The Nasal Ligaments and Tip Support in Rhinoplasty: An Anatomical Study

Rollin K. Daniel, MD; and Peter Palhazi, MD

Abstract

Background: In 1971, Janeke and Wright1 published a now classic study on the support of the nasal tip in which they found four areas of anatomic support. These findings led to the “tripod concept” of tip support. Recently, surgeons have begun repairing and/or preserving the nasal ligaments as a method to control tip projection and rotation. Therefore, a reassessment of the nasal ligaments and tip support is warranted.

Objectives: The present study was done to investigate the ligamentous and structural support of the nasal tip. Clinically, surgeons are aware of the role of the nasal ligaments and are beginning to utilize tip suture techniques to achieve greater tip refinement and long-term support.

Methods: Anatomic studies were conducted on 24 fresh cadavers at the time of autopsy. The two groups consisted of the following: (1) group 1 included dissection of 10 cadavers concentrated on the various ligaments of the nose; and (2) group 2 involved dissections of 14 cadavers analyzing the relationship between the alar domes and the anterior septal angle (ASA).

Results: Regarding the ligaments of the nose, we were able to consistently identify the following ligaments: (1) interdomal; (2) intercrural; (3) Pitanguy’s midline; (4) pyriform; and (5) a scroll ligament complex consisting of the longitudinal and vertical scroll ligaments. We did not find two commonly accepted ligaments: (1) a “footplate ligament” from the footplate of the medial crus to the caudal septum; and (2) a “sesamoid ligament” attachment from the accessory cartilage to the pyriform aperture. Dissections done to study the relationship between the domes and ASA revealed that the domes projected an average of 5.7 mm (range, 2.2-9.6 mm) above the ASA and were longitudinally 5.5 mm (range, 2.9-9.5 mm) caudal to the ASA. Thus, there was no direct support from the ASA to the domes.

Conclusions: It is our recommendation that surgeons should consider preservation of the nasal ligaments whenever possible and utilize them to manipulate tip projection, position, and rotation. Awareness of the relationship between the dome and the caudal septum will hopefully minimize problems with the tongue-in-groove operation.
METHODS

This study was conducted in accordance with the Declaration of Helsinki. Anatomic dissections were done in 24 fresh cadavers at the time of autopsy. These were fresh Caucasian cadavers, without freezing or any storage distortions. The cadavers had a mean age of 65.8 years (range, 47-89 years) with a sex distribution of 14 females and 10 males. The dissections can be divided into two broad groups: group 1 consisted of 10 cadavers, with an emphasis on dissecting the various ligaments of the nose; and group 2 consisted of 14 cadavers, with an emphasis on the relationship between the alar domes and the anterior septal angle (ASA) as well as the contour of the caudal septum. The dissections were done between May 2015 and August 2016. Because the mean age of the cadavers was 65.8 years, the fact that the ligaments were present in the elderly discounts the idea that they might be difficult to identify in older individuals. It should be noted that the two groups of dissections were done sequentially and thus the assignment of cadavers to the two groups was not an issue.

In group 1, the skin envelope and then the subcutaneous fatty tissue was meticulously removed. Care was taken not to disturb the superficial muscular aponeurotic system (SMAS) layer of the nose, especially the transversalis muscle and its ligamentous connections to the scroll area, tip, and columella. Simultaneously, the connections between the paired domes were preserved. Then the intercartilaginous and osseocartilaginous connections were studied between the pyriform aperture and the cartilaginous components of the nose, the caudal border of the ULCs, and the cephalic border of the lateral crus, as well as the paired alar cartilages and septum. Photographs were taken to document the individual ligaments of the nose.

In group 2, the entire right side of the nose was removed, exposing the septum. The mucoperichondrial coverage of the septum was removed to reveal precisely the caudal border of the septum. Then the dome on the opposite side was identified and dissected without disturbing its position in the soft tissue nor changing its relationship to the ASA. Standardized photographs (true lateral views) were taken, including placement of a ruler in the field of interest. Measurement were done to document the dome and ASA locations as well as the contour of the caudal septum.

RESULTS

Group 1

As will be discussed in depth, we were able to identify consistently the following ligaments: (1) interdomal ligament; (2) intercrural ligament; (3) Pitanguy’s midline ligament; (4) a transverse footplate ligament; (5) the pyriform ligament; (6) a longitudinal scroll ligament; (7) a vertical scroll ligament; and (8) a vertical pyriform aperture ligament. There was no ligament from the medial crural footplate to the caudal septum nor was there a sesamoid fibrous attachment to the pyriform aperture.

Group 2

Dissections were done in 15 fresh cadavers to study the relationship between the domes and the ASA. The domes projected an average of 5.7 mm (range, 2.2-9.6 mm) above the ASA and were longitudinally 5.5 mm (range, 2.9-9.5 mm) caudal to the ASA. There was no direct support from the ASA to the domes. The convexity of the caudal septum is marked by the presence of a caudal point (CP) above the posterior septal angle (PSA). The CP can be defined as the most CP of the septum and is readily apparent. We utilized two methods for evaluating the contour and inclination of the caudal septum. For evaluating the contour of the caudal septum, a line was drawn between the PSA and the ASA. For assessing the inclination of the caudal septum, a line was drawn between the CP and the ASA, which averaged 133.6 degrees (range, 119-146 degrees). In addition, we measured the distance from the caudal septum to the middle crus (ie, the largest width of the membranous septum). The width of the membranous septum averaged 4.7 mm (range, 2.0-7.1 mm). We also measured the distance between the caudal septum and the midportion of the middle crus, which indicates the distance one would shorten the nose in a tongue-in-groove (TIG) procedure. This distance was nearly averaged 4.7 mm (range, 2.1-7.7 mm), thus it was nearly identical to the average width of the membranous septum.

DISCUSSION

The anatomic term “ligament” is defined in Terminologia Anatomica as “a band or sheet of fibrous tissue connecting two or more bones, cartilages or other structures.” Therefore, this broad definition can lead to the identification of a large number of ligaments. We will review the most commonly accepted ligaments and discuss their surgical relevance.

Ligaments

Interdomal Ligament

The interdomal ligament connects the two middle crura at the cephalic junction of the infralobular segment (Figure 1). Technically, the ligament does not run between the domes, but rather between the middle crura in a more posterior and cephalic location. It is easily found in all
noses and is often quite rigid. Although many surgeons cut it during the insertion of a columellar strut, the interdomal ligament can be easily preserved due to its cephalic position away from the caudal border of the middle crura. Obviously, this preservation is not possible if a tip split procedure is performed. Rohrich routinely inserts an interdomal suture to narrow the interdomal distance, which in reality merely represents reestablishment of the previously cut interdomal ligament.

**Figure 1.** The interdomal ligament runs between the cephalic border of the lobular segment of the middle crus as seen in (A) a cadaver, (B) clinically, and (C) schematically.

**Intercrural Ligament**

The intercrural ligament connects the cephalic border of the entire alar cartilages including the lateral, middle, and medial crura (Figure 2). It passes just above the mucosa and holds the alar cartilages together. In its cephalic portion along the lateral crus, it acts as the suspensory ligament of Converse passing just above the ASA. In its midportion, it is posterior to both the interdomal ligament and the deep portion of Pitanguy’s midline ligament. Its
caudal component effectively restrains the medial crus and footplate, pulling them toward the caudal septum. The intercrural ligament unifies the two alar cartilages and acts as a suspensory sling over the anterior septum. During rhinoplasty surgery, this ligament can either be preserved or disrupted. In an open approach, a “tip split” procedure will divide the ligament and require the surgeon to restore support, usually with a columellar strut. However, downward traction on the alar cartilage followed by a “dorsal split” allows one to maintain the intercrural ligament. A bilateral transfixion incision through the membranous septum will disrupt the intercrural ligament support between the footplates. Alternatively, one can perform a high septal transfixion incision utilizing the technique of Cakir, which is a modification of the original technique by Parkes and Brennan. Essentially, one makes the transfixion incision
through the caudal septum approximately 2 to 3 mm back from the caudal border, thereby ensuring total preservation of the intercrural ligament.

**Footplate Ligament**

In their classic study of nasal tip support, Janeke and Wright\(^1\) listed the junction of the medial crura and caudal septum as one of the four pillars of nasal tip support. Tardy et al\(^2\) considered it one of the three major tip support mechanisms. Subsequently, Gunter\(^12\) diagrammed these as a distinct fibrous attachment between the footplates and the caudal septum. Based on numerous dissections, a distinct footplate ligament between the footplate of the medial crus and the caudal septum does not exist. Clinically, one only has to pull on his or her own columellar to note its mobility and the absence of a restraining ligament. Our conclusion is that there are three components to the relationship between the medial crus and the caudal septum. First, the intercrural ligament acts as a suspensory ligament uniting the entire alar cartilage complex without direct fixation to the dorsum and caudal septum. Second, there is a transverse ligamentous attachment in between the lobular segments of the medial crus, but not to the caudal septum. Third, the footplates wrap around the caudal septum in a caudal to cephalic direction, but they rest upon the soft tissue in the columellar base.\(^13\) There is a distinct anatomic variation between the length of the footplates and the height of the columellar. The longer the footplates, the shorter the columellar base.\(^14\)

**Sesamoid Ligament**

Numerous surgeons described a narrow circular fibrous attachment beginning at the latera crus, incorporating sesamoid cartilages, and then attaching to the pyriform aperture.\(^15,16\) This observation is incorrect for two reasons. First, these attachments are not inconsistent small fragmented sesamoid cartilages, but rather distinct consistent accessory cartilages. In many anatomic texts, these accessory cartilages are named “the lesser alar cartilages.”\(^17\) Second, they are attached to the mucosa and are part of an alar ring without a direct attachment to the pyriform aperture.\(^18\) The accessory cartilage chain is part of the alar ring, which begins at the footplate of the medial crus, passes along the entire length of the alar cartilage, and continues in the accessory cartilage chain toward the anterior nasal spine. Functionally, this flexible alar ring undergoes dilation or compression depending upon the nasal musculature. Thus, there is little evidence of a significant supporting ligamentous structure between the accessory cartilages and the pyriform aperture. Despite the beliefs of the advocates of the tripod concept, these structures do not provide major direct structural support to the tip.

**Pyriform Ligament**

Rohrich et al\(^19\) has identified a broad ligament between the bones of the pyriform aperture and the adjacent cartilages. Although the purpose of their study was to describe the static ligamentous connections of the alar base, it was obvious that the pyriform ligament runs in too deep a plane to have any direct connection to the alar base. The pyriform ligament is probably a vestigial ligamentous sheet left over from absorption of the cartilaginous capsule between the periosteum of the bony pyriform aperture and the perichondrium of the adjacent cartilage (Figure 3). However, it does reinforce the mucosal space, which is a dynamic structure that functions as the bellows of the nose and is associated with lateral wall insufficiency.\(^20\) Because surgeons have sought total exposure of the bony vault for piezoelectric surgery, it has become necessary to cut a portion this ligament.\(^21\)

**Scroll Ligament Complex**

A longitudinal fibrous attachment has long been recognized in the scroll area between the cephalic border of the LLCs and the caudal border of the ULCs. Recently, Saban and Polselli\(^22\) identified a distinct fibrous attachment from the undersurface of the transversalis muscles to the scroll junction. Thus, we now have a “longitudinal and a vertical scroll ligament” that can be collectively referred to as the “scroll ligament complex.” The longitudinal scroll ligament occurs at the junction between the LLC and ULC and often has interspersed sesamoid cartilages within the fibrous tissue (Figure 4). Drumheller\(^23\) found three distinct variations between the cartilages including appositional, alar overlap, and alar underlap. Preservation of this ligament can be achieved by maintaining the cephalic lateral crus. Alternatively, one can do a “cephalic preservation” procedure as recommended by Ozmen et al.\(^24\) When the longitudinal scroll ligament is divided through an intercartilaginous incision, it can theoretically be repaired with two interrupted sutures. Saban and Polselli\(^22\) introduced the concept of a “vertical scroll ligament” that emerges from the undersurface of the deep SMAS layer and inserts into the internal nasal valve area (Figure 5). Saban and Polselli\(^22\) also noted distinct superior and inferior lateral nasal ligaments along the pyriform aperture, which they designated “ligamentum laterale superius and inferius nasi.” We have found these ligaments to be inconsistent as distinct entities, but we have found a consistent vertical attachment between the entire pyriform aperture and the overlying soft tissue envelope, which we have designated as the “pyriform aperture ligament” (Figure 5). It is particularly dense at the keystone area and on occasion along the lateral border. Release of this pyriform aperture ligament has become important in the total dorsal exposure associated with complete lateral osteotomies done with a piezoelectric saw.\(^21\)
Pitanguy’s Midline Ligament

Pitanguy described a ligament originating on the undersurface of the dermis and running tangentially down to and in between the alar cartilages. He reported a connection between this ligament and the depressor septi nasi (DSN), which was later confirmed by de Souza Pinto. Recently, Saban et al demonstrated that the medial SMAS at the level of the internal nasal valve divides into a superficial layer and a deep layer. The superficial medial layer runs caudally below the interdomal fat pad, but above the interdomal ligament into the columella. The deep medial layer of the SMAS runs beneath the interdomal ligament, but above the ASA into the membranous septum and then downward toward the anterior nasal spine. Saban et al concluded that the deep medial SMAS could correspond to Pitanguy’s ligament.

Based on the accepted five-layer laminate concept of the nasal soft tissue envelope, Pitanguy’s ligament cannot be a true dermocartilaginous ligament, because it would have to run tangentially from the dermis across and through the SMAS to reach the cartilaginous structures in the tip. We have modified the original terminology and advocate the use of the term “Pitanguy’s midline ligament,” which reflects its origin as part of the midline SMAS layer. Our dissections confirm previous observation. We would emphasize that Pitanguy’s midline ligament divides into a “superficial portion,” which passes above the interdomal ligament and becomes continuous with the superficial orbicularis oris nasalis (SOON) muscle, and a “deep portion,” which passes below the interdomal ligament and becomes continuous with the DSN muscle (Figure 6).

Surgically, division and repair of Pitanguy’s midline ligament has become an important method of supporting the nasal tip. However, it must be emphasized that it is the deep branch that is repaired, whereas the superficial branch is usually irreparably disrupted during exposure. Utilizing a closed approach, Cakir identifies, marks, divides, and then repairs Pitanguy’s midline ligament. He feels that this method allows him to ensure long-term tip support. In our thick-skin patients, we often excise the SMAS tissue in the supratip region to reduce the bulk of the soft tissue envelope. Once the tip suturing is completed, we often utilize a tip position suture to rotate and support the tip. The suture passes from the distal deep SMAS of Pitanguy’s midline ligament to the dorsal septum near the ASA. One is utilizing the ligament as a tether to control tip position.
Structural Tip Support

In addition to nasal ligaments, another source of tip support has been postulated to be the relationship between the anterior nasal septum and the alar domes. Bitik et al.28 stated that in the normal nasal anatomy, “an anterior septal angle of sufficient height keeps the feet of the medial crura off the anterior nasal spine; the medial crura do not bear a significant load.” Constantian29 considers the ASA-to-tip relationship to be the cardinal point in planning and performing tip surgery. However, what is the actual anatomic relationship between the ASA of the dorsal septum and the alar cartilage? Our studies indicate that four landmark points must be defined (Figure 7). The anterior septal prominence (ASP) is the most projecting point on the dorsal septum. It may range from the ASA to the keystone area depending on the patient’s dorsal hump. The anterior septal angle is a commonly used term, but rarely defined. The consensus is that the ASA represents the junction between the dorsal and caudal septa. The posterior septal angle (PSA) is the junction between the caudal septal cartilage and the anterior nasal spine, which is easily defined. Based on our dissections, we have identified a new landmark—the caudal point (CP)—which is the most caudal portion of the caudal septum.

From our dissections, it is obvious that the domes are caudal to the ASA (average, 5.7 mm; range, 2.2-9.6 mm) while projecting above the ASA (average, 5.5 mm; range, 2.9-9.5 mm). This anatomic finding confirms the observation in 1985 by Lessard and Daniel,30 who stated that “in more than 80% of dissections, the alar domes projected far above the septal angle (8.0 mm), thus discounting the concept of the septum providing direct support to the nasal tip.” Interestingly, Byrd et al.31 recommended that the tip projection above the septum should be 6 mm in thin-skin patients and 10 mm in thick-skin patients, for an average of 8 mm. Thus, anatomically and surgically, the domes should project above the ASA.

Surgical Implications

Preservation vs Transection

With a clear understanding of the nasal ligaments, surgeons must decide whether to preserve, transect, or repair
the ligaments they encounter during rhinoplasty surgery. One only has to watch intraoperative videos of surgeons performing an open “tip split” procedure to see the division of the interdomal and intercrural ligaments. In primary rhinoplasty cases, one can achieve adequate exposure of the dorsum and septum with simple downward retraction of the alars, followed by a distal dorsal split in the area of the ASA. Rather than a transfixion through the membranous septum that disrupts the intercrural ligaments, one can do either a unilateral or a complete septal transfixion incision, which preserves the entire ligamentous membranous septum. Preservation of the cephalic portion of the lateral crus with its associated ligamentous scroll attachment is possible in many cases. Automatic resection of the cephalic

Figure 5. Vertical scroll ligament (VSL) and pyriform aperture ligament (PAL). (A) Cadaver dissection showing the vertical scroll ligament (VSL) at the junction between LLC and ULC and the vertical pyriform ligament (VPL) between the ULC and the NB. (B) Origins of VSL and VPL. (C, D) Schematic representation of the vertical scroll ligament and pyriform aperture ligament. LLC, lower lateral cartilage; LSL, longitudinal scroll ligament; NB, nasal bone; PAL, pyriform aperture ligament; PL, pyriform ligament; STE, soft tissue envelope; ULC, upper lateral cartilage; VPA, vertical pyriform attachment (VPA); VSL, vertical scroll ligament.
lateral crus should be avoided, as well as the creation of a standard 6 mm rim strip. An individualized approach should be taken, beginning with the question “Can the entire lateral crus be preserved?”

For almost a century, surgeons have tried to achieve a desired tip shape by incision and excision of portions of the alar cartilages. However, the almost routine excision of the cephalic lateral crus can be associated with tip deformities, alar rim retraction, and external valve collapse. In 2010, Gruber et al32 popularized the concept of preserving an “island” of the cephalic lateral crus to prevent alar rim retraction. His technique consisted of the following steps: (1) an open approach; (2) an intercartilaginous incision; (3) a transcartilaginous incision through the lateral crus 6 mm back from the caudal border; (4) correction of any bulbosity with a lateral crura convexity suture; (5) sliding the island of cephalic lateral crus under the rim strip; (6) trimming of any distorting irregularities at the cephalic border; and (7) fixation of the two segments with two sutures of 5-0 PDS. Ozmen et al24 had described a similar technique of simply sliding the intact cephalic portion of the lateral crus under without the intercartilaginous incision and the creation of an island. The method of Ozmen et al ensures preservation of the longitudinal scroll ligament between the ULCs and LLCs.

Figure 6. Pitanguy’s midline ligament. (A, B) Cadaver dissection showing a split of the midline superficial muscular aponeurotic system (SMAS) (pink) into its superficial (yellow) branch, which continues to the superficial orbicularis oris nasalis (SOON) muscle and its deep branch (green), which continues to the depressor septi nasi (DSN) muscle. (C) Schematic representation of Pitanguy’s midline ligament and its muscle junction.

Ligamentous Tip Suturing

Obviously, preservation of the nasal ligaments during exposure is highly recommended. If transected, the ligamentous structures can be repaired as part of the tip suturing process. The most obvious example is the repair of Pitanguy’s midline ligament. During exposure, the ligament can be isolated and then divided between two 6-0 marking sutures. At the end of the case, the ligament is repaired, which pulls the soft tissue envelope downward, thus reducing the supratip dead space and potentially stabilizing the tip. In thick-skin noses, one often resects the SMAS layer in the supratip region to debulk the area, which includes the proximal portion of Pitanguy’s midline ligament. However, its distal portion is not resected, and a
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Tip-position suture can be inserted for rotating the tip. Its effectiveness is indicated by the greatest risk being over-rotation of the tip. The concept of a “scroll ligament complex” has important surgical and functional implications (Figure 8). In the standard sub-SMAS dissection, one cuts through the fusion of the vertical and longitudinal scroll ligaments at the insertion of the vertical scroll ligament into the longitudinal scroll ligament. At the time of closure,
the vertical scroll ligament can be sutured to the underlying structures to both accentuate the alar groove and to close lateral dead space. Alternatively, if one performs a meticulous subperichondrial dissection over both the ULC and the LLC, one can split the longitudinal scroll ligament below the sesamoid cartilages and raise the scroll ligament complex intact. Reattachment to the underlying structures not only accentuates the alar groove and closes lateral dead space, but also potentially minimizes functional disruption. Surgeons are now emphasizing preservation or repair of the nasal ligaments as a means of achieving tip projection and rotation without the use of classic columellar and septal extension grafts.\textsuperscript{5,28} Also, it is logical to assume that if the scroll ligaments are not disrupted during exposure, that nasal function will be maintained with minimal risk of scar contracture.

**Tongue-in-Groove Procedure**

One of the most valuable findings from our structural study was the observation of the relationship between the alar cartilages and the inclination of the caudal septum, which explains many of the problems that occur with the TIG operation. Kridel et al\textsuperscript{33} popularized the TIG operation for treating the hanging columellar. The specific steps are as follows: (1) correction of any caudal septal deviation through bilateral full-transfixion incisions; (2) retrograde dissection between medial crura with optional soft tissue excision; (3) telescoping of the columellar on to the caudal septum; (4) fixation with 4-0 chromic sutures; and (5) bilateral membranous septum excision. Based on our experience with secondary rhinoplasty patients having had a previous TIG procedure, the most common errors include the following: (1) undersection of the anterior nasal spine; (2) persistent deviation of the caudal septum; and (3) excessive upward tip rotation. Excessive upward columellar/tip rotation is a devastating deformity for the patient to accept and for a subsequent surgeon to fix. Why does it occur? As seen in Figure 9, the inherent inclination of the caudal septum is 145 degrees, and any suture fixation of the middle crus to the caudal septum will result in too much upward rotation. Therefore, we advocate a modified TIG in which only the medial crus is sutured to the caudal septum, thereby setting columellar inclination. The middle crus is sutured to a shortened free-floating columellar strut, thus allowing the direct control of tip rotation and projection independent of the caudal septum.

**CONCLUSION**

Based on our studies, two of the four ligamentous structures identified by Janeke and Wright\textsuperscript{1} are inaccurate. There is no distinct fibrous attachment between the medial crural footplates and the caudal septum, nor is there a distinct ligamentous attachment between the accessory cartilages and the pyriform aperture. However, the alar cartilages are joined together by the interdomal and intercrural ligaments. Rather than utilizing the fixed structural “tripod concept” of the alar cartilages, we propose a more dynamic concept of the tip. It begins with the intrinsic integrity of the alar cartilages, which are held together by ligaments. These cartilages are then encased in the nasal SMAS, which attaches through insertions and even muscle origins (anterior dilator, compressors). Thus, the alar cartilages are controlled by the SMAS and act as a dynamic structure that abuts the cartilaginous framework. Our second group of dissections indicate that there is no direct fixation or support between the domes and the ASA. Thus, the alar cartilages are dynamically mobile and can be surgically manipulated. It is our recommendation that surgeons should consider preservation of
the nasal ligaments whenever possible and utilize them to control tip projection, position, and rotation. Awareness of the relationship of the dome and caudal septum will hopefully minimize problems with the TIG operation.

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