



Evaluation of Nasal Tip Support in Septorhinoplasty

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Abstract

Background A good understanding of nasal tip support mechanisms is essential for achieving successful and functional rhinoplasty results. The loss of nasal tip support resulting from different maneuvers adopted during rhinoplasty and how this loss is affected by reconstructive applications should be known. This study evaluated and compared changes in nasal tip support perioperatively after different techniques were used during septorhinoplasty.

Methods Patients who underwent primary open rhinoplasty between January 2018 and March 2018 in a tertiary medical center were included in this prospective blind case series. Nasal tip resistance measurements were taken after perioperative maneuvers by creating enough force to achieve 1 mm, 2 mm and 3 mm of displacement at the tip region. Measurements were obtained during six different stages using a Newton meter: preoperatively, after caudal septal resection, after skin flap elevation, after the columellar strut or tongue-in-groove procedure, after tip suturing and postoperatively. Our hypothesis was that during septorhinoplasty, each maneuver used changes the

tip support intraoperatively. The predictor variables were the different rhinoplasty techniques used. The outcome variable was nasal tip resistance to compression intraoperatively and immediate postoperatively. Appropriate statistics were computed, and a $p < 0.05$ value was considered significant.

Results Ten of the 15 patients were female, and 5 were male. The patient age ranged from 19 to 40 (mean 24.8 ± 4.9). The tongue-in-groove technique was applied in 5 of the patients, while columellar strut grafting was performed in 10. The application of columellar strut grafting did not create a significant increase in nasal tip support ($p > 0.05$). An increase in nasal tip support was observed at each stage (85%, 53%, 35%) after application of the tongue-in-groove technique ($p < 0.05$).

Conclusions A novel and reproducible technique for digitally evaluating manual force is presented for determining changes in nasal tip support with different maneuvers applied in living patients undergoing rhinoplasty. No significant difference was noted between the preoperative and postoperative measurements for columellar strut grafting. The tongue-in-groove technique is an important maneuver that has a significant effect on nasal tip support. According to our data, the interdomal and intercrural ligaments, the medial crus–septum connections and the connections between alar cartilage and overlying skin and muscle tissue are important structures for tip support.

Level of Evidence IV This journal requires that authors assign a level of evidence to each article. For a full description of these Evidence-Based Medicine ratings, please refer to the Table of Contents or the online Instructions to Authors www.springer.com/00266.

Keywords Rhinoplasty · Nasal tip · Tip surgery · Tip support · Newton meter

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Introduction

Septorhinoplasty (SRP) has both physical and psychological effects on patients because it changes the aesthetics and function of the nasal structures. Nasal tip surgery as a part of SRP is often challenging due to the various techniques that can be applied and individual anatomical differences among patients [1].

The bilateral lower lateral cartilage, the interdomal soft tissue and the nasal tip, including the overlying skin, play key roles in the anatomy, physiology and aesthetic appearance of the nose. In 1971, Janeke and Wright [2] first described the nasal tip support areas: (1) the scroll ligaments between the upper and lower lateral cartilage; (2) the sesamoid complex expanding the support of the lateral crus to the pyriform aperture; (3) the interdomal ligament between the bilateral lower lateral cartilage; and (4) the attachment of the medial crura to the posterior caudal septum. Various SRP and/or tip surgery procedures, such as caudal septal resection and cephalic resection, usually damage the tip support mechanism during surgery, and care must be taken to reinforce the support of the tip.

Many studies have analyzed the anatomical structures related to the strength of the nasal tip. However, only some have presented objective measurements of nasal tip support based on computer-assisted simulations [3] or cadavers [4–7]. To the best of our knowledge, there have been no studies that have objectively evaluated the resistance to the force directed toward the nasal tip in living subjects.

The purpose of the present study was to evaluate the intraoperative changes in nasal tip support resulting from two different surgical techniques. Our study hypothesis was that there would be differences in nasal tip support after the two specific rhinoplasty maneuvers. The specific aim was to analyze the intraoperative changes in nasal tip support during SRP based on objective measurements.

Methods

The study was designed as a prospective blind case series and was conducted in the Department of Otorhinolaryngology at Başkent University Medical Faculty, in Ankara, Turkey. Patients who underwent primary open rhinoplasty between January and March 2018 were included in the study. The study protocol was approved by the Başkent University Medical and Health Sciences Research Council and Ethics Committee (project no: KA17/359) and was supported by the Research Fund of Başkent University. Written informed consent was obtained from all patients.

As a part of a complete otorhinolaryngological examination, the nasal cavity and nasopharynx were evaluated

preoperatively by anterior rhinoscopy, flexible endoscopy and paranasal computed tomography, if needed. Preoperative photographs were taken of all patients in a standardized six-view fashion.

Study Exclusion and Inclusion Criteria

Patients with excessive caudal septal deviation, apparent external nasal deviation and a history of previous nasal (septum, aesthetic or tumor) surgery or with systemic disease affecting the connective tissues were excluded from the study. Patients who underwent similar surgical methods, such as caudal septal resection, cephalic resection, transdomal matrix suturing, “cap” grafting, projection control suturing and columellar support techniques (columellar strut with septocolumellar suturing or tongue-in-groove method) as the case required, were included in the study.

Surgical Method

All patients were operated on under general anesthesia by the same surgeon (F.B.). After topical decongestion with 0.05% oxymetazoline, 1% lidocaine with 1/100,000 epinephrine was injected in the following volumes to the corresponding structures: 4 mL into the septum; 0.1 mL into the columella; 0.2 mL into the tip area; and 0.2 mL into the osteotomy lines. Flap elevation began approximately 30 min after the injections and indicated the initiation of septoplasty. We believe that this time gap, together with the minimal amount of lidocaine used over the tip region (approximately 0.3 mL), makes the possibility of the injections interfering with the measurements unlikely. Septoplasty was carried out using the Cottle technique, and mucoperichondrial flap fixation was performed with transseptal sutures using 4-0 rapid Vicryl. An excision approximately 2 mm wide was made in the caudal septum as the case required. An inverted V incision and bilateral marginal incisions were made with a no. 15 blade. During skeletonization, the Pitanguy ligament was transected, and the interdomal and intercrural ligaments in the tip area were dissected. A dorsal reduction and a bilateral lateral osteotomy were performed using piezosurgery. Subsequent to the middle vault modifications, tip surgery was performed as the final stage of the operation. Lateral crus cephalic excisions were performed in all patients, and no additional procedure was applied to the lower lateral cartilage. The surgical steps were applied in all patients in almost the same order.

Study Design and Tip Resistance Measurement Protocol

The degree of tip resistance was measured and quantified in Newton using a commercially available digital Newton meter (EgeRate SF-50, EgeRate Elektronik, İstanbul) (Fig. 1). For each patient, measurements were taken (1) at the beginning of the operation (before the local anesthetic injections), (2) after caudal septal resection, (3) after skin flap elevation, (4) after the columellar strut or tongue-in-groove procedure, (5) following tip suturing and (6) at the end of the operation. For each measurement, a ruler was first placed in front of the patient's columella, serving as a tool for the measurement of the nasal tip displacement. The probe of the Newton meter was then placed on the skin of the nasal tip. Keeping the ruler still, gradual pressure was applied to the Newton meter to displace the nasal tip. All of the measurements were recorded on video using the digital camera of a cell phone (iPhone®7 Plus, Apple, Inc., Cupertino, California). The video-records were then analyzed in a digital environment (Photoshop CS 6, Adobe Systems, San Jose, California) by a researcher who was blinded to the timing of the measurement and the procedure applied. The values read on the screen of the Newton meter at 1 mm, 2 mm and 3 mm of nasal tip displacement were noted (Fig. 2). To confirm that the ruler did not move during the measurements, the movement of the tip was controlled by defining a reference point on the face of the



Fig. 1 Digital Newton meter and measuring probe



Fig. 2 A ruler was placed in front of the columella during the measurement

patient (Fig. 3). Each measurement was compared with that of the previous step and not with the preoperative assessment. Only the postoperative period was compared with the preoperative period.

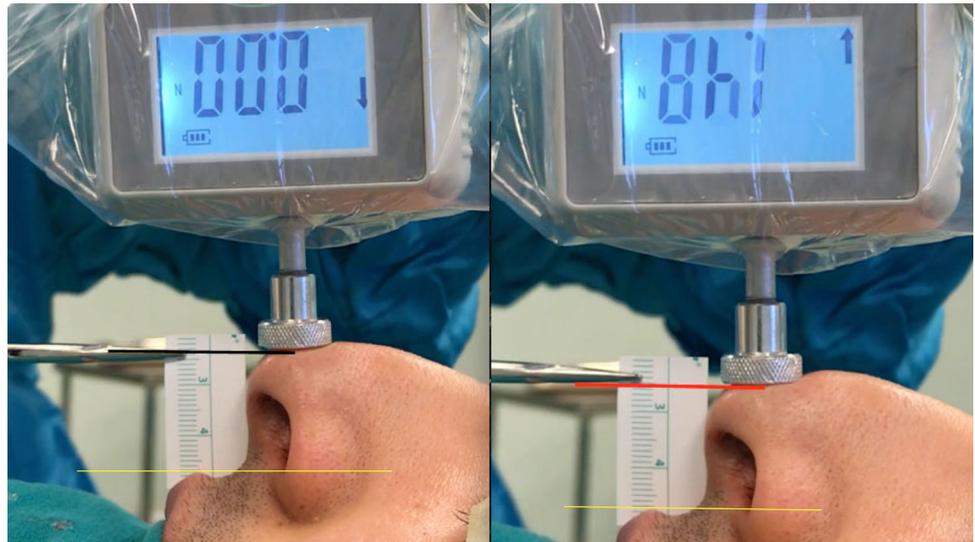
Statistical Analysis

Statistical data were analyzed using the SPSS 20.0 software package (SPSS, Chicago, IL, USA). The number of patients was determined by a power analysis based on a previous study [4, 6, 7]. It was determined that at least 15 patients should be included in the study for 90% significance and $\alpha = 0.05$. Continuous variables are presented as the mean \pm standard deviation. Differences between repeated measurements were analyzed using Friedman's test, and to determine the stage at which the differences occurred, a Bonferroni-adjusted Wilcoxon signed-rank test was used. A $p < 0.05$ value was considered significant.

Results

The study included 15 patients, 10 females and 5 males. The mean patient age was 23.2 ± 3.35 (19–27) and 25.5 ± 4.9 (20–35) for patients who underwent the tongue-in-groove and columellar strut procedures, respectively. None of the participants suffered complications of excessive bleeding or unexpected cartilage or soft tissue damage.

Fig. 3 The Newton meter probe touched the tip skin is accepted as zero point, the values obtained at the displacements of 1 mm, 2 mm and 3 mm were recorded. (Between the lower limit of the black line and the upper limit of the red line is 2 mm.)



The patients were further categorized into two groups, comprising patients who underwent the tongue-in-groove procedure ($n = 5$) and the columellar strut procedure ($n = 10$). There were no significant differences between these groups in terms of age, sex or skin type.

The anatomy and skin structures of the patients were similar. No significant difference was noted in the preoperative tip resistance between the groups ($p > 0.05$), and no significant difference was found in the preoperative tip resistance between the males and females ($p > 0.05$).

In the group of patients who underwent the columellar strut procedure, it was found that the tip resistance at 1 mm, 2 mm and 3 mm of displacement was significantly decreased after caudal septal resection (22%, 19% and 18%, respectively, $p < 0.05$). The tip resistance was determined to be significantly lower at all levels after flap elevation subsequent to caudal septal resection (10%, 6% and 7%, $p < 0.05$), whereas the tip resistance was found to be significantly increased at all levels following the columellar strut procedure (49%, 36% and 28%, $p < 0.05$). A significant increase was also observed in the resistance after the tip suturing procedure (6%, 4% and 3%, $p < 0.05$). Finally, after the skin was closed at the end of the operation, it was determined that the tip resistance was greater than that recorded after tip suturing (3%, 5% and 3%, $p < 0.05$). However, when the preoperative and postoperative measurements were compared, no significant differences were noted, despite the increased resistance ($p = 0.203$) (Fig. 4).

In the group of patients who underwent the tongue-in-groove procedure, it was found that the tip resistance at 1 mm, 2 mm and 3 mm of displacement decreased significantly following caudal septal resection (32%, 28% and 25%, respectively, $p < 0.05$). The tip resistance at 1 mm and 2 mm of displacement was found to be significantly

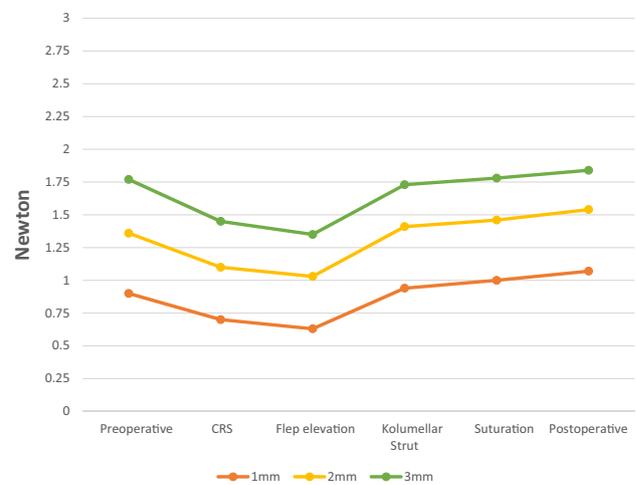


Fig. 4 Mean Newton values in the columellar strut group. CRS: caudal septum resection

lower after flap elevation subsequent to caudal septal resection (8% and 7.6%, $p < 0.05$); whereas there was a decrease at 3 mm of displacement, the difference was not significant (2.6%, $p = 0.225$). After the tongue-in-groove procedure, the tip resistance was found to have significantly increased at all levels (185%, 118% and 85%, $p < 0.05$); the tip resistance also significantly increased after tip suturing (2%, 2.5% and 2%, $p < 0.05$). Finally, after the skin was closed at the end of the operation, the tip resistance was greater than that after the suturing procedure (3%, 2.5% and 2%, $p < 0.05$). In addition, when the preoperative and postoperative measurements were compared, the values determined at the end of the operation were significantly greater than those determined preoperatively ($p = 0.043$) (Fig. 5).

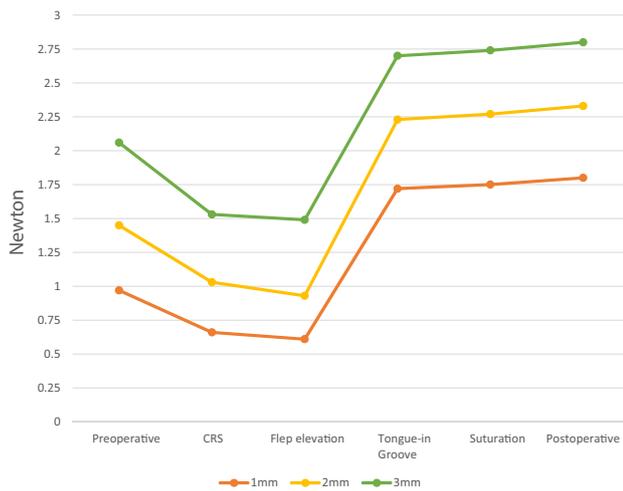


Fig. 5 Mean Newton values in the tongue-in-groove technique method. CRS: caudal septum resection

Discussion

Nasal tip support consists of a complex interplay of factors involving the cartilaginous skeleton, bony base and fibrous attachments. The structure of the cartilaginous skeleton resists compressive forces that converge on it from many vectors. The durability of the form and position of the reshaped nasal tip is one of the most challenging aspects of rhinoplasty. The surgeon must understand the anatomy and tip support mechanisms and should account for the alteration of these structures during tip plasty maneuvers [8]. This study sought to determine the important factors that play a crucial role in supporting the tip region. We objectively assessed the effects of various tip plasty maneuvers on tip resistance in living patients undergoing rhinoplasty. Similar to the evaluation based on a finger compression test used by clinicians to evaluate intrinsic tip support, a digital Newton meter was used, which can be considered a more objective and technical evaluation method. There have been few reports quantifying nasal tip support in a scientific manner.

While there are many studies in the literature related to nasal tip anatomy and surgical techniques, the structures that provide nasal tip support still remain controversial. After Janeke and Wright described the support areas of the nasal tip, the support structures were divided into major and minor groups by Tardy et al. [9]. The three major tip support mechanisms were defined as the size, shape and resilience of the medial and lateral crura of the lower lateral cartilage, the attachment of the medial crural footplate to the caudal septum, the interdomal ligaments and the scroll ligaments between the upper and lower lateral cartilage. On the other hand, Janeke and Wright [2] described the scroll connections as “fibrous ligaments”, whereas Han

et al. [10] described the connections as “ligaments”, and Gunter described this region as “connective tissue” [11]. Moreover, Janeke and Wright referred to a “thin and loose connection” between the medial crura and the caudal septum [2], whereas McCollough reported only a “membranous connection” in this area [12]. Kridel mentions ligamentous connections between the medial crura and the caudal septum [13].

Finally, in a study by Daniel and Palhazi, two of the four connective structures described by Janeke and Wright were claimed to be wrong; the authors stated that no apparent fibrous ligament exists between the medial crural footplates and the caudal septum or between the accessory cartilage and the pyriform aperture. The medial footplates wrap around the caudal septum in a caudal cephalic direction and settle on the soft tissue at the base of the columella. In addition, they showed that no direct fixation or support exists between the dome region and the anterior septal angle, arguing instead that the alar cartilage is bound and suspended by interdomal and intercrural ligaments and that these ligaments must be protected or repaired during surgery to protect the dynamism and support of the tip [14].

The role of the medial crus–caudal septum relationship in tip support is also controversial, with some arguing that this relationship is a major factor in support [6, 9, 14, 15], whereas others argue that this fibrous structure is not a real ligament but a structure that contributes to tip support only marginally [4]. Shamouelian et al. used finite element modeling of the nose to evaluate the major types of support. The medial crura and caudal septum were assessed, and it was determined that the tension decreased when the connection between the medial crura and septum deteriorated. In conclusion, they argued that the relationship between the medial crura and caudal septum is a major element of tip support [15]. Using a similar model, Manuel et al. found by palpation that stress and tension decreased in the tip after caudal septal resection [3]. In the present study, the significant reduction in tip resistance following caudal septal resection suggests that this relationship is one of the most important supportive mechanisms of the nasal tip.

In a cadaveric study, Beaty et al. measured the amount of tip support before and after surgery and the displacement in the direction of multiple vectors using a tensesgrometer. When the intercrural ligament was completely separated, the nose support decreased by 35%, and this lost support was recovered after repair; as such, one-third of the nose tip support depended on the presence of the intercrural ligament. The authors also noted that tip support weakened after skin elevation [4]. As intercrural and dome ligaments are repaired through tip suturing methods, an increase in tip support can be theoretically expected. In our study, a significant reduction in tip support was observed in relation to

these ligaments and the connections between the skin and cartilaginous structures, which were cut during the elevation; however, this loss was recovered after surgical grafting, the reconstruction of these regions and suturing. It can therefore be considered that intercrural and interdomal connections and skin are important elements in tip support. The variability of tip grafts and surgical maneuvers may also affect tip resistance. Our study included patients who underwent lateral crus cephalic resection, cap grafting, transdomal matrix suturing and projection control suturing in tip surgery. Those who were subjected to extra tip maneuvers, such as alar rim grafting, batten grafting, shield grafting and lateral crural set back, were not included.

Columellar strut grafts are placed by creating a small pocket anterior to the most caudal aspect of the septum. The medial crura are not completely divided while this pocket is created. This graft is commonly used to achieve columellar stability, although it has not been shown to increase tip support in cadaveric studies [6, 16]. In a study by Dobratz et al., although the supportive structures were preserved as much as possible using a columellar strut graft following caudal septal resection, a 16% reduction in support compared to the preoperative value was noted [6]. Conversely, Beaty et al. stated in their study that a columellar strut graft alone may increase the strength of the tip by an average of 40% [4]. Beaty et al. did not specify how the columellar strut was positioned or placed. If it was in full contact with the anterior nasal spine, an approximately 40% increase in tip support could have been achieved. In the current study, although there was a slight increase in tip resistance after each step, no significant difference was found between the preoperative and postoperative data of patients who underwent columellar strut grafting in the present study, which is consistent with the findings of other studies [6, 7, 16].

The tongue-in-groove technique can be successful if attention is paid to the maxillary deviation, malocclusion and midline condition, as the case requires. The main disadvantage of this method is its unnatural tip rigidity. In a study by Karaiskakis et al., nasal tip support was measured through palpation by the patients themselves [17]. Of the 33 patients, 27 patients (81.8%) reported that their nasal tip had hardened postoperatively, and only 18.2% of the patients reported that their nasal tip felt normal in the postoperative period. Among the patients who underwent the tongue-in-groove procedure, 92.3% reported nasal tip rigidity in the postoperative period, compared to 75% of the patients who underwent columellar strut grafting. In a cadaveric study by Dobratz et al., it was reported that the tongue-in-groove and septal extension graft maneuvers increased tip resistance [6]. The present study also shows that the tongue-in-groove method significantly improved nasal tip support at each level. In our study, we used the

tongue-in-groove or columellar strut graft procedures and measured the contributions of these two maneuvers to tip support. The intent of the study was not to divide the patients into two groups. At the completion of the study, two methods were used for stabilization of the nasal tip, the strut method in 10 patients and the tongue-in-groove technique in 5 patients. The two groups were then compared with each other. These choices reflect the surgeon's preference. The fact that there were no significant differences in the preoperative tip support among all patients indicates that the judgment of the surgeon is not biased and there was no bias toward selection of the tongue-in-groove technique. Undoubtedly, maneuvers such as caudal septal extension grafting can also affect tip support in different ways. Wilson et al. showed in their experimental study on cadavers using a Newton meter that septal extension grafts maximize tip strength, whereas columellar strut grafts make no significant difference in tip strength [7].

We acknowledge a few limitations of this study. The high sensitivity of the device becomes a disadvantage when trying to capture the exact moment of the correct position and value of the force displayed on the device's screen during the measurement. That is why we decided to record the entire measurement as a video clip for later analysis. These records were then evaluated in a digital environment. Additionally, supratip area resistance may be influenced by skin thickness and middle vault strength; this can be noted as a weakness of the study because these factors can affect the measurements. Another limitation of the study is the number of patients. The sample size was determined according to a power analysis based on previous studies. Additionally, this study solely focused on intraoperative changes in tip resistance with different maneuvers. A new study investigating the 6- and 12- month postoperative follow-up measurements may be planned.

Conclusion

It is very important to understand the anatomy of the nasal tip and its support mechanisms if successful aesthetic and functional rhinoplasty results are to be assured. It is further necessary to understand how the various maneuvers applied during rhinoplasty lead to the loss of tip resistance and how they are affected by corrective applications. In this study, changes in tip resistance following different maneuvers during rhinoplasty were observed in living patients. The results of this study show that the tongue-in-groove method provided the greatest level of support when tested under compressive forces. In the columellar strut group, no significant difference was identified between the pre- and postoperative values, although the resistance increased. According to the data produced in this study, the

interdomal and intercrural ligaments, the medial crus-septum connections and the connections between skin, muscle tissue and alar cartilage are thought to be important structures in tip support. The primary goal of our study was to detect the intraoperative effects of different surgical maneuvers. However, further studies are needed to demonstrate how the tip support changes in the long term.

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Compliance with Ethical Standards

Conflict of interest The authors declare that they have no conflicts of interest.

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