The Pi Graft for Correction of Severe Saddle Nose Deformity

Jonathan Zelken, MD[1] Chun-Shin Chang, MD[2] Yen-Chang Hsiao, MD[2]

[1] Private Practice, Newport Beach, California
[2] Department of Plastic and Reconstructive Surgery, Chang Gung Memorial Hospital, Taipei, Taiwan

Facial Plast Surg 2016;32:452–459.

Address for correspondence Yen-Chang Hsiao, MD, Department of Plastic and Reconstructive Surgery, Chang Gung Memorial Hospital, F11, No. 213, Wen-Shin Road, Taoyuan, Taipei 3, Taiwan (e-mail: b8301063@gmail.com).

Abstract

Saddle nose deformity is challenging because there is both aesthetic and functional compromise, and high rates of recurrence have been reported. Autologous costal cartilage is the widely preferred medium for reconstruction, but there may be room for improvement in the configuration of the cartilage struts. The pi graft is stabilized at two points, proximally and distally, distinguishing it from the traditional L-strut. Indications include severe (Types III and IV) saddle nose deformity with collapse of the mid-vault, and recurrence after prior reconstruction. Costal cartilage is harvested and three struts are crafted to make the foundation layer: a dorsal strut, caudal strut, and mid-vault strut. An aesthetic layer is composed of a carefully crafted dorsal graft and tip graft. Three men and 11 women were treated from 2013 to 2015 using this method for severe saddle nose deformity. Aesthetic and functional outcomes were evaluated. Patients were followed up for 12 months (range, 8–14 months). There was no recurrence of deformity or warping of the aesthetic or foundation layers. All patients were guided to anticipate refinement of the tip at 3 months to ease the burden on the skin envelope in stage I, but only five patients (35.7%) opted for it, as the remaining patients were satisfied with their appearance. The pi graft is a composite reconstructive method that is designed to minimize warping and recurrence of the saddle nose deformity. This method was successful in this series, although objective comparisons with traditional methods were not made.

Keywords
► saddle nose
► rhinoplasty
► nasal reconstruction

The saddle nose deformity is both aesthetically and functionally displeasing. It arises from various etiologies that dissolve the critical bony and cartilaginous support structures of the nose. Most often, the deformity results from facial trauma, cocaine abuse, and prior rhinoplasty. Classification schemes have been described that drive treatment plans,[1–8] but outcomes are not extensively reported. In a recent series, Hyun and Jang reported unsuccessful outcomes in 22% of their patients; this appeared to be unrelated to the severity of their deformity.[4] Because warping can occur and often is a cause for surgical revision with costal cartilage, many strategies have evolved to prevent or correct that deformity.[9–14]

Recurrence is another reported complication of saddle nose deformity. If the keystone area is destabilized or the caudal septum gives way, the dorsal septum or graft may buckle. To address this, Aziz et al reinforced an L-shaped strut with an oblique crossbar.[15] The team did not compare outcomes against traditional methods but did remark that there was no airway obstruction or persistent deformity in any of the cases. More traditional approaches include paired extended spreader grafts (ESGs) and one or more septal

Issue Theme Challenging Problems in Rhinoplasty; Guest Editor, Hossam M.T. Foda, MD

DOI http://dx.doi.org/10.1055/s-0036-1584555.
ISSN 0736-6825.

extension grafts (SEGs) that are bolstered to the anterior nasal spine (ANS).[1–3,5,7,8,16]

While traditional methods address anatomic deficiencies, there may be room for improvement. Jung et al bring into question the safety of paired ESGs.[17] They observed that many Asian patients who had paired ESGs placed for treatment of contracted or under projected noses returned with recurrence and necrotic breakdown of native cartilages. In response, the Korean group advocated for unilateral ESGs supplemented by a columellar strut in their patients. In a more recent article, Jung introduced the "X-graft," which relies on a single ESG and SEG for cosmetic rhinoplasty.[18] Jung states that the durability and cosmetic outcome are excellent.

Of course, reconstruction of the saddle nose deformity follows a different set of guidelines than for primary rhinoplasty. There is little, if any, septal cartilage to harvest, as is used in the "X-graft." Soft-tissue contracture will impose greater demands on the constructed framework, and no existing structures will reliably support the autograft. To address these discrepancies, costal cartilage is typically harvested. A generous donor supply allows for harvest of a second strut. Because costal cartilage is prone to warping, the authors suggest placing the second strut more proximally so that it abuts the deep scar tissue, or in severe cases, the vomer bone. The construct is named the pi graft because of its resemblance to the Greek letter. It is intended to reduce warping through a second point of fixation proximally and confer additional stability to the mid-vault. In this series, we aim to explain the method, report outcomes, and validate the concept of the pi graft.

Methods

This study was a prospective, observational case series for those with severe saddle nose deformity treated with the pi graft. The study analyzed clinical outcomes of 14 patients (3 men, 11 women) treated from 2013 through 2015. Ethnically, Taiwanese patients were 22 to 49 years old (average, 34.3 years) with Type III (8 cases) or Type IV[2] (6 cases) saddle nose deformity. Every subject provided written informed consent. Etiology of their deformity was posttraumatic (4 cases, 29%), cocaine abuse (4 cases, 29%), tumor resection (2 cases, 14%), septoplasty (2 cases, 14%), and cosmetic rhinoplasty (2 cases, 14%). Five patients (36%) had septal perforations that were not greater than 2 cm in any dimension. ►**Table 1** summarizes patient demographics. Preoperative and postoperative photographs were obtained at every visit.

Indications

Indications for the pi graft procedure include severe saddle nose deformity with or without a septal defect and severe collapse of the mid-vault. It should be considered for recurrent cases of saddle nose deformity, particularly if previously corrected using a different approach.

Table 1 Patients' information

Age/Sex	Fig.	Etiology	Type[a]	Septal perforation (cm)	Additional procedures	Follow-up (mo)	Outcome		Revision	
							Recurrence	Warping	Tip	Dorsum
27/M		Septoplasty	IV	–	Remove silicone implant	8	No	No	No	No
38/F	3	Oncologic	III	–	–	14	No	No	No	No
49/F		Oncologic	III	–	–	13	No	No	No	No
23/M		Trauma	III	–	–	14	No	No	No	No
26/F		Cocaine	III	2 × 1.5	–	12	No	No	No	No
32/F		Cocaine	IV	2 × 2	–	10	No	No	No	No
39/F		Trauma	III	–	–	11	No	No	Yes	No
45/M		Rhinoplasty	IV	2 × 1.5	–	12	No	No	Yes	No
39/F		Cocaine	IV	1.5 × 1.5	–	14	No	No	Yes	No
36/F		Rhinoplasty	IV	–	Remove silicone implant	9	No	No	Yes	No
28/F		Cocaine	III	1.5 × 1.5	–	12	No	No	No	No
22/F	9	Trauma	IV	–	Pyriform graft	10	No	No	No	No
23/F		Trauma	IV	–	–	12	No	No	No	No
40/F		Septoplasty	IV	–	–	13	No	No	Yes	No

[a]Based on Daniel's classification.[2]

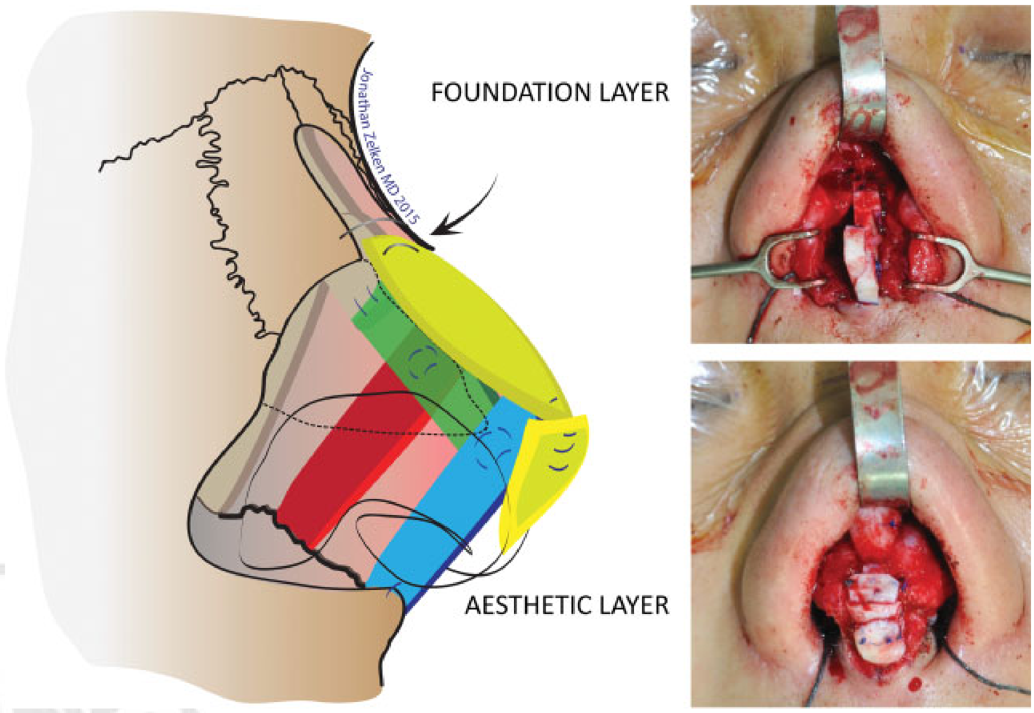

Fig. 1 Schematic showing the pi graft components. The dorsal strut ("C," *green*), caudal strut ("A," *blue*), and proximal strut ("B," *red*) comprise the foundation layer (*upper right*) of the pi graft. The B strut is placed halfway along the dorsal strut, accounting for the width of the A strut, at the point of maximal weakness. The dorsal onlay graft and tip graft (*yellow*) comprise the aesthetic layer (*lower right*). The strut is fixated to the nasal bone using steel wire (*black arrow*).

Surgical Technique

The senior author (Y-C.H.) operated on all patients under general anesthesia. Autologous rib cartilage was used in every case. The surgical methodology in every case was largely borne from the teachings of Daniel and Jung,[2,18] yet with several important modifications (►**Fig. 1**). After vibrissae were trimmed, existing structures were evaluated using rhinoscopy to assess the mucosa and septal remnants. Based on these findings, cartilage was harvested from the cartilaginous portions of the seventh rib. The soft tissue was elevated delicately and the nose was explored. The lower lateral cartilages were separated from midline structures to identify the ANS. The caudal edge of the nasal bridge was identified and the length discrepancy was measured. This would determine the length of the dorsal (C) strut. Similarly, the planned tip projection was measured to the ANS to determine the length of the caudal strut (A). These structures were sutured together with 5–0 nonabsorbable monofilament and overlapped to create an "X" configuration as close to 90 degrees as possible.[18]

The A–C construct (X-graft) was placed in the soft-tissue envelope. A shortened cotton-tip applicator was placed halfway between the junction of the C strut and existing dorsal structures and the A strut. The tip was driven perpendicularly until a hard stop was reached. This represented a stable foundation for the proximal (B) strut, which was principally composed of scarred, collapsed existing nasal structures. The length of the applicator was measured. The X-graft was removed and a B strut was measured to that length and placed in the same position along the C strut and perpendicular to it. It was placed on the opposite side of the A strut to confer a lateral counterforce to the A strut. The A–B–C construct (pi graft, ►**Fig. 2**) was replaced. The base of the A strut was sutured to the ANS and the proximal end of the C strut was

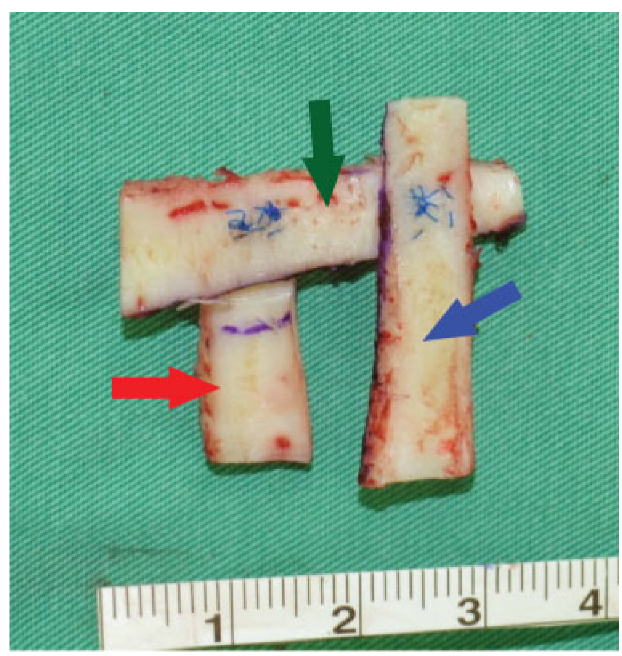

Fig. 2 The foundation layer of the pi graft. The A (*blue*) and C (*green*) struts create an "X-graft" and the addition of the B (*red*) strut at the midpoint of the dorsal graft completes the foundation layer. The construct resembles the Greek letter pi.

Fig. 3 A 38-year-old woman developed Type III saddle nose deformity due to intranasal tumor extirpation. Preoperative frontal view.

wired to the nasal bone using stainless steel surgical wire and a two drill holes. The B strut was designed to abut deep structures; no deep sutures were placed. Existing membranous septum and scar was recruited to provide a sufficient vascular envelope for the pi graft in every case.

The skin envelope was replaced over the pi graft (foundation layer). The integrity and position of the graft was confirmed and contour irregularities were identified. A composite reconstruction was performed,[2] crafting remaining costal cartilage to an aesthetically pleasant and contoured dorsal onlay graft (aesthetic layer). Costal cartilage, septal cartilage fragments, or conchal cartilage was used to contour the tip conservatively. Conservative grafting was intended to protect the skin envelope and minimize stress on the tenuous blood supply. Excess cartilage was banked in the scalp for future surgery. Accordingly, patients were informed preoperatively that additional tip grafting and refinement would be planned at 3 months. Of course, they would have the liberty to opt out if so desired.

Results

Patients were followed up for 11.7 months (range, 8–14 months). Grafts were placed successfully in every case with excellent on-table results and there were no peri- or postoperative complications. In two cases that followed cosmetic rhinoplasties, a silicone dorsal strut was removed. One deformity that was secondary to childhood facial trauma was reinforced with rib graft to the pyriform aperture for premaxillary deficiency. There was no recurrence of the saddle nose deformity and there were no revisions for persistent deformity of the nasal dorsum. Similarly, warping did not occur in any of the cases of either the foundation layer or the aesthetic layer. In five cases (35.7%), the tip was revised at 3 months in patients who sought further refinement. Representative cases are shown in ►**Fig. 3** to **14**.

Discussion

Because the etiologies, severities, and management options for saddle nose deformity are various, it is difficult to generate important comparisons across series. It is well established that costal cartilage, though abundant, has great potential to

Fig. 4 Preoperative three-quarter view.

Fig. 5 Preoperative lateral view.

Fig. 6 The patient was treated using the pi graft with autologous costal cartilage. Thirteen-month postoperative frontal view.

Fig. 8 Thirteen-month postoperative lateral view.

warp and resorb. Numerous strategies have been devised to combat this problem,[4,9–14,19,20] but long-term outcomes, diagnostic standards, and comparative studies are limited. ►**Table 2** compares the outcomes of three recent studies that used other techniques with the outcome of one study that used the pi graft. Using an L-strut alone, Qian reported no recurrence or warping at 3 years in a small series of patients with autoimmune disease.[20] Eren reported warping in 5 out of 5 patients with an unstabilized dorsal strut.[10] Hyun's more extensive study of 45 patients who received autologous or homogenous costal grafts reported a 2% warping rate when one of three cartilage configurations were used.[4]

The pi graft borrows from preexisting techniques to correct the saddle nose deformity. The literature is shy in reporting long-term outcomes after correction of saddle nose deformity, but there is a wealth of studies addressing techniques to prevent and correct warping and recurrence. This speaks to the existence and frequency of these

Fig. 7 Thirteen-month postoperative three-quarter view.

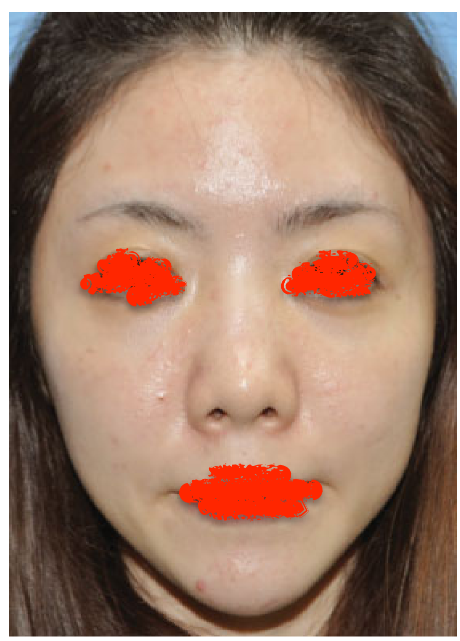

Fig. 9 A 22-year-old woman presented with Type III saddle nose deformity that resulted from cocaine use. Preoperative frontal view.

Fig. 10 Preoperative three-quarter view.

Fig. 12 The patient was treated using the pi graft with autologous costal cartilage. Twelve-month postoperative frontal view.

complications. The authors agree that costal cartilage is the ideal donor for reconstructing the nasal skeleton. However, there seem to be two shortcomings in the way of preventing warping and recurrence. Namely, the deformity occurs when there is loss of support at the mid-vault. Traditional methods rely on reinforcement of the caudal skeleton through columellar struts and SEGs.

Bilateral spreader grafts confer important stability to the nasal dorsum,[4] but may become irrelevant in the absence of a dorsal septal remnant. The two support columns of the pi graft act as spreaders by conferring lateral stability to the overlying dorsal strut. Each component may warp individually but is expected to prevent significant deviation of the pi graft construct through added points of fixation. Unless a cantilever bone graft is used, a powerful moment arm occurs at the junction of the dorsal strut and existing nasal skeleton, and sutures may not provide adequate stability at that junction.

Fig. 11 Preoperative lateral view.

Fig. 13 Twelve-month postoperative three-quarter view.

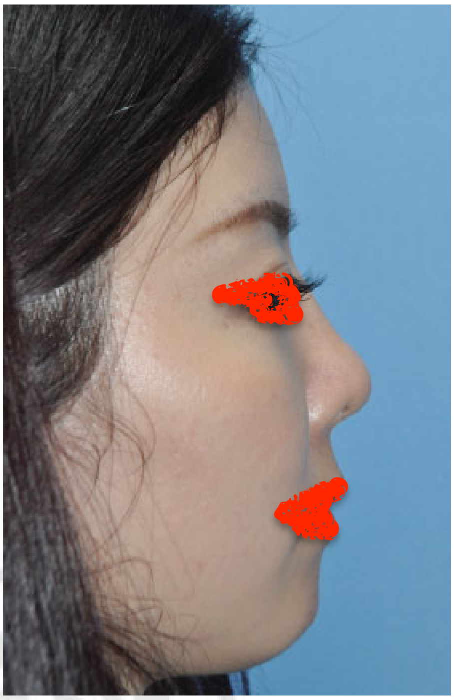

Fig. 14 Twelve-month postoperative lateral view.

In addition, costal cartilage is notorious for its tendency to warp and absorb.[21] Elaborate strategies to prevent warping include harvest of bone graft and reinforcement with Kirschner wires, laminate construction, microplates, chimeric autologous graft, or crossbar grafts.[10,11,13,15,22,23] The authors feel that a simpler approach is to fixate the dorsal strut at a second point. The pi graft was designed with a structural engineer's mindset: the second strut is intended to (1) reduce the moment arm on the nasal-graft junction and (2) provide a third point of fixation, on the opposite side of the caudal strut, to minimize lateral warping. A second benefit of placing it proximally is that airflow obstruction is minimized near the external nasal valve, since one strut is present at that point. This is consistent with Jung's experience using unilateral ESGs.[17,18]

Daniel's composite method for nasal reconstruction was respected.[2] The authors agree that the primary objective of foundation grafts is to provide support, and that refinement in the way of an aesthetic layer is crucial. An additional benefit of the aesthetic layer is protection against protrusion of the A and B struts, lest dorsal graft resorption were to occur. We did not observe protrusion of either strut in any patient. We advised our patients that further tip refinements should be expected to reduce soft-tissue demands from excessive grafting during the initial operation. Nonetheless, the majority of patients in this series was pleased with the aesthetic outcome after their initial operation and opted out of the preplanned revision at 3 months.

Limitations

Important limitations of this study must be considered. Though we did not experience nasal airway obstruction in this series, we also did not perform a functional analysis and cannot provide objective data. Another limitation is that we did not perform a comparison of using one versus two struts; this is perhaps the greatest limitation of the study. It is important to note that there were no recurrences or warping at 11.7 months; however, this is not so for every series reporting outcomes of traditional L-struts.[1,4,12,24] Future studies with longer follow-up will more closely examine changes of the framework with time. Photogrammetric parameters will assess change in nasal shape over time and objectively quantify warping. Many surgeons reconstruct severe saddle deformities with full- or partial-length dorsal grafts with ESGs and strong columellar struts with equally good results in terms of cosmesis and long-term support. There are not sufficient data to confirm superiority of the pi graft against other techniques.

Technical challenges with the pi graft technique include ensuring adequate soft-tissue coverage of the bulky graft. The B strut is a sizeable graft that requires a dependable vascular envelope to maintain its strength and combat infection and exposure. Most cases, including those with subtotal perforations, collapsed cartilages, or cartilaginous remnants, provide a dependable envelope. Large septal perforations are

Table 2 Comparative series

Series	Etiology	Subjects	Technique	Follow-up (y)	Infection (%)	Exposure (%)	Warping (%)	Recurrence (%)
Qian and Malata[20]	Autoimmune	5	L-strut costal	2.8	0	0	0	0
Eren et al[10]	Trauma iatrogenic	7	Microplate + cartilage	1.3	0	0	0	0
		4	K-wire + cartilage	1	25	75	0	0
		5	Costal cartilage	1.3	0	0	100	0
Hyun and Jang[4]	Multiple	45	Various configuration costal cartilage	3.8	1	0	2	5
Hsiao et al[23]	Multiple	14	Pi graft	1	0	0	0	0

therefore a contraindication to the pi graft and a cantilever strut may be considered as an alternative solution for those cases. The B strut relies on tenuous tissues surrounding collapsed existing structures for perfusion. We have not formally analyzed long-term survival of that component, or the pi graft as a whole, but clinical outcomes are reassuring. Also, it was time consuming in several cases to identify a stable foundation and design for the B strut. We palpated for a "hard stop," but it is more likely that the B strut abuts remnant septum or collapsed mid-vault structures, not bone. Such a foundation might not confer the same stability as the ANS.

Conclusion

The pi graft was designed to confer additional torsional stability to the nasal dorsum and better resist recurrence of the saddle nose deformity. In our series, patients did not report nasal airway obstruction. Two operations are planned for every case to ease the burden on the soft-tissue envelope, but the majority of patients are sufficiently satisfied after a single operation. We cannot say whether the additional strut is to credit for these outcomes, but we did not observe warping, recurrence, or infection and all patients were satisfied with the aesthetic result.

References

1 Cakmak O, Emre IE, Ozkurt FE. Identifying septal support reconstructions for saddle nose deformity: the Cakmak algorithm. JAMA Facial Plast Surg 2015;17(6):433–439
2 Daniel RK. Rhinoplasty: septal saddle nose deformity and composite reconstruction. Plast Reconstr Surg 2007;119(3):1029–1043
3 Durbec M, Disant F. Saddle nose: classification and therapeutic management. Eur Ann Otorhinolaryngol Head Neck Dis 2014;131(2):99–106
4 Hyun SM, Jang YJ. Treatment outcomes of saddle nose correction. JAMA Facial Plast Surg 2013;15(4):280–286
5 Kim DW, Toriumi DM. Management of posttraumatic nasal deformities: the crooked nose and the saddle nose. Facial Plast Surg Clin North Am 2004;12(1):111–132
6 Stuzin JM, Kawamoto HK. Saddle nasal deformity. Clin Plast Surg 1988;15(1):83–93
7 Tardy ME Jr, Schwartz M, Parras G. Saddle nose deformity: autogenous graft repair. Facial Plast Surg 1989;6(2):121–134
8 Young K, Rowe-Jones J. Current approaches to septal saddle nose reconstruction using autografts. Curr Opin Otolaryngol Head Neck Surg 2011;19(4):276–282
9 Bhat U, Garg S, D'Souza EJ, Agarkhedkar N, Singh IA, Baliarsing AS. Precision carving of costal cartilage graft for contour fill in aesthetic and reconstructive rhinoplasty. Indian J Plast Surg 2014;47(1):25–35
10 Eren F, Öksüz S, Melikoğlu C, Karagöz H, Ülkür E. Saddle-nose deformity repair with microplate-adapted costal cartilage. Aesthetic Plast Surg 2014;38(4):733–741
11 Gunter JP, Clark CP, Friedman RM. Internal stabilization of autogenous rib cartilage grafts in rhinoplasty: a barrier to cartilage warping. Plast Reconstr Surg 1997;100(1):161–169
12 Ozturan O, Aksoy F, Veyseller B, Apuhan T, Yıldırım YS. Severe saddle nose: choices for augmentation and application of accordion technique against warping. Aesthetic Plast Surg 2013;37(1):106–116
13 Swanepoel PF, Fysh R. Laminated dorsal beam graft to eliminate postoperative twisting complications. Arch Facial Plast Surg 2007;9(4):285–289
14 Taştan E, Yücel OT, Aydin E, Aydoğan F, Beriat K, Ulusoy MG. The oblique split method: a novel technique for carving costal cartilage grafts. JAMA Facial Plast Surg 2013;15(3):198–203
15 Aziz ZS, Brenner MJ, Putman HC III. Oblique septal crossbar graft for anterior septal angle reconstruction. Arch Facial Plast Surg 2010;12(6):422–426
16 Byrd HS, Andochick S, Copit S, Walton KG. Septal extension grafts: a method of controlling tip projection shape. Plast Reconstr Surg 1997;100(4):999–1010
17 Jung DH, Chang GU, Shan L, et al. Pressure necrosis of septal cartilage associated with bilateral extended spreader grafts in rhinoplasty. Arch Facial Plast Surg 2010;12(4):257–262
18 Jung DH, Loh I. The "X-graft" for nasal tip surgery. Plast Reconstr Surg 2011;128(2):79e–80e
19 Ahmed A, Imani P, Vuyk HD. Reconstruction of significant saddle nose deformity using autogenous costal cartilage graft with incorporated mirror image spreader grafts. Laryngoscope 2010;120(3):491–494
20 Qian SY, Malata CM. Avoiding pitfalls in open augmentation rhinoplasty with autologous L-shaped costal cartilage strut grafts for saddle nose collapse due to autoimmune disease: the Cambridge experience. J Plast Reconstr Aesthet Surg 2014;67(8):e195–e203
21 Davis WB, Gibson T. Absorption of autogenous cartilage grafts in man. Br J Plast Surg 1956;9(3):177–185
22 Shipchandler TZ, Chung BJ, Alam DS. Saddle nose deformity reconstruction with a split calvarial bone L-shaped strut. Arch Facial Plast Surg 2008;10(5):305–311
23 Hsiao YC, Abdelrahman M, Chang CS, et al. Chimeric autologous costal cartilage graft to prevent warping. Plast Reconstr Surg 2014;133(6):768e–775e
24 Won TB, Kang JG, Jin HR. Management of post-traumatic combined deviated and saddle nose deformity. Acta Otolaryngol 2012;132(Suppl 1):S44–S51