Journal of Plastic, Reconstructive & Aesthetic Surgery (2007) 60, 152–162

ELSEVIER

JPRAS
An International Journal of Surgical Reconstruction
www.JPRASurg.com

# Reconstructive surgery of the leprosy nose: a new approach☆

Dirk-Jan Menger [a,*], Wytske J. Fokkens [a], Peter J.F.M. Lohuis [a], Koen J. Ingels [b], Gilbert J. Nolst Trenité [a]

[a] *Department of Otorhinolaryngology/Head and Neck Surgery, Center for Facial Plastic and Reconstructive Surgery, Academic Medical Center, Meibergdreef 9, 1105 AZ Amsterdam, The Netherlands*
[b] *UML St Radboud, Nijmegen, The Netherlands*

Received 5 January 2006; accepted 9 June 2006

**KEYWORDS**
Saddle nose;
Leprosy;
Reconstruction;
Costal rib cartilage;
Implants

**Summary** There has still been no reduction in the detection rate worldwide for leprosy, despite supervised multi-drug therapy. In time, leprosy can result in a severe saddle-nose deformity leading to functional problems, disfiguration and stigmatization. In severe cases, only the nasal skin tissue and the lower lateral cartilages are preserved. In such cases, the ideal would be to restore the cartilaginous skeleton but, by contrast with other causes of saddle-nose deformities, this is complicated by the quantity and the poor quality of the remaining nasal mucosa. Leprosy-related saddle-nose deformities are therefore challenging and difficult to reconstruct with the techniques that have been proposed in the past. In this study, 24 patients underwent rhinoplastic surgery involving the use of autogenous costal and/or auricular cartilage or composite grafts. The nasal septum, the upper laterals and the anterior nasal spine were reconstructed with a dorsal onlay attached to a columellar strut with an extension on the proximal side. Before surgery, the saddle-nose deformities were classified according to severity with a new system based on clinical symptoms and signs. Postoperative evaluation was performed at least two years after surgery ($N = 17$). Functional and aesthetic improvement, resorption rate, warping, infection and extrusion were analysed. Functional and aesthetic improvements were achieved in 15/17 patients. None of the patients developed an infection and extrusion or warping of the implants was not observed. The resorption rate depended on the localization and the type of cartilage implant. In general, auricular conchal cartilage implant grafts resulted in less resorption

☆ Figure consent: All photographs in the article 'Reconstructive surgery of the leprosy nose: A new approach' are taken from patients who had surgery in the Lauro de Souza Lima Institute in Bauru, Brazil. Before surgery all patients gave permission to use the pre-, per- and postoperative photographs for clinical demonstrations and for publication.

* Corresponding author. Tel.: +31 20 5668586; fax: +31 20 6913850.
*E-mail address:* d.j.menger@amc.uva.nl (D-J. Menger).

1748-6815/$ - see front matter 
doi:10.1016/j.bjps.2006.06.015

than costal cartilage. Least resorption (4/17 patients) was observed in the dorsal onlay grafts of both conchal (1/6) and costal cartilage grafts (3/11). Resorption of columellar strut implants and shield grafts was observed in 7/17 patients. No resorption was seen of composite grafts (0/4) and alar battens (0/7). Autogenous cartilage implants can be used to reconstruct saddle-nose deformities in leprosy with a minimum risk of complications. The preoperative grade of severity was used as a basis for the development of guidelines for optimal long-term functional and aesthetic outcome.


Leprosy, or Hansen's disease is a chronic granulomatous infection of skin tissue and peripheral nerves caused by *Mycobacterium leprae*, an intracellular bacterium. In the past this disease was widespread. However, at present, it is mainly seen in tropical regions such as Africa, South America and Asia. The widespread implementation of supervised multi-drug therapy has been associated with a fall in the prevalence of leprosy but there has not yet been any reduction in the case detection rate worldwide. Nevertheless, 107 of the 122 countries endemic for leprosy in 1985 have achieved the WHO elimination target of a reduction in the prevalence of leprosy patients receiving antimicrobial therapy to less than one per 10 000 population. At present, 83% of recorded cases are concentrated in only six countries: India, Brazil, Burma, Indonesia, Madagascar and Nepal.[1] Although many classifications have been proposed, Ridley and Jopling's spectrum of disease model[2] is still widely used. It combines clinical and histological findings into five groups expressing patient immunity. These five groups are indeterminate (I), tuberculoid (TT), borderline tuberculoid (BT), borderline borderline (BB) and the most severe stage, lepromatous disease (LL). The port of entry is considered to be the respiratory tract, with the nose playing a central role[3,4] in spreading the disease through nasal secretions.[5,6] The clinical symptoms include skin lesions, nerve damage, blindness, hair loss of the eyebrows and systemic features like testicular atrophy and involvement of bone, the renal system and the nasal mucosa.

## Destruction of the nasal lining and saddle-nose deformity

One sequel of leprosy is visible in the middle of the face and cannot be concealed by the patient: the development of a severe saddle-nose deformity caused by the destruction of the nasal skeleton. This process is probably induced by damage to the mucosal lining of the nose. These changes to the mucosa are only visible microscopically in indeterminate (I) and tuberculoid (TT) conditions with signs of cellular infiltration and vasculitis. However, in time, mucosal disintegration occurs and severe damage can also be seen macroscopically in lepromatous disease (LL).[7] At this stage of disease, this lining is destroyed and the underlying cartilage is exposed, resulting in secondary infection and necrosis of the nasal septum and subsequently a septal perforation. Together with resorption of the nasal spine, a saddle-nose deformity can develop with an acute nasolabial angle and lack of columellar show. The causes of the destruction of the nasal mucosa are still not fully understood but the fact that this is mainly a feature in lepromatous patients (LL) suggests that non-mechanical factors such as secondary infections — rather than nose picking and sensitivity disorders — are the main reason. The process can extend to involve the nasal bones, with flattening of the nasal bridge and complete destruction of all nasal turbinates. As the disease progresses, typical vertical alar grooves and vestibular stenosis may develop due to scar tissue retraction. The final result, a severe saddle-nose deformity, not only causes functional difficulties such as impaired nasal breathing and crusts, but also aesthetic problems, and particularly stigmatization. The ideal solution would be to restore the normal cartilaginous skeleton but, in saddle-nose deformities caused by leprosy, this is precluded by the quality and the quantity of the nasal mucosa. The nasal mucosa is of poor quality, causing the destruction of the nasal septum and upper laterals, but there is also damage to the lateral wall of the nasal cavity. As with the resorption of the nasal septum, the turbinates also disappear completely. The remaining mucosa is prone to inflammation, chronic infections and excessive crust formations. These conditions make the reconstruction of the nasal septum with the use of local mucosal flaps impossible

and inadequate for a good functional and aesthetic result in the long term. Severe saddle-nose deformities caused by leprosy therefore require reconstruction techniques that are outside the scope of the techniques required when only the septum has disappeared, for instance after a septal abscess.

## Materials and methods

Between 1995 and 2000, we performed rhinoplastic surgery on 24 Brazilian lepromatous leprosy (LL) patients, 19 men and 5 women, average age 40 years (range 16–63). All patients had a severe saddle-nose deformity. They had completed multi- or monotherapy and were being treated in the leprosy centre in Bauru, Instituto Lauro de Souza Lima. A standardized history was taken and ENT examination was performed in all patients. The questions focused on the history and functional symptoms such as impaired nasal breathing and the formation of nasal crusts. Nasendoscopy and nasopharyngoscopy, including intranasal photography, were performed on every patient using a Storz 30° and 70° optic scope (Fig. 1). Resorption of the anterior nasal spine and cartilaginous septum was diagnosed by palpation and standard sinus X-rays. Standardized photographs of the face of all patients (frontal, lateral, oblique and basal view) were taken preoperatively and in the immediate postoperative stage.

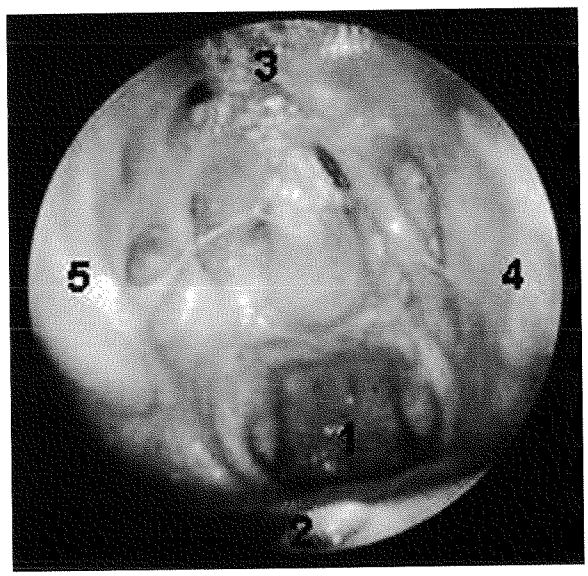


**Figure 1** Endoscopic view of the nasal cavity. The nasal septum has completely disappeared due to leprosy. (1) Nasopharynx, (2) floor of the nasal cavity, (3) roof of the nasal cavity, skull base, (4) lateral wall, left side, (5) lateral wall, right side. On both sides there is complete destruction of the inferior and middle turbinates.

### Definitions: severity of the saddle-nose deformity

On the basis of the history and examination, we classified the saddle-nose deformities into four grades of severity (Table 1). The first grade (I) consisted of mild saddle-nose deformities on clinical grounds, a partly destroyed cartilaginous framework with a septal perforation and absence of the anterior part of the anterior nasal spine (Fig. 2). The second grade (II) consisted of moderate saddle-nose deformities, subtotal destruction of the cartilaginous framework with a large septal perforation and partial destruction of the turbinates, absence of the entire anterior nasal spine and retraction of the columella (Fig. 3). The third grade (III) consisted of severe saddle deformities with total destruction of the cartilaginous framework and complete loss of the nasal septum, subtotal destruction of the turbinates and absence of the entire nasal spine (Fig. 4). The fourth grade (IV) consisted of severe saddle deformities with absence of both the cartilaginous framework and

**Table 1** Grade of severity of saddle-nose deformities in leprosy

| | Grade of saddle-nose deformity | | | |
|---|---|---|---|---|
| | I | II | III | IV |
| Saddle deformity | | | | |
| Mild | x | | | |
| Moderate | | x | | |
| Severe | | | x | x |
| Cartilaginous framework[a] | | | | |
| Partial destruction | x | | | |
| Subtotal destruction | | x | | |
| Total destruction | | | x | x |
| Nasal cavity | | | | |
| Septal perforation | x | x | | |
| Complete loss of septum | | | x | x |
| Complete loss of turbinates | | | | x |
| Nasal spine | | | | |
| Anterior part absent | x | | | |
| Entire spine absent | | x | x | x |
| Alar grooves | | | | x |
| Vestibular stenosis | | | | x |
| Columella retraction | | x | x | x |

[a] Includes the nasal septum and the upper laterals.

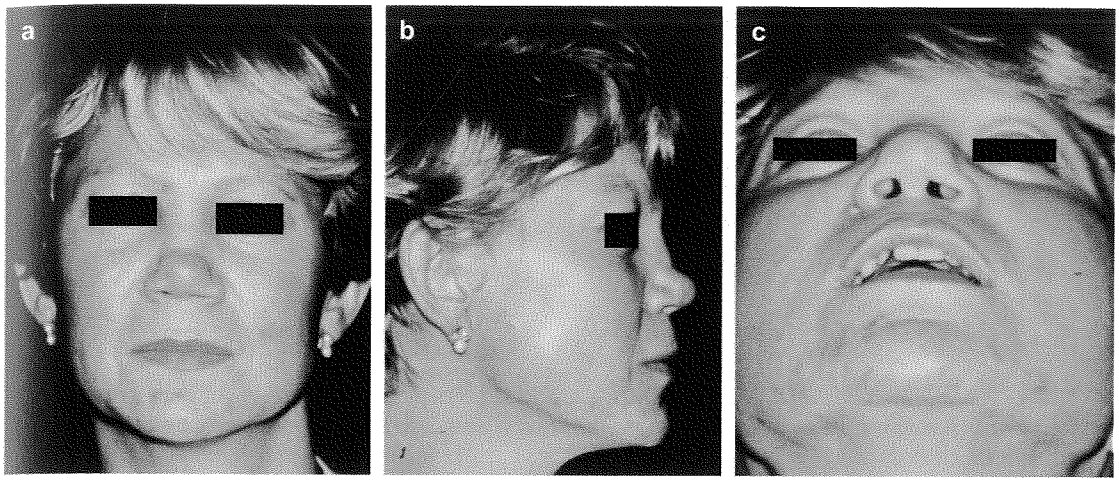


Figure 2 (a–c) Preoperative views of a patient with a grade I saddle-nose deformity. There is partial destruction of the cartilaginous framework, resulting in a mild saddle-nose deformity.

the anterior nasal spine, a complete loss of the nasal septum and turbinates, the presence of vertical alar grooves with vestibular stenosis and flattening of the bony nasal bridge (Fig. 5).

## Surgical techniques and cartilage implants

All 24 patients were treated in general anaesthesia using an external approach. A broken columella incision was used in 20 patients; a V–Y procedure was used in four patients in order to lengthen the retracted columella. Typically, in rhinoplasty of the leprosy nose, scar tissue is present in nearly all parts of the nose, accompanied by resorption, and therefore elimination, of the cartilaginous framework. However, it was possible to free and use the soft tissue envelope in all patients after the dissection and removal of scar tissue. Even in grade IV deformities there was no need for additional skin tissue using cutaneous rotation or free transplant grafts in the reconstruction. On the contrary, the outer lining of the nose was well preserved in all patients. However, with the progression of disease, scar tissue retraction in the area of the lateral crus of the lower lateral cartilages could cause vertical alar grooves where the alar soft-tissue sub-units meet the cheek and upper lip units. In the case of a severe vertical alar groove, there was a shortage of vestibular skin. This was dealt with by using an auricular composite graft. By contrast with the upper lateral cartilages and the nasal septum, the lower lateral cartilages, like the soft tissue envelope, were relatively well preserved. The condition and the amount of mucosal lining of the remnants of the nasal septum and the lateral walls of the nasal cavity decreased with progression of disease. Especially in the more severe cases, there was complete destruction of

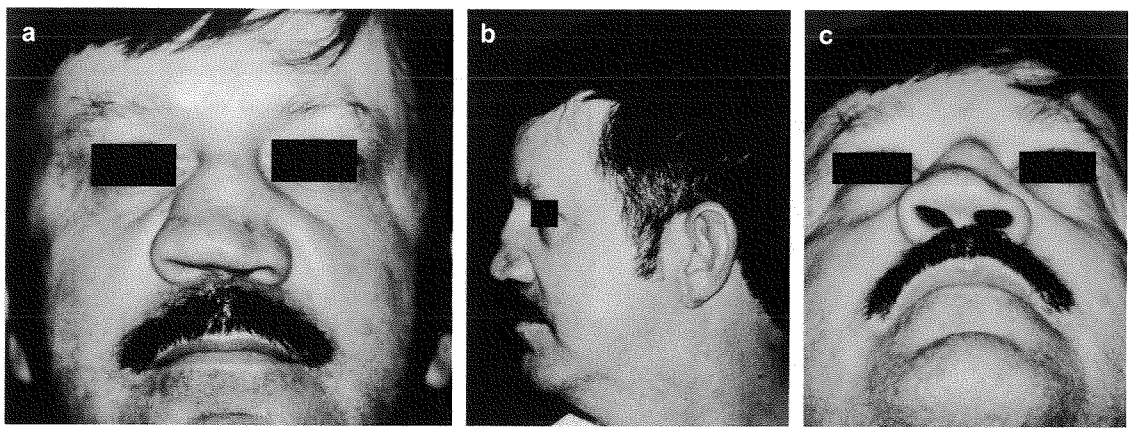


Figure 3 (a–c) Preoperative views of a patient with a grade II saddle-nose deformity. There is a moderate saddle-nose deformity, subtotal destruction of the cartilaginous framework, absence of the entire anterior nasal spine and retraction of the columella.

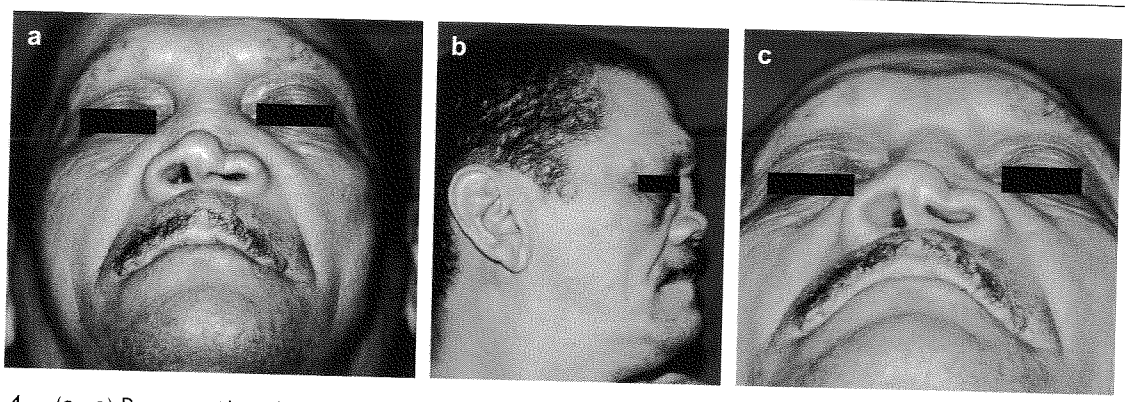


**Figure 4** (a–c) Preoperative views of a patient with a grade III saddle-nose deformity. Total destruction of the cartilaginous framework has caused a severe saddle-nose deformity. The columella is retracted due to the absence of the entire anterior nasal spine.

the nasal septum and all turbinates with crust formation and severe secondary inflammation. Given this, none of the remaining mucosa could be used for reconstructive purposes as local flaps or as a recipient site, for example for the transplantation of oral mucosa. Since only skin tissue and the lower lateral cartilages were preserved, the reconstruction of the nasal skeleton was performed using cartilage grafts to replace the nasal septum, the upper laterals and the anterior nasal spine. Depending on the level of severity of the saddle deformity, conchal ear cartilage alone (grade I) or costal cartilage from the seventh or eighth rib combined with auricular composite grafts was required for the reconstruction. From these different cartilage grafts, implants were sculptured for reconstructive purposes for each patient. All patients needed a dorsal onlay and a columellar strut made from either conchal or rib cartilage. In order to reconstruct and camouflage the acute nasolabial angle due to the absorption of the anterior nasal spine we created a new type of columellar strut from rib cartilage. This strut had an extension at the proximal side to replace the absent anterior nasal spine (Fig. 6). The onlay graft was attached to the columellar strut with non-soluble sutures (Ethilon® 5/0). Alar battens were used in 7/24 patients (29%) to correct vestibular insufficiency or to camouflage and reconstruct vertical alar grooves in grade IV saddle deformities. In order to improve tip projection, to camouflage asymmetries of the lower nasal third or to lengthen the nose, shield grafts were used in 23/24 patients (96%). In 7/24 patients (29%), the inner lining of the vestibule had to be restored or retraction of the columella had to be prevented. Auricular composite grafts were used in these cases. To prevent infection in the postoperative period, amoxicillin 500 mg was administered to all patients three times daily for seven days.

## Evaluation of the postoperative results

To evaluate the postoperative results, we assessed both functional and aesthetic parameters in relation to the preoperative situation and the rate of resorption, warping, infection and extrusion of the cartilage grafts and morbidity of the donor sites.

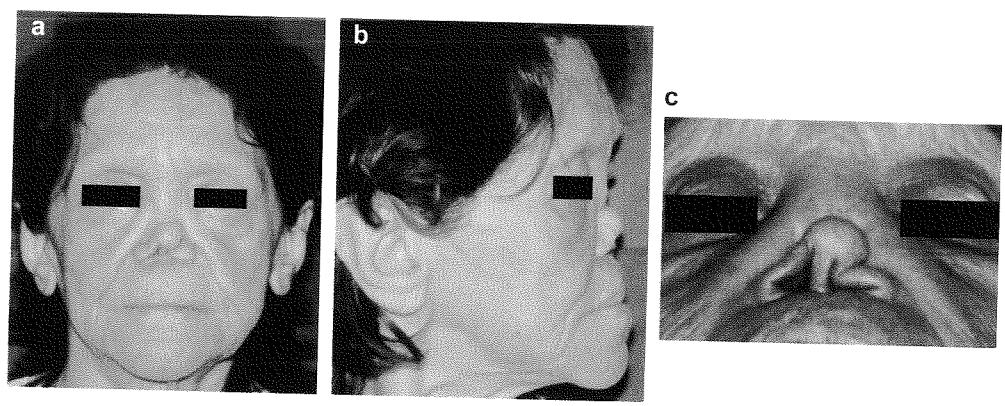


**Figure 5** (a–c) Preoperative views of a patient with a grade IV saddle-nose deformity. Absence of both the anterior nasal spine and the total cartilaginous framework, typical vertical alar grooves and vestibular stenosis.

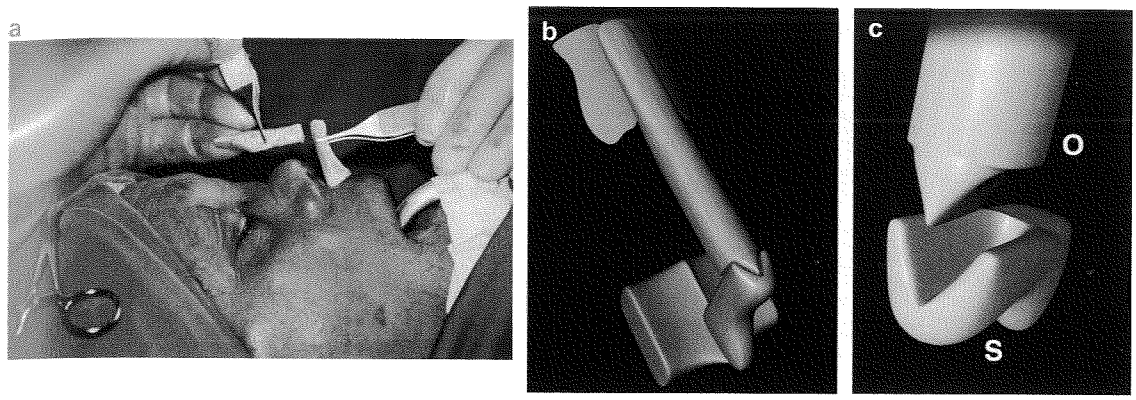


Figure 6 (a) Peroperative view of a patient with a grade III saddle-nose deformity. Autogenous costal cartilage was sculptured into a dorsal onlay and a columellar strut. This strut had an extension at the proximal side to replace the missing anterior nasal spine in order to reconstruct both the acute nasolabial angle and the retracted columella. (b) Illustration of a dorsal onlay graft and a columellar strut with an anterior nasal spine replacement extension on the proximal side. (c) Detailed illustration showing the connection between the strut (s) and the dorsal onlay (o). Using this connection, it was possible to adjust the height of the dorsal onlay before permanent fixation with a non-soluble suture.

Functional improvement was defined as a subjective improvement of nasal breathing compared to the preoperative condition. Aesthetic improvement was considered to have been achieved if the patient concluded that there was aesthetic improvement and if two out of three parameters had improved at least two years after surgery compared to the preoperative condition. These parameters were as follows: (1) the presence and severity of recurrence of a saddle-nose deformity due to resorption of the dorsal onlay graft, (2) loss of nasal tip projection due to resorption of the shield graft, (3) the presence and severity of columella retraction due to resorption of the columellar graft. The existence and severity of vertical alar grooves due to the resorption of composite and alar batten grafts was evaluated. In order to examine these parameters, each cartilage implant was compared visually with the postoperative photographs and by palpation to assess graft integrity and the degree of resorption and warping (Fig. 7a–f). Graft resorption was classified as none (0–25%), partial (25–75%) or complete (>75%).

## Results

Before surgery, 1/24 patients (4%) had a grade I deformity, 2/24 (8%) cases had a grade II deformity, 12/24 (50%) patients had a grade III deformity and 9/24 (38%) patients had a grade IV deformity. We examined the postoperative results at least two years after surgery. Patients treated in 2000 had not yet undergone long-term follow-up (5/24 patients and two revision cases, 29%). Some patients received follow-up several times during the five years after surgery (Figs. 8a–c and 9a–c). Seventeen of all 24 patients (71%) received follow-up lasting at least two years. Patients with a grade I deformity ($N = 1$) and a grade II deformity ($N = 2$) showed no signs of the recurrence of a saddle-nose deformity, retraction of the columella or loss of nasal tip projection (Table 2). Of the 12 patients with a grade III deformity, eight were followed up for a period of between two and five years. Of these eight, one patient suffered a mild recurrence of a saddle-nose deformity due to the partial resorption of a costal cartilage dorsal onlay graft. Three out of eight patients with a grade III deformity had a mild recurrence of retraction of the columella due to the partial resorption of the columellar strut. Four out of eight patients had some loss of nasal tip projection compared to the immediate postoperative period as a result of the partial resorption of the shield graft. The follow-up of grade III saddle-nose deformities did not identify any cases of complete recurrence of a saddle-nose formation, columella retraction or a total loss of tip projection (Table 2). Six out of nine patients with a grade IV deformity were followed up for at least two years. No recurrence of a saddle deformity was detected in three out of six patients. Mild recurrence was found in two patients, one with an auricular onlay graft and one with a costal onlay graft. Complete resorption of costal dorsal onlay cartilage with major saddle-nose formation after a two-year follow-up period was seen in one patient. This patient also had a complete recurrence of columella retraction

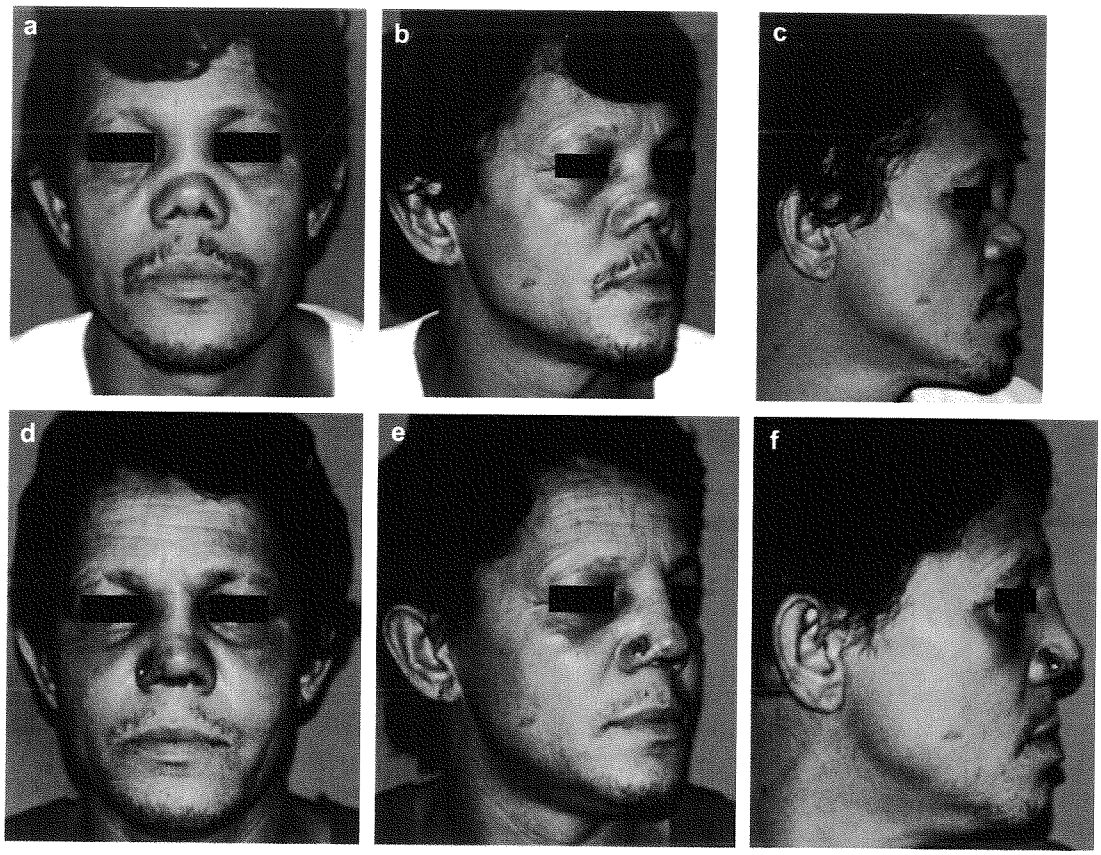


**Figure 7** Pre- (a, b, c) and immediate postoperative (d, e, f) views of the same patient of Fig. 6a. Leprosy resulted in the destruction of the cartilaginous framework, causing a severe saddle-nose deformity with a retracted columella due to the absence of the entire anterior nasal spine. Reconstruction was performed using autogenous costal cartilage from the eighth rib via an external approach using a broken columella incision. A columellar strut with extension and a dorsal onlay were used from this graft to augment the nasal bridge and to restore the retracted columella. The projection of the nasal tip was increased with a shield graft. Silicone alar battens, visible on the skin of the nostrils, were used to support the distal part of the lateral crura of the lower laterals and were removed two weeks after surgery.

and lost all nasal tip support, as was the case prior to surgery. Another patient from this group also suffered complete resorption of a costal columellar strut and shield graft combined with partial resorption of the dorsal onlay graft. These last two patients did not achieve functional or aesthetic improvement as defined in Materials and methods (2/17 patients). Resorption of auricular cartilage alar battens (0/7, 0%) or composite grafts (0/4, 0%) was not observed. We found no warping of autogenous rib dorsal onlay implants (0/11). None of the patients (0/17, 0%) developed infection or extrusion of the implants or complications during or after surgery of the donor sites.

## Discussion

In addition to leprosy, a range of pathological factors can result in a saddle nose. The main aetiology of these deformities is the destruction of the nasal septum with loss of support of both the upper and lower laterals. This can be caused by a nasal septal abscess after trauma or prior nasal surgery, but cocaine abuse, relapsing polychondritis, Wegeners's granulomatosis, syphilis and cancer are other factors that must be ruled out in case of a saddle deformity of unknown cause. A variety of graft materials have been studied in recent decades for the reconstruction of saddle-nose deformities. The general materials of choice were autogenous cartilage and bone grafts or synthetic alloplasts such as silicones, Teflon and expanded polytetrafluoroethylene (PTFE). The most frequently used grafts for nasal reconstruction are, however, autogenous cartilage implants, either from donor sites of the nasal septum, auricular concha or costal cartilage.[8] Autogenous cartilage is successful in the long term, and infection or resorption in the nose is rare.[9–11]

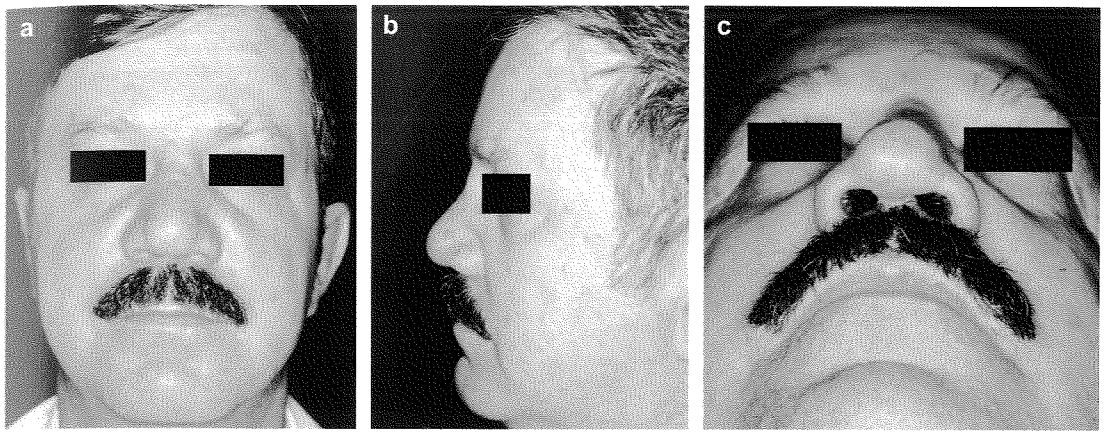


Figure 8 (a–c) Follow-up of the same patient as in Fig. 3a–c. Postoperative result, two years after surgery for a grade II saddle deformity. Reconstruction was performed with a dorsal onlay, a columellar strut with an extension to rebuild the anterior nasal spine and a shield graft from autogenous rib cartilage.

Autogenous bone grafts, on the other hand, have higher resorption rates, are more difficult to shape and sculpture to the recipient site and their biomechanical features are less tolerated in the natural flexibility of the nasal tip area.[12–16] Alloplasts are appealing because of their relative ease of use and availability in unlimited supplies but they have the disadvantage of a relatively high incidence of infection and extrusion.[17–22] Autogenous cartilage is therefore still the current material of choice for the reconstruction of saddle-nose deformities.[18,23–26] In leprosy, saddle-nose deformities are often more severe than those in other aetiologies. This is due to the destruction of the nasal septum, which is a feature of saddle deformities with other aetiologies, and additional damage to the nasal spine, the rest of the cartilaginous framework and sometimes even the nasal bones and turbinates. The literature concerning saddle-nose deformities in leprosy describes a variety of reconstruction techniques and graft materials. Bone grafts, nasolabial skin flaps, forehead flaps, postnasal inlay of split-skin grafts, auricular and costal rib cartilage grafts and alloplasts are the most widely studied graft materials.[23,27–32]

Bone grafts were associated with a 50% complication rate of infection or graft resorption in 24 leprosy patients in a study by Schwarz et al.[23] Despite these findings, they recommended bone grafts and skin flaps in more severe cases of saddle deformities. However, the same group concluded that the use of conchal cartilage in moderate cases was associated with minimal complications and the best aesthetic results. Tovey suggested another type of reconstruction of the leprosy nose in his description of the 'Crockett operation'.[27] In this procedure, bone grafts, a skin graft and diced

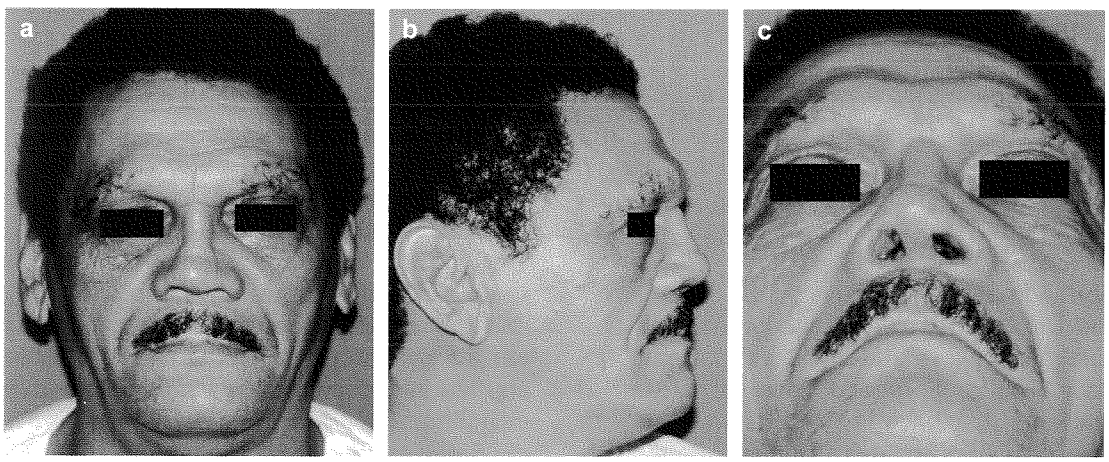


Figure 9 (a–c) Postoperative result, four years after surgery, for the patient in Fig. 4a–c. The grade III saddle-nose deformity was reconstructed with the use of a costal dorsal onlay that was attached to a columellar strut with an extension on the proximal side and a shield graft.

**Table 2** Follow-up 2–5 years: resorption of implants $N = 17$ patients (1995–2000)

| | Grade of saddle-nose deformity and resorption rate of implants | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | I ($N = 1$) | | | II ($N = 2$) | | | III ($N = 8$) | | | IV ($N = 6$) | | | Total ($N = 17$) | | |
| | $N^a$ | $P^b$ | $C^c$ | $N^a$ | $P^b$ | $C^c$ | $N^a$ | $P^b$ | $C^c$ | $N^a$ | $P^b$ | $C^c$ | $N^a$ | $P^b$ | $C^c$ |
| Auricular cartilage | | | | | | | | | | | | | | | |
| Dorsal onlay ($N = 6$) | 1 | | | 2 | | | 2 | | | | 1 | | 5 | 1 | |
| Columellar strut ($N = 6$) | 1 | | | 2 | | | 1 | 1 | | | 1 | | 4 | 2 | |
| Shield graft ($N = 7$) | 1 | | | 2 | | | 1 | 1 | | 2 | | | 6 | 1 | |
| Alar batten ($N = 7$) | | | | | | | 2 | | | 5 | | | 7 | | |
| Composite graft ($N = 4$) | | | | | | | 3 | | | 1 | | | 4 | | |
| Rib cartilage | | | | | | | | | | | | | | | |
| Dorsal onlay ($N = 11$) | | | | | | | 5 | 1 | | 3 | 1 | 1 | 8 | 2 | 1 |
| Columellar strut ($N = 11$) | | | | | | | 4 | 2 | | 2 | 1 | 2 | 6 | 3 | 2 |
| Shield graft (N = 9) | | | | | | | 3 | 3 | | | 1 | 2 | 3 | 4 | 2 |

[a] None: 0–25% resorption.
[b] Partial: 25–75% resorption.
[c] Complete: >75% resorption.

cartilage cubes were used for reconstruction. The reported resorption rate of autogenous iliac bone dorsal onlay grafts was low. Total resorption was found in 2/31 patients (6%) and partial resorption in 1/31 patients (3%). Bone grafts from the second metatarsal of the foot were used by Malaviya and Husain in 23 leprosy patients[30]. They observed total resorption of the implants in 2/23 (9%) and partial resorption in 5/23 patients (22%). However, there was late postoperative morbidity – an overriding toe in the donor foot – in the donor site in 15/23 (65%) patients. Bone grafts from the olecranon were used by Antia and Pandya in 14 leprosy patients.[29] In this group, the bone graft was partially resorbed in 6/14 patients (43%) and infected in 2/14 patients (14%). Nasolabial skin flaps, forehead flaps and postnasal inlay of split-skin grafts were also described by Antia and Pandya.[29] The technique of a postnasal inlay of split-skin graft was used in 72 leprosy patients.[31] In this procedure, a split-skin graft was wrapped onto a gutta percha mold with the raw side outwards to create a skin-lined nasal cavity. After 6–9 months, the gutta percha was replaced by a permanent acrylic prosthesis.[31] This technique produced fair results in 8/72 patients (11%) and poor results in 6/72 patients (8%). However, 9/72 patients (12%) developed erythaema of the overlying soft tissue envelope and 6/72 patients (8%) a cutaneous fistula. Nasolabial flaps were used in four patients, all with poor results. Forehead flaps were used in three patients, two with fair results and one with a poor result.[29] Reports about the use of alloplasts in leprosy are less frequent in the literature. One study was performed by Wyss, who found relatively good short-term results with a soft polyethylene L-shaped implant.[32] In theory, however, the risk of infection and extrusion of synthetic materials in the leprosy nose is higher than in saddle-nose deformities due to other causes. The first reason is that the condition of the remaining mucosal lining of the nasal cavity is poor even after mono- or multitherapy and asepsis. Secondly, the risk of a port of entry from the nasal cavity is higher per- and postoperative as a result of scar formation, the severe pathology and chronic crusting and rhinitis in these patients. We do not therefore consider alloplasts to be the materials of choice in leprosy. This is supported by the follow-up of 8 leprosy patients with silicone implants.[29] Fifty percent of them were infected and had to be removed. Based on our findings, we developed a surgical decision tree for the use of cartilage grafts (Table 3). In this model, the grade of severity of the saddle-nose deformity (Table 1) determines the donor site for harvesting cartilage and the implants that are sculptured and used for an optimal aesthetic and functional reconstruction (Table 3). For grade I saddle-nose deformities, we recommend conchal ear cartilage from either one or two ears. In general, this graft would be sufficient to sculpture a columellar strut, a shield graft and a small dorsal onlay for an excellent functional and aesthetic result. The onlay graft does not need fixation to the columellar strut. In certain cases, two layers of cartilage need to be applied in order to camouflage the saddle deformity. In grade II and grade III deformities the saddle deformation is more severe and camouflage of the dorsum and tip area alone is not satisfactory. Because of the significant destruction of the cartilaginous framework, the dorsal onlay cannot just

Table 3 Grade of saddle-nose deformity and preferred reconstruction

| | Grade of saddle-nose deformity | | | |
|---|---|---|---|---|
| | I | II | III | IV |
| Conchal ear cartilage | x | | x | x |
| Rib cartilage | | x | x | x |
| Auricular composite graft | | | | x |
| Columellar strut | c | r | r | r |
| Dorsal onlay | c | r | r | r |
| Shield graft | c[a] | r | c | c |
| Alar batten | | | c[b] | c |
| Composite graft | | | | a |

c: Conchal cartilage, r: rib cartilage, a: auricular composite graft.
[a] To lengthen the nose or to increase the projection of the nasal tip.
[b] To correct vestibular insufficiency or mild vertical alar grooves.

rest on the upper laterals as in grade I deformities. On the contrary, the dorsal onlay should be elevated and held in position by a firm and strong columellar strut with an extension to rebuild the anterior nasal spine (Fig. 6). We therefore recommend both autogenous rib cartilage and auricular conchal cartilage as donor material. The ear cartilage can be used to sculpture a shield graft to increase the projection of the nasal tip, to lengthen the nose or to camouflage asymmetries of the lower nasal third. There are two reasons for the use of conchal rather than rib cartilage for the shield graft. Firstly, with the technique using autogenous rib dorsal onlay implants attached to a columellar strut, there was more resorption of elements in the nasal tip area like the columellar strut and shield graft (11/20 patients, 55%) than of the dorsal implant (3/11 patients, 27%) and there was a rather high percentage of complete or partial resorption of rib cartilage in the nasal tip area. Our data suggest that there is a lower risk of partial or complete resorption of the shield graft and columellar strut when ear cartilage is used (3/13 patients, 23%) than when rib cartilage is used (11/20 patients, 55%) (Table 3). Ear cartilage is probably more resistant to long-term pressure and tension from the overlying soft tissue envelope on the implant than rib cartilage. Secondly, ear cartilage feels more flexible and natural when compared to the rigidity of rib cartilage, especially in the – normally mobile – nasal tip area. For the most severe level of saddle-nose deformities, grade IV, we recommend the use of conchal ear cartilage, rib cartilage and auricular composite grafts. The latter can be used to restore the inner lining in the caudal region of the nasal septum and to correct severe retraction of the columella. In these patients, alar batten implants from auricular cartilage should be used to reconstruct and camouflage the typical vertical alar grooves. In conclusion, we believe the use of this classification provides structured and practical guidelines on how to define the grade of severity of the saddle-nose deformity (Table 1) and about which type of cartilage and implant grafts to use in the reconstruction of the pathological features (Table 3). It should be noted that reconstruction of the nasal septum is not essential and in more severe cases even impossible. The difficulty is not the surgical technique but rather the very poor quality of the remnants of mucosal lining. Furthermore, impaired nasal breathing in these patients is mainly caused by a collapse of the inner nasal valve or stenosis of the vestibulum nasi. In our population, most patients (15/17, 88%) underwent a normalization of nasal breathing after surgery without reconstruction of the nasal septum. A sequel that we did not encounter, despite the fact that we did not stabilize the autogenous rib cartilage with Kirschner wires, was warping of the autogenous rib implants. This is probably because only the central portion of the rib grafts was used, after removal of the perichondrium and superficial parts. We do not therefore advocate internal stabilization as described in the literature.[33]

## Acknowledgements

We would like to thank Marcos Virmond, director of the Lauro de Souza Lima Institute in Bauru, who made it possible for us to work in Brazil and helped us to recruit our patients. We would like to thank Nino van Baar, ENT surgeon and founder of the Lazarus Leprosy Society, and Ben Naafs, dermatologist, for their dedication, expertise and participation in this study and Paul Michel de Grood and Marijke Hoen, anaesthesiologists and members of the team, who made it possible to perform surgery in general anaesthesia.

## References

1. Britton WJ, Lockwood DNJ. Leprosy. *Lancet* 2004;**363**: 1209–19.
2. Ridley DS, Jopling WH. Classification of leprosy according to immunity. A five-group system. *Int J Lepr Other Mycobact Dis* 1966;**68**:255–73.

3. Rees RJW. The impact of experimental human leprosy in the mouse on leprosy research. *Int J Lepr* 1971;**39**:201–15.
4. Das PK, Naafs B. Lepra: Aetiologie, pathogenese en epidemiologie. *Import Dermatologie*. Nieuwegein: Glaxo; 1995. p. 31–6.
5. Huang CL. The transmission of leprosy in man. *Int J Lepr* 1980;**48**:309–18.
6. Pedley JC. The nasal mucus in leprosy. *Lepr Rev* 1973;**44**: 33–5.
7. Fokkens WJ, Nolst Trenité GJ, Vinmond M, et al. The nose in leprosy: immunohistology of the nasal mucosa. *Int J Lepr* 1998;**66**(3):328–39.
8. Stucker FJ, Gage-white L. Survey of surgical implants. *Facial Plast Surg* 1986;**3**:141–4.
9. Beekhuis GJ. Polyamide mesh used in facial plastic surgery. *Arch Otolaryngol* 1980;**106**:642–4.
10. Sheen JH. Secondary rhinoplasty. In: Mac Carthy JG, editor. *Plastic surgery, The face, part II*, vol. 3. Philadelphia: WB Saunders Co; 1990. p. 1895–923.
11. Ortiz-Monasterio F, Olmedo A, Oscoy LO. The use of cartilage grafts in primary aesthetic rhinoplasty. *Plast Reconstr Surg* 1981;**67**:597–605.
12. Powell NB, Riley RW. Facial contouring with outer table calvarian bone. *Arch Otolaryngol Head Neck Surg* 1989;**115**: 1454–8.
13. Kridel RWJ, Kraus WM. Grafts and implants in revision rhinoplasty. *Facial Plast Surg Clin North Am* 1995;**3**:473–86.
14. Daniel RK. Rhinoplasty and ribgrafts: evolving a flexible operating technique. *Plast Reconstr Surg* 1994;**94**:597–609.
15. Colton JJ, Beekhuis GJ. Use of mersilene in nasal augmentation. *Facial Plast Surg Int Quart Monogr* 1992;**8**:149–56.
16. Farina R, Villano JB. Follow-up of bone grafts to the nose. *Plast Reconstr Surg* 1971;**48**(3):251–5.
17. Lovice DB, Mingrone MD, Toriumi DM. Grafts and implants in rhinoplasty and nasal reconstruction. *Otolaryngol Clin North Am* 1999;**32**(1):113–41.
18. Vuyk HD, Adamson PA. Biomaterials in rhinoplasty. *Clin Otolaryngol* 1998;**23**:209–17.
19. Burget GC, Menick FJ. Nasal support and lining: the marriage of beauty and blood supply. *Plast Reconstr Surg* 1989;**84**(2):189–203.
20. Deva AK, Merten S, Chang L. Silicone in nasal augmentation rhinoplasty: a decade of clinical experience. *Plast Reconstr Surg* 1998;**102**:1230–7.
21. Mendelsohn M, Dun lop G. Gore-tex® augmentation grafting in rhinoplasty: is it safe? *J Otolaryngol* 1998;**27**:337–41.
22. Godin MS, Waldman SR, Johnson CM. Nasal augmentation using gore-tex®: a 10-year experience. *Arch Facial Plast Surg* 1999;**1**:118–21.
23. Schwarz RJ, Macdonald M. A rational approach to nasal reconstruction in leprosy. *Plast Reconstr Surg* 2004;**114**(4):876–82.
24. Riechelmann H, Rettinger G. Three-step reconstruction of complex saddle nose deformities. *Arch Otolaryngol Head Neck Surg* 2004;**130**:334–8.
25. Toriumi DM. Grafts in rhinoplasty: autogenous grafts are worth the extra time. *Arch Otolaryngol Head Neck Surg* 2000;**126**:562–4.
26. Parker Porter J. Grafts in rhinoplasty: alloplastic vs autogenous. *Arch Otolaryngol Head Neck Surg* 2000;**126**:558–61.
27. Fl Tovey. Reconstruction of the Nose in Leprosy patients. *Lep Rev* 1965;**36**(4):215–20.
28. Wintsch K. Nasenrekonstruktion unter Berücksichtigung der Lepra-Nase. *Handchir Mikrochir Plast Chir* 1986;**18**:231–5.
29. Antia NH, Pandya NJ. Surgical treatment of the nasal deformities of leprosy: a 16-year review. *Plast Reconstr Surg* 1977;**60**(5):768–77.
30. Malaviya GN, Husain S. Surgical correction of saddle nose deformity in leprosy – one stage procedure. *Acta Leprologica* 1994;**9**(2):76–82.
31. Antia NH. Reconstruction of the face in leprosy. *Ann R Coll Surg Engl* 1963;**32**:71.
32. Wyss T. New method of nose reconstruction. *Lep Rev* 1964; **35**:47–9.
33. 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):161–9.