Video Article

Endoscopic Septoplasty with Limited Two-line Resection: Minimally Invasive Surgery for Septal Deviation

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Abstract

Endoscopic septoplasty is a surgical procedure in otolaryngology that is commonly performed to treat nasal airway obstruction caused by nasal septal deviation. It has a long history with multiple variations. In this article, a modified endoscopic septoplasty procedure using the limited two-line resection (2LoRs) technique at the posterior and inferior junction of the cartilaginous and bony septum is presented based on embryologic and anatomic knowledge of the nasal septum and the biomechanics of cartilaginous behavior. With this procedure, the quadrangular cartilage can be preserved as much as possible, which is helpful in retaining the supporting framework and rigidness of the septum. 2LoRs has been proven effective and sound for the correction of nasal septal deviation with rare complications. This modified procedure can be applied to correct the deviated nasal septum in the absence of any external nasal deformity to improve nasal patency or to improve access to the middle meatus or to the axillary region of the middle turbinate. It may also be used to expand the indications of septoplasty to children and adolescents because of its minimally invasive approach.

Video Link

The video component of this article can be found at https://www.jove.com/video/57678/

Introduction

Endoscopic septoplasty is a commonly performed surgical procedure in otolaryngology to treat nasal airway obstruction caused by nasal septal deviation[1]. The purpose of the septoplasty with the indication of nasal airway obstruction is to provide a functional improvement in nasal airway patency, and the principle is to correct the septal deviation with a minimal surgical invasion[2].

The beginning of septoplasty, a procedure that is still used today, traces back to the technique that Freer and Killian published in the early 20th century, which was called submucous resection (SMR)[3]. SMR is characterized by its direct removal of a nasal cartilaginous deviation in a subperichondrial plane, leaving an L-shaped strut to structurally support the appearance of the nose[4,5]. SMR showed advantages over the previous techniques at its time, so it gradually gained acceptance. In the 1990s, endoscopy was applied to septoplasty[1]. The illumination and visualization of the surgical field were highly improved, and the resection could be performed directly and precisely[6]. Thereafter, the indications of SMR were extended, and various septoplasty techniques were developed. While these techniques may be diversified in incision, flap elevation, excision, suture, or packing, the essence of direct removal has not changed. Therefore, once the cartilage was significantly resected, complications such as large septal perforations or a saddle nose deformity would occur[7,8].

As Cottle and Loring suggested in 1948, the resection of deviated cartilage should be conservative[9]. Different from the direct removal of cartilaginous deviation, the biomechanics of cartilage as applied to septoplasty require the utilization of the inherent elastic property of cartilage to straighten the cartilaginous deviation by a limited surgical intervention, such as partial incisions (*e.g.*, scratches or thin slices) and full incisions (*e.g.*, full cuts or wedges). In 1958, Gibson and Davis first reported that cartilage has an internal self-locked stress system as a result of its growth pattern[10]. Partial incisions on the concave side would release the stress, thereby decreasing the bowing of the cartilage, while the incisions on the convex side would increase the bowing. In 1963, Kenedi, Gibson, and Abrahams further demonstrated the self-locked stress system through a series of studies on mapping the force distribution in a cross-section of rib cartilage[11]. In the same year, Stenstrom verified the effect of partial incisions on the antihelix[12]. A few years later, Fry published results on the human nasal septal cartilage that were consistent[13]. In other words, the biomechanics of cartilage can be used to alter the morphology of cartilage by releasing the forces within the cartilage. Based on this theoretical foundation, a surgical procedure that takes advantage of the biomechanical features of cartilage was developed[14].

Combining previous surgical procedures with the embryologic and anatomic knowledge of the nasal septum, here, a modified endoscopic septoplasty procedure with the technique of limited two-line resection (2LoRs) at the posterior and inferior junction of the cartilaginous and bony septum (**Figure 1**) is presented in detail. This procedure is recommended to correct deviated nasal septa when external nasal deformities are

absent, to improve nasal patency or to improve access to the middle meatus or to the axillary region of the middle turbinate as a preoperative operation. This procedure may also be used in children to correct septal deviation because of its minimally invasive approach.

Protocol

This procedure, which involved human subjects, was approved by the Institutional Review Board of the Eye and ENT Hospital, Fudan University, China. All the enrolled patients provided written informed consent.

1. Preparation for Surgery

1. Before surgery, examine the patient's nasal cavity with anterior rhinoscopy, endoscopy, and computed tomography (CT) scans to confirm and locate the deviations and to identify the indications[15].
2. Ask the patient to assess the patency of their nose as a whole and to indicate this on a visual analog scale (VAS) before surgery.
   NOTE: The total length of the scale was 10 cm, with one extreme being an entirely clear nose (*i.e.*, 0 cm scoring 0%), the other extreme a completely blocked nose (10 cm scoring 100%), and the center a nose with a 50% blockage.
3. Remove the vibrissae in both nasal vestibules 1 day before surgery.
4. On the day of the surgery, administer general anesthesia to the patient after placing them on the operating table[16].
   NOTE: Induce anesthesia with 2 - 2.5 mg/kg of propofol, 0.2 µg/kg of sulfentanyl, and 0.6 of mg/kg rocuronium. Maintain the anesthesia with a continuous intravenous infusion of remifentanil of 0.1 µg/kg/min and an inhalation of sevoflurane (0.8 minimal alveolar concentration).
5. Tilt the operating table 30° (to the dorsal elevated position) and put the patient's head in a neutral position (neither flexed nor extended).

2. Surgical Procedure

NOTE: Use a 0-degree endoscope during the entire operation.

1. Steep 8 pieces of gauze (6 cm x 60 cm) with a mixed solution of 20 mL of 1% tetracaine and 4 mL of 0.1% epinephrine. Put 1 soaked piece of gauze into each nasal cavity for 5 min to shrink the nasal mucosa.
2. Put the inferior turbinate toward the lateral wall of the nasal cavity with the elevator at the end of the procedure.
3. Infiltrate the septum using a needle attached to a 5 mL syringe with several milliliters of a mixed solution of 20 mL of 0.9% NaCl and 0.05 mL of 0.1% epinephrine in the subperichondrial and subperiosteal planes of both sides of the septum.
   NOTE: If the septum was deviated to both sides, we defined the convex side as the side of the anterior deviation.
4. Make a Killian incision at the mucocutaneous junction ipsilaterally on the side of the maximal deviation (*i.e.*, the convex side) of the septal cartilage with a No. 15 blade. Start the vertical incision on the septum as high as possible, continue to the floor of the nasal cavity, and curve posteriorly as it reaches the floor of the nasal cavity.
   NOTE: The incision needs to penetrate the mucous-perichondrium of the nasal septum.
5. Raise the mucosal flap in the subperichondrial plane with the suction elevator in case of bleeding. Without bleeding, raise the flap with a 2 mm or 5 mm elevator. Extend the elevation as high as possible upwards and to the floor of the nasal cavity downwards to fully expose the cartilaginous and bony septum on the convex side.
6. Make a vertical incision using the sharp end of the 2-mm elevator or a number 15 blade on the cartilage inferior to the dorsum and anterior to the junction of the quadrangular cartilage and perpendicular plate of the ethmoid bone (*i.e.*, the first line of the 2LoRs). Likewise, make a horizontal incision on the cartilage superior to the junction of the quadrangular cartilage, vomer bone, and maxillary crest (*i.e.*, the second line) (**Figure 2A**).
   NOTE: In this way, the septal cartilage is mobilized from its posterior and inferior attachment to the bony septum, and the anterior and superior attachment is kept intact.
7. Elevate the contralateral mucoperiosteum to expose the bony septum bilaterally with the suction elevator.
8. Resect two strips of the posterior and inferior margins of the septal cartilage and the adjacent bony septum (**Figure 1B**).
   1. Resect 1/4 to 1/3 (occasionally 1/3 to 1/2) of the original width of the cartilage in the anteroposterior dimension on the first line (**Figure 2B**).
   2. Resect 1/4 to 1/3 (occasionally 1/3 to 1/2) of the original height of the cartilage in the vertical dimension on the second line (**Figure 2C**).
9. Remove the thickening bony septal deviations and perform a partial fracture displacement to move the deviation back to the midline.
   NOTE: The extensive removal of the posterior and inferior bony septum is to clear all of the thickness and deformities in this region.
10. Control any intraoperative bleeding by electrocoagulation.
11. Approximate the mucosal flaps by two interrupted sutures with absorbable materials (**Figure 2D**).
    1. Start the sutures posterior to the incision, pass them through the septum to the opposite side, and then pull them back from the skin anterior to the incision site.
    2. Knot the sutures on themselves, respectively. Place the two sutures parallel, one above the other.

3. Procedure and Assessment After Surgery

1. Pack the nasal cavity with nasopore.
2. Review the patient 1 week after the surgery to check if there is a hematoma or infection of the septum.
3. Examine the nasal cavity with anterior rhinoscopy and 0-degree endoscopy and ask the patient to assess the patency of their nose with VAS 6 months after the surgery.
4. Record postoperative septum hematoma, transient dental pain, hypesthesia, synechiae, epistaxis, septum abscess, septum swing, septal perforation, and dorsum collapse as surgical complications.

Representative Results

Adult patients (>18 years of age) with nasal septal deviation were included in this study. Patients with nasal septal deviation accompanied by chronic rhinosinusitis, sinonasal tumors, external nose deformities, and those with a previous surgical history of septoplasty were excluded. Patients with a straight dorsum but who had caudal cartilage dislocated off the greater alar which had protruded into one of the nasal vestibules were excluded as well.

Thirty-two patients were included in this study. The patients' average age was 44.7 years (with a range of 19 - 72 years) and 68% were male and 32% were female. The VAS score was shown as the mean ± the standard deviation. Comparisons between groups were made with a paired Student's *t*-test. The VAS decreased from 7.67 ± 1.13 before surgery to 1.84 ± 1.17 at 6 months after the surgery, which was statistically significant (P <0.01) (**Figure 3A**). The deviation had returned to the midline of the nasal cavity in most cases, as shown in the representative CT images (**Figure 3B**).

Only one septum hematoma was recorded as a complication postoperatively. No cases of transient dental pain, hypesthesia, synechiae, epistaxis, septum abscess, septum swing, septal perforation, or saddle nose were recorded in the follow-up visits at 6 months after the surgery.

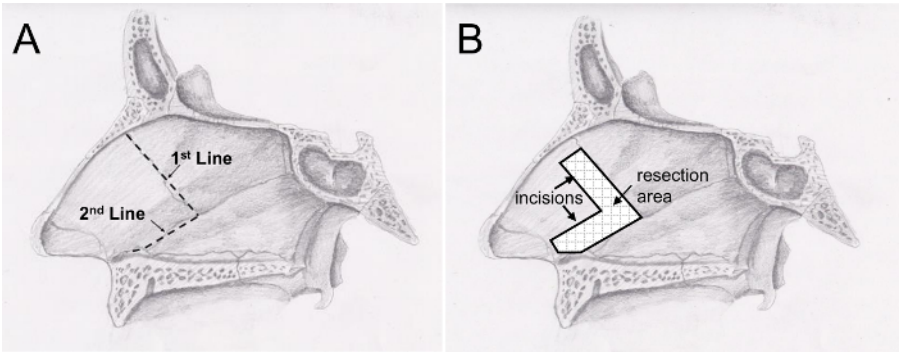

Figure 1: Location of the two-line and the resection area. (**A**) The first line is located at the junction of the quadrangular cartilage and the perpendicular plate of the ethmoid bone, and the second line is at the junction of the quadrangular cartilage, vomer bone, and maxillary crest. (**B**) Two incisions were carried out through the quadrangular cartilage. Two strips of septal cartilage and the adjacent bony septum were resected. Please click here to view a larger version of this figure.

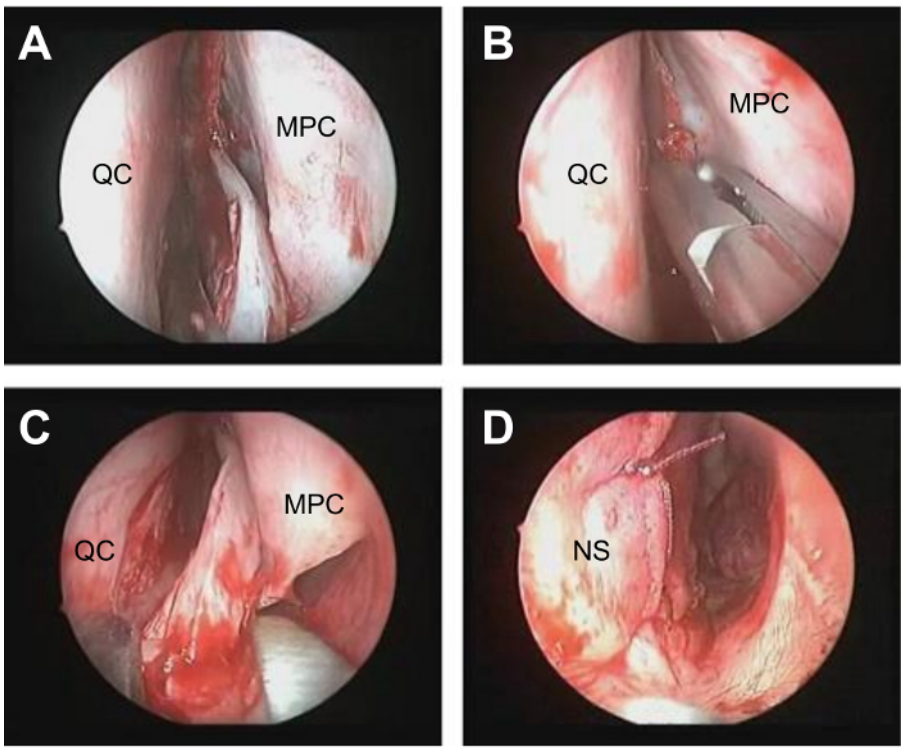

Figure 2: Intraoperative endoscopic photographs. (**A**) After the mucosa was elevated on the convex side, the incisions were made on the septal cartilage anterior to the first line and superior to the second line, and then the contralateral mucoperiosteum was elevated. (**B**) A strip of the septal cartilage and the adjacent bony septum was resected from the first line. (**C**) A strip of the septal cartilage and the adjacent bony septum was resected from the second line. (**D**) Two interrupted sutures were made to reapproximate the flaps. QC = quadrangular cartilage; MPC = mucoperichondrium; NS = nasal septum. Please click here to view a larger version of this figure.

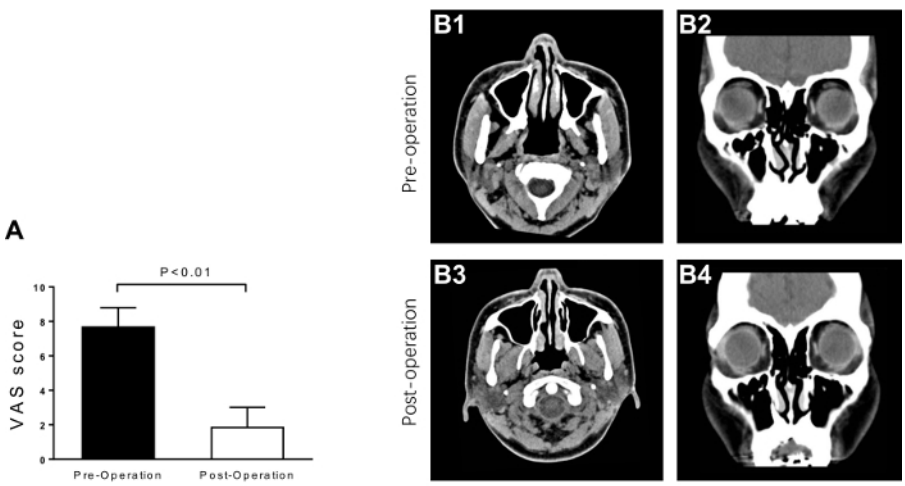

Figure 3: The effect of 2LoRs. A total of 32 patients with the indication of nasal airway obstruction caused by septal deviation were included in this study. None of the patients had a previous history of septoplasty. To eliminate nasal obstruction caused by other diseases, the patients with chronic rhinosinusitis, a nasal tumor, septal perforation, or with external nose deformities were excluded from this study. (**A**) The mean VAS score decreased from 7.67 ± 1.13 to 1.84 ± 1.17 (*P* <0.01). (**B**) The septum was deviated to the left nasal cavity before surgery (B1, B2) and was returned to the midline of the nasal cavity after surgery (B3, B4). The data are expressed as the mean ± the standard deviation. Please click here to view a larger version of this figure.

Discussion

The 2LoRs procedure is based on embryological and anatomic knowledge of deviated nasal septa. The nasal septum consists of three different components: the anterior membrane, cartilage in the middle, and posterior and inferior bone. During the development of the nasal septum, the different components ossify in different time sequences. It is commonly held that the bone finishes its extension while the cartilage still grows. Therefore, stresses accumulate on the margins of the cartilage adjacent to the osseous septum, resulting in the initial forces that may deform the

nasal septum. As a consequence, in most cases, the nasal septum deviates to some degree from the midline position[14]. Therefore, the principle of 2LoRs is to change the anatomy of the nasal septum by releasing the forces at the junction of the cartilage and osseous septum that cause the nasal septal deviation and the ones that impede the shaping and repositioning of the cartilage.

In this septoplasty procedure, two strips of the septal cartilage and its adjacent septal bone were resected to remove the excess cartilage and bone and release the stresses that have accumulated on the two lines. The extent of the removal depended on the significance of the cartilaginous deviation. Generally speaking, the more significant the deviation, the more excess was removed. Based on our clinical observation, in most cases, the vertical dimension of the resected cartilage strip on the second line was from 1/4 to 1/3 of the original height of the septal cartilage and similar to the anteroposterior dimension of the cartilage resection on the first line. For those with the septal cartilage of abnormal thickness and/or lack of elasticity, the dimensions were adjusted to 1/3 to 1/2 of the original height of the cartilage. As reported by Meeuwis *et al.*, the partial resection of the margins of the septal cartilage as large as the extent in 2LoRs has no effect on the postnatal growth of the nasal dorsum[17]. Therefore, 2LoRs might be performed on children and adolescents with nasal airway obstruction who fail medical treatments and pursue surgical intervention.

The septoplasty technique with 2LoRs presented here had a fairly low rate of complications and satisfied the subjective and objective assessment results. This should be attributed to the following surgical tips. First, care should be taken when the mucosa is elevated, as a full elevation of mucosa helps to release the forces that may impede the shaping and repositioning of the cartilage[18]. To this end, the Killian incision was started as high as possible and continued to the floor of the nasal cavity. We then fully elevated the unilateral mucoperichondrium on the convex side and the bilateral mucoperiosteum, vertically from the anterior margin of the quadrangular cartilage to the floor of the nasal cavity and horizontally from the mucocutaneous junction to the extent that the bony deformities were fully exposed and visualized. In addition, as suggested in the biomechanical principles applied to septoplasty, the elevation of the mucoperichondrium from the convex side bows the cartilage toward its intact surface, thereby moving back to the midline[18]. Moreover, the intact mucoperichondrial attachment on the concave side stabilizes the cartilage and potentially provides a blood supply in favor of the healing process[19]. Second, the interrupted sutures are used to approximate the mucosal flaps and to stabilize the septal cartilage and overlying mucosa; this can prevent postoperative complications, such as septal hematoma, bleeding, and perforation. Third, based on clinical observations, the straight rigid framework helps move the septal cartilage back to the midline via the fixation of the cartilage and mucosa. This is probably because the studied cases excluded the abnormal appearance of the nose (*e.g.*, a crooked nose and caudal dislocation), so the whole surrounding anatomic structure adjacent to the margins of the septal cartilage was on the midline after the correction of the bony septum.

It should be noted that, in rare cases, there were still visible residual deviations within the remaining quadrangular cartilage after 2LoRs in our study. Usually, this is due to the high anterior or superior bends and the severe inherent deviation of the quadrangular cartilage. In this situation, the concave surface of the deviation should be exposed, and multiple scratches might be needed on this side for the adequate repositioning of the quadrangular cartilage to the midline.

Two caveats of this study must be acknowledged. First, it would be more comprehensive if there had been a control group of traditional septoplasties, such as SMR, which has effective results in morphology correction and functional improvement. Therefore, the effect comparison of 2LoRs and traditional septoplasties warrants further investigation, especially by means of a prospective randomized controlled study. Second, a longer follow-up period might be needed to record complications such as saddle nose.

To sum up, 2LoRS provides an effective and safe procedure that can be used to correct the deviated nasal septum in the absence of external nasal deformity to improve nasal patency or to improve access to the middle meatus or to the axillary region of the middle turbinate as a preoperative operation. This procedure helps to minimize the removal of quadrangular cartilage and may expand the indication of septoplasty in children and adolescents.

Disclosures

The authors have nothing to disclose.

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