginous vault, so the structure could be controlled in a more precise manner.

OBJECTIVES

Our goal was to examine the anatomy of the lateral crus of the lower lateral cartilage, not to be taken out from its environment, but to embed it in the whole nose. Thus, we define its position, axis and dimensions. With anatomical dissections we aimed to determine the normal static anatomy and with clinical measurements we aimed to determine the morphological and positional changes in nasal surgery. Our goal was to compare the surgical concepts with the anatomical reality, and to evaluate the anatomical properties of the cartilage in conjunction with its aesthetic effect on the surface.

We have set the goal of reviewing and comparing the previous literature of the lower nasal base with the results of our own cadaver dissections. Since the lower nasal base is not formed by cartilage tissue, its static shape and dynamic function are determined jointly by the skin, subcutaneous tissue and the nasal muscles, which is clinically difficult to investigate. We searched for information about the following muscles and performed dissections: levator labii superioris alaeque nasi, orbicularis oris, depressor septi nasi, myrtiformis, dilator naris.

Among our objectives was the anatomical definition of the bony-cartilaginous arch dimensions and structure, and the detection of morphological changes in the structures of the nasal dorsum during rhinoplasty. Furthermore, we intended to review the clinical relevance of this area in our study.

It was our intention to describe a virtual graft planning process that fits into the cleft of the upper dental arch and the pyriform aperture. Furthermore, our goal was to create a real-size nasoalveolar graft sample for clinical use.

We have set a goal to investigate a minimally invasive surgical technique that is simple and reliable to reduce the height of the nasal dorsum. Surgeons begin to recognize the functional and aesthetic consequences of breaking the integrity of the bony-cartilaginous vault with the classical dorsal resection techniques. These techniques provide an opportunity to preserve the original nasal dorsum and to treat straight deviations, which are often the characteristics of the nasal deformity of the cleft lip and palate patients.

METHODS

Lateral crus of the lower lateral cartilage

Between 2012. December and 2013. January, we carried out 41 consecutive aesthetic open rhinoplasty on Caucasian women. The tests were conducted prospectively. Asian and Afro-American patients were excluded from the study, as their nasal tip morphology considerably differs from the Caucasian. We made standard photo shots before surgery after marking the nasal tip. After the skin has been lifted, the lower lateral cartilage was photographed, and multiple measurements were performed. To fully understand the morphology of the lower lateral and accessory cartilages - especially the area that is not visible under an open rhinoplasty - we also performed fine macroscopic anatomical dissections. The noses of 20 fresh cadavers have been dissected on both sides.

The lower nasal base

In 45 fresh cadavers we performed anatomical dissections in the area of the lower nasal base, the average age of which was 67 years. The specimens were randomly selected into the study. The excluding criteria was the previous rhinoplasty or nasal trauma. All dissections were performed with the help of a 2.5-3.5x magnification lupe. We performed a classic layered anatomical preparation to the SMAS layer and then we proceeded to the deeper layers with surgical preparation. Photo documentation was always done in standard views and measurements were also made directly in the specimens.

The osseocartilaginous vault

In the clinical study, 9 patients undergoing rhinoplasty were included prospectively. All patients were female of Caucasian race, with an average of 23.8 years of age. The surgeries were carried out in November and December 2013. All these investigations have been carried out in accordance with the Helsinki Declaration guidelines. Patients were involved in the study, who needed to reduce their dorsal height. Only preliminary nasal trauma or nasal surgery were exclusion criteria. A photo documentation was performed, and measurements were carried out on the intact osseocartilaginous vault to evaluate the changes after nasal dorsum reduction. The bony dorsum was then reduced, and the measurements were carried out. It was followed by cartilaginous dorsum reduction, which was also followed by photodocumentation and measurements. We also made dissections on 15 fresh cadavers (30 heminoses) with an average age of 67 years. None of them had any previous nasal trauma or rhinoplasty. The soft tissue envelope of the nose has been removed, then the perichondrium of the upper lateral cartilages and the periosteum of the bony vault have been removed by the help of a 4.3x magnification lupe. Measurements were made to determine the dimensions of the intact osseocartilaginous vault from the nasofrontal suture line to the anterior septal angle. In the next step, the nasal bones were removed en bloc, then we measured the dimensions of the uncovered keystone area and the entire cartilaginous vault. Photo documentation was performed during the dissections.

3D simulation of the alveolar cleft defect

10 unilateral cleft lip and palate patients were included randomly into our study from the common database of the I. Pediatric Clinic of the Semmelweis University and the AZ Sint Jan Craniofacial Centre. CBCT data has been obtained to visualize the alveolar cleft, to design a virtual nasoalveolar graft and to print out its real-size template. CBCT data was processed that was transferred to a computer workstation in a navigation system. After the designing process, the planned objects have been exported to a 3D printer, and then the printing has been performed. In one case, the clefted upper jaw was also printed.

Dorsal preservation techniques

Between January 2011. and June 2016. we performed 740 rhinoplasties and we examined this sample retrospectively. The study was conducted in accordance with the Helsinki Declaration guidelines. Exclusion criteria was a former of any rhinoplasty, so 540 primary cases were selected into the study. In which patients we performed nasal preservation and in which patients we performed nasal resection, the characteristics of the nasal dorsal hump determined it. In the case where the dorsal hump was a straight profile, we preserved it. In case where it was kiphotic, we examined it further. If a predominantly cartilaginous vault was the hump, it is a dorsal preservation, if it was formed by a predominantly bony vault, dorsal resection was performed. The average age of the 320 patients undergoing primary dorsal preservation was 29 years. The follow-up time was on average 2 years 5 months.

RESULTS

Lateral crus of the lower lateral cartilage

The length of the nostrils varied in an anteroposterior direction between 13 and 18 mm, with an average length of 16.1 mm. The distance between the midpoint of the alar rim and the caudal edge of the lateral crus varied between 3 to 9 mm, on average 5.9 mm. The axis of the lateral crus has been classified by Zelnik and Gingrass on the basis of the determination of Johnson and Toriumi with the concave-flat-convex terminology. The shapes of the lateral crus on the horizontal (transverse) axis were found as follows: flat-straight, n = 13 (32.5%); convex, n = 9 (22.5%); concave, n = 7 (17.5%); flat-convex, n = 6 (15.0%); convex-concave-convex, n = 5 (12.5%). The shapes of the lateral crus were found on the vertical axis: flat-straight, n = 11 (27.5%); convex, n = 10 (25.0%); flat-convex, n = 8 (20.0%); concave, n = 6 (15.0%); convex-concave-convex, n = 5 (12.5%). The relationship between the cephalic and caudal edge of the lateral crus was found as follows: the cephalic edge is higher than the caudal (more lateral), n = 24 (60.0%); the cephalic and the caudal edge are at the same level, n = 14 (35.0%); the caudal edge is higher than the cephalic, n=2 (5.0%). The inclination angle between the caudal edge of the lateral crus and the parasagittal plane through the tip defining point varied between 30 to 60 degrees, with an average of 43.6 degrees. The width of the lateral crus has been measured along the vertical axis at the turning point. The value varied from 7 to 14 mm, on average 10.1 mm. The scroll area (the area where the lower lateral cartilage scrolls over the upper lateral cartilage) was found as an S-shape junction in all cases at the widest point of the lateral crus. The average dimensions of the lateral crus of the lower lateral cartilage are as follows: length on the transverse axis 23.4 mm; width at the lateral genue 6.4 mm; width at the turning point 11.1 mm; distance between the dome and the turning point 13.3 mm; thickness 0.5 mm. The accessory cartilage chain was present at all dissections with an average length of 18 mm in total. The incidence of the accessory cartilages is: first accessory cartilage 100%, second 94%, third 38%, fourth 19%. The average length and width of the first accessory cartilage: 8.5 x 4.5 mm, the second 6.5 x 3.4 mm, the third 6.3 x 3.6 mm, fourth 4.7 x 3.0 mm. Despite the diverse occurrence of the accessory cartilages, the total length of the accessory cartilage ring is relatively constant. The first cartilage in all cases, the fourth one in only 19% of the cases was a part of the accessory cartilage chain, the alar ring. It is important to point out that the accessory cartilages do not reach the pyriform aperture, but course medially towards the anterior nasal spine. Like the other nasal cartilages, the accessory cartilages can be found directly beneath the mucosa. They are separated from the subcutaneous tissue by the superficial musculo-aponeurotic system of the nose.

The lower nasal base

As part of our study, we performed a literature review, searching for articles related to the levator labii superioris alaeque nasalis, orbicularis oris, depressor septi nasalis, myrtiformis, and dilator naris. The following review of our results is an attempt to simplify and reconcile the surgical anatomy of the nasal musculature that affects the lower nasal base, as derived from our own cadaver dissections and those in the literature. Due to differences in terminology, any discussion of the nasal musculature is fraught with confusion and conflict. As noted in sequential editions of Gray's Anatomy, the myrtiformis muscle was included as a nasal muscle, then deleted, and eventually restored. The depressor septi nasalis is an example of a muscle whose composition, origin, and insertion can be arbitrarily redefined by surgeons with or without regard to prior anatomical terminology.

The levator labii superioris alaeque nasi (LLSAN) has often been classified as one of the many muscles of the mouth, yet its impact on the nose is even greater. The LLSAN was easily and consistently identified in all of our dissections. It originates from the frontal process of the maxilla and the medial canthal ligament. From here the muscle courses caudally and divides into two main parts: alar and labiocolumellar parts. After its alaris portion inserts into the alar base, the medial border of the labial portion becomes the defining muscle of the alar crease, and the lateral border helps define the triangle area between the nasolabial line and alar base. The labiocolumellar portion continues toward the columellar base with its inferior border joining the superficial portion of the orbicularis oris. Through its intermingling with the superficial orbicularis oris muscle, it acts as a significant depressor of the nasal tip.

Nicolau has divided the orbicularis oris muscle into a *deep and a superficial portion*. The superficial portion of the orbicularis oris is divided into a lower *labial bundle* and an upper *nasal bundle*. The labial bundle is essentially a transverse muscle originating on each side from the modiolus, then running across the lip to insert into the skin as either short fibers (ipsilateral philtral column) or long fibers (contralateral philtral column). The nasal bundle originates laterally from the two zygomaticus and two levator muscles on either side and then runs on an angle up into the columellar base. From our dissections, the superficial orbicularis oris was extensive and easily divided into labial and nasal bundles based on the orientation of the muscle fibers. In 14 of 15 cadavers in our study, the depressor septi nasalis was a paired deep muscle originating from the maxilla and did not provide the majority of the muscle mass to the columellar base. The insertion of the nasal bundle was into the footplate of the medial crura and the continuation of the superficial medial SMAS within the tela retinacular cutis above the interdomal ligament. In contrast to most surgical illustrations, the entire paranasal and upper lip area is encircled by a continuous superficial layer of muscle composed of the LLSAN and superficial orbicularis oculi. The myrtiformis muscle has been described and omitted by anatomists through the years and currently is absent from most surgical atlases of nasal surgery. Because of their surgical relevancy, we will consider the depressor septi nasalis and myrtiformis as two separate muscles. The myrtiformis muscle originates from the canine fossa, just above the lateral incisor and canine teeth. It divides into an anterior labial part, which goes to the upper lip, and a posterior nostril part, which inserts on the nostril floor. Its fibers intertwine with the dilator naris and the alar portion of the LLSAN. It depresses and expands the nostrils. Based on our dissections, the myrtiformis muscle was easily identified in all cadavers through transgingival approach. Few muscles have been as ignored or misrepresented as the depressor septi nasalis (DSN). The median part of the DSN passes through the membranous septum to connect with the deep part of Pitanguy's ligament. On the basis of our dissections, we found distinct paired DSN muscles originating from the maxilla directly above the central incisor in 14 of 15 cadavers. In all cadavers, the midportion of the muscle was beneath and easily separated from the overlying superficial orbicularis oris. Anatomists always described a *dilator naris* in the nose, however its multiple variations have been described. Based on our dissections, we consider it a distinct, individual muscle, that originates from the maxilla above the canine teeth, directly lateral to the origin of the myrtiformis muscle and medial to the origin of the transversalis muscle. We consider it the main dilator of the nostrils. After skin elevation, we identified in all cases a fibrotic structure originating from the dermis, that was connected to the deep muscles running to the ala. This structure is called the *tela subcutanea cutis*. This soft tissue fibrous envelope has been found in the area of the alar and alar rim. After skin removal, the form of the alar has been maintained.

The osseocartilaginous vault

Based on cadaver dissections, the size and shape of the intact *osseocartilaginous vault* varied in both the cephalocaudal and anteroposterior directions. In cephalocaudal direction, the mean median length from the nasofrontal suture to the most caudal point of the upper lateral cartilages was 41.3 mm. The average distance from the nasofrontal suture to the *nasion* is 5.3 mm, to the *sellion* 11.6 mm, and to the *keystone point* 24.7 mm. The average distance from the *keystone point* to the most caudal point of the upper lateral cartilages is 15.8 mm, to the anterior septal angle is 20.1 mm. The average distance from the most caudal point of the upper lateral cartilages to the anterior septal angle was 4.4 mm, while the average distance between the widest point of the bony nasal vault and the pyriform aperture is 6.5 mm. Between the caudal end of the dorsal edge of the *upper lateral cartilage* and the *cartilaginous dorsal septum*, an obvious macroscopically visible cleft has been observed in 30% of the heminoses (9 heminoses). The average length of this cleft was dorsally 1.55 mm. When the perichondrium of the dorsal nasal septum and the upper lateral cartilage were removed, it became obvious under magnification of lupe, that the aforementioned macroscopic fissure continued cephalically in an earlier not visible thin cleft. The total length of the paraseptal cleft was 6.2 mm. This value varied widely between 3-14 mm. In two heminoses, this paraseptal cleft was present all the way up to the bony vault. Both the macroscopically easily recognizable and the microscopic cleft varied in length in the right and left side, thus we did not find them symmetrical in any case. With en bloc elevation of the nasal bones, we visualized the entire *keystone area* and we could clearly separate it into 2 parts: the *dorsal keystone area (DKA)* and the *lateral keystone area (LKA)*.

DKA is created by the dorsal cartilaginous septum, while LKA is the cephalic part of the upper lateral cartilages. The separation line can be easily established on the basis of the dorsal aesthetic lines. The cartilaginous nasal septum widens dorsally and in frontal crossection it forms a T-shaped pillar for the *bony vault*. The average length of DKA in the 15 cadavers was 8.9 mm (range: 4-14 mm) from the *keystone point* to the most cephalic point of the *cartilaginous vault*. In 5 cadavers (33%), when hump was not present on the profile view, this length averaged 9.6 mm (range: 6-12 mm). In 10 cadavers (67%) certain degree of nasal hump was present, in which cases the average length of DKA was 8.6 mm (range: 4-14 mm). The length of the DKA did not diverged significantly in noses with hump and without. The maximum transverse average width was 4.9 mm (range: 3-9 mm). The location of the widest transverse diameter of the DKA in the cephalocaudal direction was inconsistent, although it was mostly found at its caudal end. LKA has been identified in 24 of the 30 heminoses (80%) in very varied forms. When LKA was present, the transition of DKA to LKA along the dorsal aesthetic lines followed 3 basic patterns: continuous, stepped, minimal transition. The stepped transition is divided into 2 subgroups: round-edge stepped or sharp-edge stepped transition.

After the removal of the *bone cap* in 9 patients undergoing rhinoplasty, the cartilaginous vault was revealed in its entirety. It became apparent with endoscopic examination that the cartilaginous vault under the bony vault causes the *dorsal aesthetic lines* on the skin surface. The average length of the exposed DKA measured in cefaphalocaudal direction is 7.6 mm (range: 4-10 mm). Since only the *bony cap* was treated during the operation, so we could not see the entire keystone area extending laterally. In all cases, we could reveal an intact cartilaginous vault after the removal of the *bone cap*. The postoperative dorsal aesthetic lines are thus determined by the bony vault, which we treated usually with osteotomies. Caudally it is obviously defined by the cartilaginous vault, which have been reconstructed with spreader graft or flap (used to reconstruct the open roof, which sets the optimum dorsal width).

3D simulation of the alveolar cleft

A planning process has been developed as the most suitable and time-saving method for visualization of the alveolar cleft and the design of a nasoalveolar graft. In maxillofacial surgery, the planning of bone grafts is not a recent, quite an automated process. However, even in cases of unilateral alveolar clefts, the graft cannot be completely automatically planed, as the intact side is also deformed. After mirroring the intact side to the defect side, they cannot be substracted from each other, because even the intact side is not perfect. Our result here is a precise description of the design process, which includes partly automated steps and partly manual elements. In all cases, using this procedure we were able to create the 3D bone graft of the alveolar cleft. In one case, the real-size sample of both the nasoalveolar graft and the cleft maxilla were also printed.

Dorsal preservation techniques

An endonasal approach is done in all primary rhinoplasties. An open approach can be added, but only in cases with difficult tips. A hemifixion incision is performed on the right side at the caudal border of the quadrangular cartilage, then a unilateral submucoperichondrial undermining is done on the right side. Next, a superior tunnel is made on the contralateral left side. Exposure of the septum is continued until the keystone junction area is reached. Then a partial elevation of the perichondrium-periosteum from the deep aspect of the dorsum is performed. Next, the soft tissue covering of the dorsum is undermined and continuing upward up to the glabella and laterally. Dissection can be done either under the subsuperficial musculo-aponeurotic system (sub-SMAS) plane or the subperichondrial/subperiosteal plane. In case when the nasal dorsum soft tissue was too thin, we dissected under the perichondrium and periosteum. The advantage or that exposure is the possible preservation of the nasal ligaments. The amount and shape of the subdorsal septal resection is critical, because it determines the final height and shape of the desired nasal dorsum. The resection of the cartilaginous septum begins at the most caudal point of the junction of the upper lateral cartilages and the dorsal septum. We call this point as W-point. The incision proceeds from this point directly under the dorsal vault until there is bony contact at the perpendicular plate of the ethmoid beneath the bony cap. A second incision is made below the first at a lower level. The lower cut is relatively straight, sometimes even concave. The septal strip must reflect the amount of dorsal reduction. Then, the perpendicular plate must be resected using a small Rongeur. In general, we resected 2 to 4 mm septal strip but maximum 8 mm. During the clinical series, we concluded that the segment between the W-point and the anterior septal angle is highly important to preserve to the very end of the operation. It can be resected at the end of the surgery, if necessary. By preserving this septal segment, the saddle nose deformity can be prevented. The bony vault must be mobilized completely. In cases, when less than 4 mm dorsal reduction was planned, we performed a "push down" operation, when more than 4 mm was planned, we performed a "let down" operation. In all cases the bony vault was en bloc mobilized from the frontal process of the maxilla and the frontal bone. This means complete lateral, transverse and radix osteotomies. It is important to understand, that in case of “push down”, we perform a simple straight line osteotomy, while in case of a “let down”, we perform the lateral osteotomy in two heights or we remove a triangular bony segment by the help of a Rongeur. In case of small humps, we prefer the “push down” technique. For the lateral osteotomy, the tip of the osteotome must be perpendicular to the lateral bony wall. A true horizontal cut is important, because it allows a better sliding of the bony surfaces and facilitates the push down maneuver while reducing the risk of excessive narrowing of the base. Next, a percutaneous radix osteotomy is done using a 2 mm osteotomy according to Gola. Finally, the two osteotomies were connected by transversal osteotomies. If a more than 4 mm lowering of the nasal pyramid is required, a “let down” technique was usually preferred by performing a triangular bony wedge resection. This excision must be done very low laterally, in the nasofacial groove to avoid any palpable or visible step. The new height of the nose is determined by the level of the septum, which acts as the central pillar of the nasal framework. If a straight nasal dorsal contour is desired, then the lower cut of the septal strip is cut straight. A more concave dorsal contour can be achieved by making the lower cut of the septal cut concave. To fixate the dorsum is key. By pushing the nasal dorsum against the septum the dorsum flattens, because the junction of the bony and cartilaginous vault is flexible. This is why it is so important to suture the dorsum to the septum at the keystone point during let or push down operation.

27 of 320 patients had to be reoperated. In 16 cases, the problem was the nasal tip and not an error of the dorsal preservation. In 11 cases, the main complication was caused by the dorsal preservation technique: recurrent nasal hump, nasal axis deviation, or the widening of the middle third of the nose (cartilaginous vault). Thus, our reoperation rate due to a complication in the dorsal preservation technique is only 3.4% (11/320). No serious complications were observed in the sample: saddle nose deformity, cerebrospinal fluid leakage, anosmia or narrowing of the nasal airway. In 2 cases the nasal hump returned as isolated problems, which were eliminated with closed rhinoplasty with simple rasping. In 9 cases the problem was more complex, so a complex revision had to be done by removing an additional nasal septal strip. Meanwhile, the bony vault had to be mobilized again, which could be done without a new osteotomy. With the mobilization of the vault and the re-resection of the nasal septum, the returned hump and daviation

could be treated. The widening of the middle third can be corrected by partial separation of the upper lateral cartilages from the nasal septum and a triangular cartilage resection. 309 of 320 patients undergoing dorsal preservation was satisfied with his or her nasal dorsum, only 11 had to be reoperated for this reason. At these 309 patients improvement or no change were noted in nasal breathing. This improvement was not always measured by objective methods. However, in 30 random cases of 309, standard questionnaire was given to assess their nasal breathing, known as the NOSE (Nasal Obstruction Symptom Evaluation Scale). In 27 cases (90%), improvement was observed, in 3 cases (10%) we did not observe any change. As with all rhinoplasty, functional intervention (septoplasty, turbinectomy) was carried out if necessary.

CONCLUSIONS

Based on our prospective clinical studies, the caudal edge of the lateral crus averaged 5.9 mm from the alar rim at the midnostril point. The angle of the cephalic orientation along the caudal edge was on average 43.6 degrees. The most common shape of the lateral crus was smooth-straight for both the transverse and vertical axes. Contrasting with the aesthetic ideal at the end of the procedure, which arguably consists of the 2 margins at or near the same horizontal level, the cephalic border is higher or equal to the level of the caudal border in 95% of cases on initial exposure. Further, cadaver dissections revealed that the accessory cartilage chain was present in all cadavers; the first accessory cartilage forms the vestibular baffle, while the rest of the chain completes the alar ring. The correlation between the lateral crura and surgical techniques is provided as it relates to the following areas: alar groove, vertical axis, horizontal axis, alar malposition, and alar ring. The accessory cartilages rarely reach the pyriform aperture. In the clinical practice, most of the lateral crural strut grafts reach the pyriform aperture, which is responsible for supporting the lateral crus from underneath, not from lateral. So these strut graft are not anatomically positioned.

Our findings indicate that a distinct lower nasal base exists, and it consists of the columellar base, nostril sills, and alar lobules. It is extremely dynamic. The interaction of the tissues influences compression and dilatation of the nostrils and external valves. We proved the existence of the Pitanguy's midline ligament, however we do not confirmed that this ligament would connect the dermis and the cartilages. The SMAS divides in the supratip area into a superficial and deep layer. The superficial layer courses anterior to the interdomal ligament and connects to the superficial orbicularis oris nasalis. The deep layer courses posterior to the interdomal ligament in the membranous septum, then it connects to the paired depressor septi nasi muscle. We proved the existence of the tela subcutanea cutis, which role is the maintenance of the form of the lower nasal base. It is our opinion that the dynamic role of the levator labii superioris alaque nasi in dilating the nostril bases has been underemphasized. Ultimately, it may be the injection of botulinum toxin to block this muscle laterally that offers the best solution for limiting dynamic widening of the alar base.

We have divided the keystone area into dorsal and lateral parts. Based on cadaver dissections, the average length and width of the dorsal keystone area measured 8.9mm and 4.9 mm respectively. In the clinical series, the average length of the exposed cartilage vault was 7.6 mm. We introduced the bony cap concept. Removal of the bony cap revealed an intact cartilaginous vault in both the dorsal and lateral keystone areas in all patients. Preoperatively, the dorsal aesthetic lines and profile are dictated by the cartilaginous vault. After dorsal reduction, the dorsal lines are determined by the edges of the bony vault. The lateral keystone area was present in 80% of the cadaver dissections. Our proposed surgical sequence allows us to preserve the entire cartilaginous vault underneath the bony cap for further modifications. This way the cartilage tissue was not wasted, that could have been resected along with the bony cap. Our findings suggest that the following surgical sequence is clinically preferable to the classic dorsal resection techniques: removal of the bony cap with rasp that reveals the underlaying cartilaginous vault and then splitting off the upper lateral cartilages from the septum and reducing it until the desired profile is reached.

3D simulation allows us to plan virtual nasoalveolar grafts. This planning method allows surgeons to create an anatomically precise virtual model. The planning process of the nasoalveolar graft sample from the virtual model is not yet fully automated, although the 3D visualization and a real-size graft sample can be clinically useful during secondary alveolar osteoplasty. Our clinical results are limited in terms of the usefulness of the graft sample, but as far as we can judge it, it is certainly useful as we can reconstruct the alveolar cleft and pyriform aperture, thus providing a more correct support the nasal base.

Dorsal preservation techniques were used in 320 primary rhinoplasties, during which by modifying the basic concept we made the technique safer by preservation of the W-point and anterior septal angle segment. We can avoid functional problems by following the indication criteria we use to perform "push down" or "let down" techniques. We preserved the integrity of the nasal dorsum, while the height of the dorsum was reduced by 2-8 mm, so it can be used specifically for large nasal dorsal humps as well. The function of the internal valve has been improved, since it was opened. Surgical time has been reduced, since there was no need for complicated nasal dorsum reconstruction. With this technique, in the future, it may be possible to reconstruct the nasal deformities of cleft lip and palate patients (especially the dorsal deviations) in a less invasive manner, more easily and more naturally.

LIST OF PUBLICATIONS

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