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Objective measurement of the deviated nose and a review of surgical techniques for correction*

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SUMMARY

Although many surgical techniques have been introduced, there are few clinical studies investigating postoperative results in crooked nose deformity. The aim of this study is to discuss the surgical choices for specific deformities and to report the long-term quantitative surgical results of our cases. One hundred and twenty cases (38 women, 82 men) with crooked noses (48 I-shaped, 72 C-shaped) operated on by the authors were included in the study. The patients have been followed for 6 to 46 months (mean 19 months) postoperatively. The Scion Image software program was utilized for numerical measurement of the nasal crookedness. In cases with I-shaped and C-shaped crooked nose deformity, preoperative and postoperative angle values were as follows: 6,84 ± 2,58°, 2,01 ± 1,53°, 152,97 ± 9,03° and 173,67 ± 4,55°, respectively. In both groups, postoperative correction rates were statistically significant (p = 0,0001). Despite these results, patients undergoing surgical treatment should be informed about imperfect outcomes, possibility of persistent deformity and the need of revision surgery.

Key words: crooked nose, twisted nose, surgical result, quantitative analysis, Scion Image

INTRODUCTION

The crooked nose has been recognized as one of the most difficult and persistent deformities to treat by facial plastic surgeons. Correction of the functional and aesthetic problems resulting from this deformity presents a major challenge. Actually, the term crooked nose implies more than one deformity. It is basically being used to define deformities of the nasal pyramid showing deviation from the vertical midfacial plane. If the deviation is linear and nasal osseous and cartilaginous dorsal margins are in line, the crooked nose deformity is described as I-shaped. Some patients with crooked noses present a concave contour in one side and a convex contour on the other side. This type of deviation is called a C-shaped crooked nose. If the patient has both convexity and concavity on one side, the patient's nose appears S-shaped. Cases with a nose placed midline, but having unilateral soft tissue, cartilage or osseous concavity mimicking a crooked appearance present a pseudo-crooked nose.

The detailed comprehension of the three dimensional nasal anatomy is essential for accurate understanding of the nasal deformity and its correction. The division of the anatomic subunits of the nose into upper, middle and lower thirds helps to understand the underlying deformity limited to subunits and to simplify the corrective techniques to be applied. Modification of the upper third of the nose requires primarily bony work by using osteotomes and rasps. The lower two thirds of the nose consist of the cartilaginous vault and its modification is obtained by soft tissue surgical techniques such as resection, weakening, suturing and reinforcing techniques. However, the inherent memory of the cartilages may render correction of the deformity difficult.

The evolution of the rhinoplasty has developed from destructive techniques to conservative, protective and augmentation techniques in recent decades. Surgical techniques being used for crooked nose deformity, generally consisting of mobilization and realignment have also been unpredictable, because of destabilization that is the nature of these surgical techniques and wound healing processes. The time, as the fourth dimension of the healing process, has also an important effect on the surgical results. Surgical correction of the crooked nose requires a meticulous realignment of each component of the nasal framework. The complexity and variability of the deformity lead to creation of new surgical methods to correct for specific purposes and classifications of the subgroups to clarify the understanding and the surgical road map. The detailed preoperative analyses and precise intraoperative management are even more crucial for the surgical correction of the crooked nose deformity[(1)].

Although many surgical techniques have been introduced,

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there are only a few clinical studies investigating the quantitative improvement in postoperative results and surgical success[2-4]. This type of deformity has also been called as deviated, twisted, deflected, asymmetric or scoliotic nose. There are many suggested surgical approaches in the literature, because no technique can ensure a perfect result and no technique has been shown to be an ideal procedure with lower revision rates than the others. The aim of this study is, to discuss the surgical choices for specific deformities and to report our long term quantitative surgical results for the crooked nose deformity.

PATIENTS AND METHODS

Patients

One hundred and twenty cases (38 women, 82 men) with crooked nose deformity (48 I-shaped and 72 C-shaped crooked noses) underwent nasal surgery through an open approach by the authors in a tertiary referral centre between May 1998 and June 2006. The age range of the patients was between 18 and 48 years (mean 26,4 years). All patients underwent a detailed physical examination and standard facial photography for rhinoplasty in six positions (postero-anterior, basal, left and right laterals and left and right obliques). The clinical examination of the nose comprised the assessment of the shape and position of the nasal bones in the upper third and the cartilaginous framework of the lower two-thirds of the nose. Nasal bony and cartilaginous frameworks were evaluated for symmetry, size, form and the presence of a dorsal hump. Also, the crucial intranasal examination was done to determine the septal and nasal valve pathologies.

Image analysis

The Scion Image (Beta 4.02 Win version) software program was utilized for numerical measurement of the nasal crookedness [5]. The measurement of the I-shaped noses were accomplished on the frontal view of the photograph as follows: I-deformity angles were measured between line-1 lying between the midpoint in the glabella and the midpoint of the upper lip and line-2 representing the nasal dorsal axis consisting both of osseous and cartilaginous parts from the nasion to the anterior nasal spine (Figure 1). For that reason line-2 was accepted as the nasal dorsal line. The line-2 lying between the nasion and the tip described and used in previous studies is not utilized for measurements, because in cases with I-nose deformity, the tip is usually closer to the midline than the dorsal axis which underestimates the real deformity (Figure 1). In repeated measurements of angles, most consistent values were accepted as I or C-angles to prevent intermeasurement variability. During repeated measurements, both authors agreed for the final angle result to eliminate inter-examiner variability.

In cases with C-shaped crooked nose, the deformity angle was measured on the frontal view of the photograph as follows: the angle between line-1, lying between the nasion and the most prominent point of convexity and line-2, lying between the most prominent point of convexity and the nasal tip was measured (Figure 2). In this way, the angle between the superior bony axis and the inferior cartilaginous axis was determined. Pre-operative and postoperative views of representative cases are shown in Figures 3 and 4.

The closeness ratio to the ideal angle was calculated by com-

Figure 1. Measurement method for I-shaped crooked nose deformity. Note that, the nasal tip is placed closer to midline according to upper two thirds of the nose.

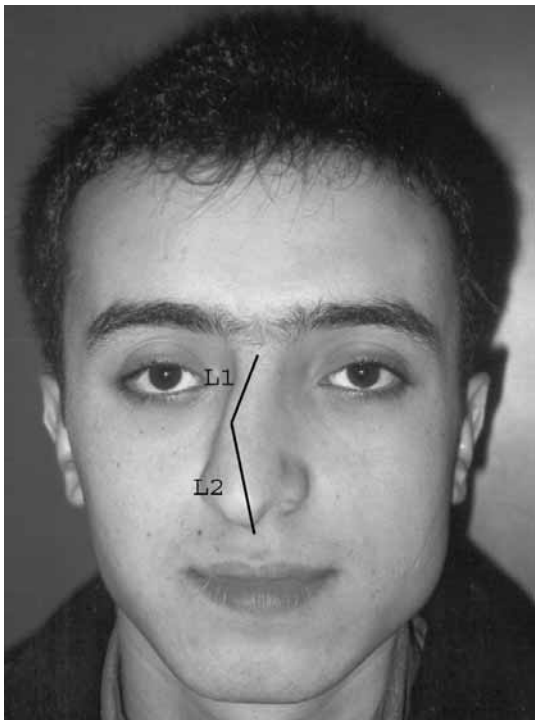

Figure 2. Measurement method for C-shaped crooked nose deformity.

Figure 3. Preoperative (A) and postoperative (B) anteroposterior view of a patient with I-shaped crooked nose deformity.

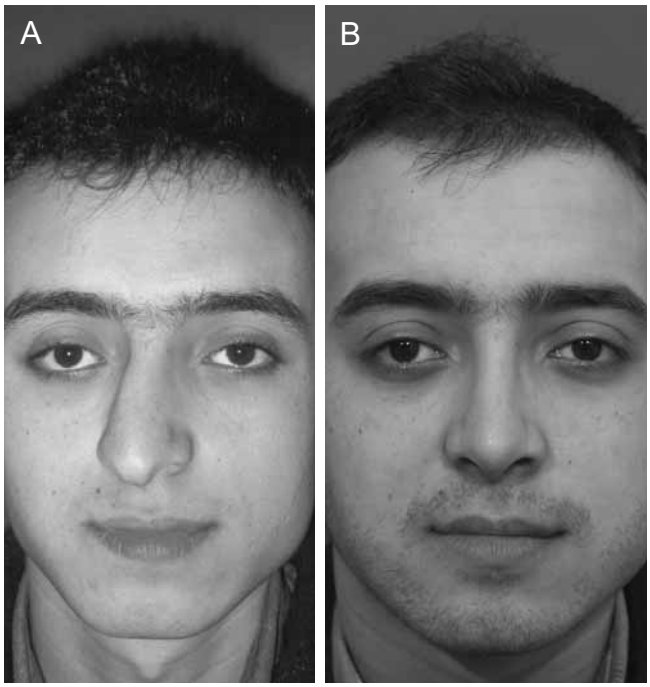

Figure 4. Preoperative (A) and postoperative (B) anteroposterior view of a patient with C-shaped crooked nose deformity.

paring the pre-operative deformity angles with the post-operative values. The pre- and post-operative deviation from the ideal situation was compared, providing a success rate that is divided in to 4 categories. If this ratio was 90-100 %, the result was accepted as "excellent". If the ratios were 70-89%, 50-69% and below the 50%, the results were accepted as "good", "moderate" and "bad", respectively. Because the evaluation of the angles of the S-shape deformity were difficult and unreliable, these S-shaped crooked noses were excluded from the study.

Statistics

All measurements were made on pre-operative and post-operative photographs taken at least sixth months' after surgery. The normality of distribution of the data in measured deformity angles was examined by a *Shapiro-Wilks test*. Individual pre-operative and post-operative deformity angle values were compared by a *paired t-test* to investigate the surgical improvement.

RESULTS

Patients enrolled in this study were followed for 6 to 46 months (mean 19 months) post-operatively. In cases with an I-shaped crooked nose deformity, pre-operative and post-operative angle values were 6,84 ± 2,58° (range 3,32 - 12,71°) and 2,01 ± 1,53° (range 0-4,56°), respectively. The avarage preoperative deformity angle value was 152,97 ± 9,03° (range 132,54 - 165,80°) in C-shaped crooked nose deformities. This angle was postoperatively found to be 173,67 ± 4,55° (164,15 - 180°). In both groups, postoperative correction rates were statistically significant ($p = 0,0001$).

Table 1. The closeness ratios to the ideal angles were given according to deformity types.

	Excellent	Good	Moderate	Bad
I-cases	9 (18,8%)	19 (39,6%)	15 (31,2%)	5 (10,4%)
C-cases	20 (27,7%)	22 (30,5%)	16 (22,2%)	14 (19,4%)

The closeness ratios of the deformities to the ideal angles are given in Table 1. Using this as previously discussed, excellent results were achieved in 9 patients (18,8%) that were I-cases and 20 (27,7%) of the C-cases. In the group I-case, 19 (39,6%), 15 (31,2%) and 5 cases 10,4%) had good, moderate and bad results, respectively. In the group C-cases, 22 (30,5%), 16 (22,2%) and 14 cases (19,4%) resulted in good, moderate and bad results, respectively.

The following surgical methods have been utilized to correct the crooked nose deformity, specific indications for which are discussed later. Bilateral and unilateral spreader grafts were applied in 34 and 32 patients consecutively. Total or subtotal septal reconstructions have been used in 38 patients with severe deformity. We have utilized a tongue-in-groove technique in 22 patients. Camouflage techniques to the dorsum and the tip were applied in 18 patients in addition to reorientation methods. A unilateral osteotomy has been used in two cases; an intermediate osteotomy was required in six cases. In five cases, the removed hump was replaced on the dorsum after achieving the desired shape and size.

DISCUSSION

The major cause of the crooked nose is trauma[6]. In cases following nasal fracture, particularly when the septum is dis-

placed from the maxillary crest, attempts utilizing closed reductions often produce unsatisfactory results in terms of aesthetics and function. Minor traumas exposed in the early years of life may lead to major deformities with continued asymmetric chondrocyte growth. Other rare causes of this deformity are congenital, infectious and iatrogenic.

The crooked nose deformity term does not indicate a single deformity. It consists of several deformities causing nasal asymmetry. This term basically is used to define deformities of the nasal pyramid showing deviation from the vertical midfacial plane. Facial asymmetry, a limiting factor for the surgical correction is rarely discussed[7]. Subtle facial asymmetry, which is not recognized by the patient, should be pointed out before surgery to indicate the surgical limitations. In four cases, we have detected mild facial asymmetry.

The variations of the crooked nose deformity were classified as mentioned before. In this study, I-shaped and C-shaped crooked noses were included. S-shaped crooked noses were excluded because of the low measurement reliability in these deformities.

The crooked nose deformity is almost always associated with septal deviation. Generally the pathology underlying the crooked nose is a malpositioned or deformed nasal septum. "As the septum goes, so goes the nose" emphasizes the importance of septal correction in crooked nose deformity[8]. The extrinsic forces arising from surrounding anatomical structures, such as upper and lower lateral cartilages, vomer, perpendicular lamina of the ethmoid and maxillary crest and the intrinsic forces arising from the quadrilateral septal cartilage itself contribute to the formation of the septal deviation[9]. The position and the form of the septum also determine the type of the crookedness of the nose. The mispositioned, but otherwise straight quadrilateral septal cartilage causes an I-shaped crooked nose deformity. In cases with C-shaped crooked noses, the asymmetric nasal appearance generally arises from the intrinsic dorsal septal quadrilateral cartilage deformity. In the C-shaped noses, in certain cases a septal deviation is seen on the convex side, but in some cases, a caudal septal luxation can be associated on the contralateral side. The aims of the surgical treatment are to create a robust and well supporting nasal septum in the midline together with cosmetic and functional correction of the nasal deformity.

The best surgical option for the correction of a crooked nose is usually an open approach. Endonasal approaches providing limited exposure are often inadequate to refine the dorsal septal deviations and to apply splinting or spreader grafts. There are several surgical methods generally used together for the treatment of the crooked nose. These are divided into reorientation techniques aiming to correct the form and the position of deformed portions of the nose and the camouflage methods concealing the underlying deformities.

Though the crooked nose deformity is accepted as a cosmetic problem, nasal obstruction is one of the major complaints of the patients. The constriction of the nasal valve area, either uni- or bilaterally, is an important problem to be addressed.

The upper third of the nose consisting of the nasal bony framework is assessed for symmetry, size, form and the presence of a dorsal hump. The dorsal profile should be assessed to see if removal of the nasal dorsal hump is required. In the majority of the cases with crooked nose deformity, the separation of the upper lateral cartilage from the dorsal septum, asymmetric hump removal[10] in cases with nasal hump, vertical, transverse and lateral osteotomies in cases without nasal hump, recreation of the attachment between the septal cartilage and the anterior nasal spine, unilateral or bilateral spreader grafts, splinting grafts, clocking sutures[11] are utilized for the correction. The existence of a large dorsal hump as well as a crooked nose usually requires asymmetric hump removal, with a greater amount from the concave than the convex side. After asymmetric hump removal and medial and lateral osteotomies, both nasal bones that have the same height meet in the midfacial plane[6,10]. In some cases with a lateral bony hump, a double lateral osteotomy is required to give the desired shape to the nasal bones after hump removal[12,13]. Preservation of periosteal and mucosal attachments of the nasal bones during osteotomies provides minimal destabilization of the nasal bony framework[12,13]. In cases that do not require hump removal, sequential osteotomies (like opening a book) are applied, starting with the lateral and medial osteotomies on the longer side, then a transverse root osteotomy to the septum, and finally medial and lateral osteotomies on the shorter side[8,13,14]. After apposition of both nasal bones, realignment is achieved by bone cutting or rasping. In certain cases unilateral osteotomy may be sufficient for the correction of the crooked nose deformity. In our study, bilateral medial oblique and lateral osteotomies were applied after hump removal in cases with a nasal dorsal hump. In cases without a dorsal hump, bilateral vertical and lateral osteotomies in sequential fashion were administered. We have used unilateral osteotomies in only two cases. Intermediate osteotomy was required in six cases. Finally, in five cases, the removed hump was replaced on the dorsum after the desired shape and size was achieved.

The correction of deformities of the lower two thirds of the nose consisting of the cartilaginous framework almost always requires the separation of the upper lateral cartilages and the septum. This separation allows complete realignment of these parts[15]. In the crooked nose, quadrilateral septal cartilage should be freed from the surrounding bony and cartilaginous structures, to eliminate the extrinsic forces on the septal cartilage, leaving only a limited attachment to the dorsal perpendicular plate of the ethmoid. After this procedure the intrinsic forces originating from the cartilage's own shape should be evaluated. Incision, resection, suturing techniques and splint-

ing grafts are used to straighten the dorsal septal C-shaped deformities and to splint it in its corrected configuration. The separation of the upper lateral cartilages from the septum to eliminate the external forces allows one to see the original shape of the cartilage without extrinsic factors per se and to realign the structures in the midline. Asymmetric hump removal, unilateral spreader graft application and differential septal sutures are applied in most of cases with I-shape crooked noses. After realignment, the upper lateral cartilages must be sutured to the dorsal margin of the septal cartilage to eliminate a significant risk of infero-medial collapse of the upper lateral cartilages[10]. Differential septal sutures are placed as follows: the upper lateral cartilage opposite the deviated side is sewn superiorly to the septal cartilage and the upper lateral cartilage on the deviated side, so that the deviated cartilage frame is pulled medially as the suture is tightened[11].

The cross-hatching of the deformed septal cartilage helps to release its inherent memory. Splinting grafts fashioned from the bony perpendicular plate or cartilage are used to straighten out the dorsal septal C-shaped deformities, to splint it in its corrected configuration and to gain functional and cosmetic improvement[10]. This graft can be harvested from the bony or cartilaginous septum in shapes measuring 5 to 12 mm in length and 3 to 5 mm in width. Bilateral spreader grafts were used in 34 patients, unilateral spreader grafts were applied in 32 patients.

Dorsal 1-1.5 cm L-shaped septal strut should be preserved to maintain the structure and the form of the nose[6,10,15]. The attachments of the L-strut should be reconstituted if these attachments have been divided. An extracorporeal total septal reconstruction[16] should only be used when absolutely necessary. In those cases, the preservation of a piece of cartilage attached to the dorsal perpendicular plate of the ethmoid facilitates the upper stabilization of the L-shaped septal strut to itself by suturing it to this remnant. If this is not possible due to unavailability of any dorsal cartilaginous remnant, upper stabilization of the septal L-strut requires making holes in both nasal bones for septonasal suturing. A septal L-strut should also be fixed to the anterior nasal spine through a hole created by a drill or needle, or to the periosteum surrounding the anterior nasal spine in the midline[15]. We used total or subtotal septal reconstruction in 38 patients with severe deformity. If the prepared L-strut is long enough, this can be used as a columellar strut graft as in a tongue-in-groove technique[10]. We utilized a tongue-in-groove technique in 22 patients.

In certain cases, camouflage techniques for nasal dorsum and the tip can be added to reorientation methods. The major advantage of these techniques is preservation of the nasal support mechanisms[17]. Camouflage techniques to the dorsum and the tip were applied in 18 patients in addition to reorientation methods.

Separation of the telescopic connection between upper and lower lateral cartilages, cephalic and caudal resections from the lower and upper lateral cartilages, respectively, should be added to the surgical methods in most of the patients for complete liberation of the nasal skeleton.

After surgical intervention, trans-septal mucosal continuous sutures and a Doyle nasal splint were placed routinely for internal splinting.

Though many surgical techniques have been introduced, there are few clinical studies investigating the quantitative postoperative results and surgical success[2-4]. Ellis and Gilbert reported that the correction rates were 90% for nasion and 75% for rhinion deformities without giving any detail about the cases and the evaluation methods[2]. Ozturan et al. obtained a significant correction in C-shaped and I-shaped crooked noses, but with closer to the ideal angles in I-shaped crooked noses than the C-ones[3]. They stressed that C-shaped crooked noses require more experience, and familiarity with a wide range of surgical techniques. They found angles of 6,4° and 150° pre-operatively and 3,2° and 164° post-operatively in 59 patients with I-shaped and C-shaped crooked noses, respectively. Okur et al. reported their correction rates and measured angles in patients with I and C-shaped crooked nose[4]. They found angles of 7,6° and 147° pre-operatively and 1,9° and 167° post-operatively in 27 patients with I-shaped and C-shaped crooked noses, respectively. These results are similar to our study (Table 2).

In conclusion, crooked nose deformity is still one of the most challenging deformities requiring complete separation and realignment of the nasal framework and nasal septum in the midline for cosmetic and functionally successful results. The patients undergoing surgical treatment should be informed prior to the operation for the possibility of persistent deformity and the need of revision surgery. This study presents baseline success figures with moderate term follow-up in a reasonably large number of patients with crooked nose deformity.

Table 2. The quantitative analysis data of the crooked nose deformity in the literature.

	I-cases, n	I-angles, before operation	I-angles, after operation	C-cases, n	C-angles, before operation	C-angles, after operation
Ozturan et al.	29	150,7 ± 8,8	163,9 ± 7,7	30	6,4 ± 2,2	2,3±1,4
Okur et al.	14	146,8 ± 10,12	167,7 ± 7,2	13	7,6 ± 2,38	1,9±1.04
Erdem and Ozturan	48	152,97 ± 9,03	173,67 ± 4,55	72	6,84 ± 2,58	2,01±1,53

However, further and longer quantitative studies on the crooked nose deformity from different centres are needed with longer-term follow-up to confirm these findings.

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