Nasal reconstruction in surgery of the anterior skull base

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OBJECTIVES: **We sought to evaluate the effectiveness of a number of surgical maneuvers in nasal reconstruction of a diverse population of patients undergoing skull base surgery.**

STUDY DESIGN: **We conducted a retrospective review of a cohort of patients undergoing nasal reconstruction during surgery of the anterior skull base and craniovertebral junction.**

METHODS: **All patients undergoing skull base surgery and nasal reconstruction by the senior author (Y.D.) with a minimum follow-up of 12 months from 1997 to 2001 were evaluated. Preoperative and postoperative photographs and clinical evaluation were examined in detail with particular attention focused on the nasal complex.**

RESULTS: **A total of 47 patients were evaluated for this study, including those who had undergone anterior craniofacial resections (n = 14), Le Fort osteotomies (n = 5), subcranial approaches (n = 10), maxillotomies (n = 8), and midfacial disassemblies (n = 10). Primary calvarial bone graft reconstruction of the anterior craniofacial group was facilitated with the use of positioning plates and resuspension of the upper lateral cartilages when available. In contradistinction to secondary bone grafting, dorsal grafts in this group extended to the native nasal bone length. A small overlay bone graft was thought to be necessary when the nasal root was osteotomized in conjunction with the orbital and/or maxillary segments to maintain dorsal height in the long term. Le Fort osteotomy patients require refixation of the septum to the anterior nasal spine region for stability.**

CONCLUSIONS: **Use of the techniques outlined in this article appears to be associated with gratifying long-term nasal form in reconstruction of the anterior skull base.** (Otolaryngol Head Neck Surg 2004; 130:176-86.)

The nose, forming a prominent aesthetic highlight of the face, remains a significant challenge both in cosmetic rejuvenation and in functional restoration. Nasal reconstruction dates back to the Ayur Veda of Sushruta, in India in 800 BC, who used a pedicled forehead flap to reconstruct the external nose after punitive amputation.[1] The modern era of rhinoplasty and the "rediscovery" of nasal reconstruction emerged in the late 1800s.[2] The basic tenets of nasal reconstruction have remained intact since that time: maintenance of an adequate osseocartilagenous framework with viable internal mucosal and intact external nasal soft tissue envelopes.

Nasal framework restoration may be performed with a number of alloplasts and autografts.[3-8] Bone of membranous origin, such as calvarial bone, has been shown to have very little propensity to resorb in the long term when rigidly fixated and represents an excellent option in dorsal augmentation.[9] Rib grafting represents an alternative. Warping of rib grafts has been well recognized to occur years after their implantation. This may be largely remedied by placement of a K-wire along its length at the initial procedure to prevent later curvature secondary to cartilage memory. Although alloplasts represent an alternative in thicker-skinned individuals, we tend not to use these biomaterials in routine nasal reconstruction.

Subsequent to the tremendous advances in surgery of the craniofacial skeleton espoused by Tessier,[10,11] there has been a prominent increase in the use of his basic tenets in the treatment of various neoplasms of the skull base. Successful surgical reconstruction of craniofacial defects and restoration of the basic 3-dimensional structure of the maxillofacial skeleton after anterolateral approaches to the skull base has become more routine and predictable during the past decade.

The form and function of the nose are often disrupted in surgery of the anterolateral skull base. Olfaction is often sacrificed in anterior craniofacial resections, midfacial disassembly, and subcranial

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Fig 1. Cutaneous markings illustrating access incision for anterior craniofacial resection. Note that the markings pass along the junctions between esthetic subunits of the nose except for a back-cut at the medial canthal level to prevent distortion.

approaches. Despite volumes being written on the various surgical approaches to the skull base and nuances of technique, and the importance of the nose aesthetically and functionally, there has been a paucity of articles addressing the restoration of the nose in this patient population.

In this article, we outline our approach to the reconstruction of the nose in skull base surgery.

MATERIALS AND METHODS

All patients undergoing nasal reconstruction during anterior craniofacial resections (n = 14), Le Fort osteotomies (n = 5), subcranial approaches (n = 10), maxillotomies (n = 8), and midfacial disassemblies (n = 10) from 1997 to 2001 by the senior author (Y.D.) were included in this review. Specific attention was focused on intraoperative maneuvers that were or were not performed in regard to nasal reconstruction. We evaluated postoperative nasal form based on clinical follow-up visits and serial photographic documentation. A minimum follow-up of 12 months was required for inclusion in this review.

Anterior Craniofacial Resection

All of these patients underwent resection of part or, in many cases, all of the nasal complex (Figs 1-4). Resulting defects varied in scope from subtotal to total. An anteriorly or a laterally based pericranial flap was used in each case to separate the intracranial from extracranial compartments.[12] The key factor we used in determining the method of nasal reconstruction was the presence or absence of an adequate soft tissue envelope overlying the osseocartilagenous framework. If there was loss of the soft tissue envelope in conjunction with complete loss of underlying structural support (total nasal defect), these may be adequately restored with a modified forehead flap and multiple bone/rib grafts. However, the ultimate nasal form achieved is suboptimal compared with prosthetic rehabilitation in this subset of patients.

In cases of adequate soft tissue coverage, the use of positioning plates is the key to successful rehabilitation of the subsequent defect. Positioning plates are miniplates that are placed before

Fig 2. Intraoperative view demonstrating nasal skin with detached upper and lower lateral cartilages retracted to the left side of photo. Positioning plates have been placed to span the proposed area of resection.

Fig 3. Patient pictured in figure 2 has undergone anterior craniofacial resection for adenocarcinoma resulting in complete loss of nasal bones, antero-medial orbit and medial aspect of maxilla at level of piriform aperture.

Fig 4. Positioning plates have been replaced across defect pictured in figure 3. Calvarial bone grafts are being brought into the plates simulating bone that has been lost.

extirpative tumor resection. They should span the area of proposed resection, having proximal and distal screw purchase in areas well away from the tumor. Two such plates are used to optimize the formation of a 3-dimensional scaffold. These plates are removed until the reconstructive portion of the procedure has commenced. At this point, they are returned into the predrilled holes, and calvarial bone grafts are rigidly affixed to the undersurface of the scaffold. Anatomically, the upper lateral cartilages normally are attached to the undersurface of the distal 3 to 5 mm of the nasal bones. Thus, once the osseous construct has been completed, 2 separate 1.5-mm drill holes are created close to the distal margin of each side of the neonasal bone complex. Then, 3.0 nonabsorbable monofilament suture is passed through these holes and affixed to the upper lateral cartilages approximately 3 to 5 mm from their cephalic edge. This will bring the upper lateral cartilages into a more appropriate spatial relationship with the nasal bones, optimizing both the external appearance and preventing significant internal nasal valve collapse. In cases of inadequate preoperative tip rotation, one can set the upper lateral cartilages in a more superior location on the undersurface of the nasal bones. This maneuver will lead to an increase in tip rotation in this population. If adequate upper lateral cartilages are not present, auricular cartilage grafts are harvested from the conchal bowl. Subsequently, they are suspended from the neonasal bone complex as above.

Midfacial Disassembly and Maxillotomy

In these patients, the nasal osseous complex is removed in conjunction with the superomedial maxilla and medial orbital wall. In cases of removal of any orbital or maxillary segments with tumor, they are replaced with either a titanium mesh scaffold impregnated with hydroxyapatite cement or titanium mesh frame with calvarial bone graft fixation.[13] In all cases of disassembly of the nasal bones in conjunction with the midface, whether pedicled (as in maxillotomy) or ostectomized, a small single layer thin calvarial bone boat-shaped graft is secured with 2 lag screws (to prevent subsequent rotation) as an onlay over

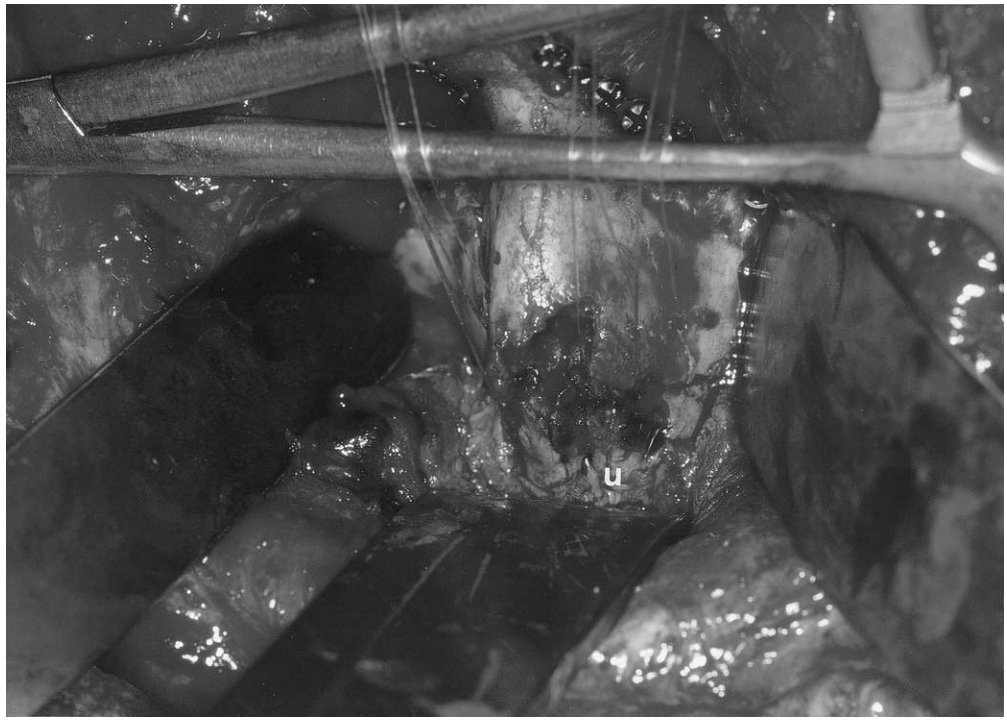

Fig 5. Intraoperative view of a patient undergoing a subcranial approach to the skull base. Bicoronal flap is being retracted inferiorly in order to demonstrate the upper lateral cartilages which are being resuspended to the undersurface of the nasal bones with non resorbable sutures. u = upper lateral cartilages.

the existing nasal bones. This is now performed routinely in this group of patients to prevent the subsequent significant loss of nasal dorsum height that occurred in our initial patients in whom no such graft was used. It should be emphasized that we now perform this technique even when the native nasal bones are rigidly affixed into their correct anatomic position with preadapted miniplates.

Subcranial Approach

The fronto-orbito-nasal segment may be removed en bloc or as a 2-piece osteotomy. The latter approach is often preferable because it avoids the significant dural tears associated with the transorbital osteotomy. In either case, the nasal bones remain attached to the frontal bar. The upper lateral cartilages should be carefully dissected free from the undersurface of the nasal bones and reattached at the conclusion of the procedure as described above. The medial canthal tendons are reattached to the nasal root/medial orbital wall complex with anchor fixation.[14] There is no need for primary bone grafting in this group of patients. Generally, we use bilateral miniplates extending from the nasal bones to the medial maxillary buttress, placed via the bicoronal flap exposure. This ensures proper spatial relationship between the nasal root and midface. If there is nasal root deviation, it may be ameliorated at this point by adjustment of the nasomaxillary miniplates, bringing the root to a more midline position. The dorsal septal attachment to the undersurface of the nasal bones is generally removed on a side table after subcranial osteotomy because it is thought to impede subsequent mucosalization.

Le Fort Osteotomy

It is important to maintain the integrity of the nasal floor mucosa/septal mucosa envelope. These should be meticulously elevated from the floor of the nose and inferior septum before the Le Fort I or II osteotomy. Next, the septum is elevated from the vomer with a periosteal elevator and fibrous attachments to the anterior nasal are completely released, effectively skeletonizing this structure. If a palatal split is required, it is performed in a paramedian position, maintaining the anterior na-

Fig 6. Intraoperative view demonstrating fixation of the caudal septum and base of the medial crura to the region of the anterior nasal spine in this patient undergoing Lefort I osteotomy approach to the skull base. s = anterior nasal spine remnant, p = piriform aperture, c = caudal septum.

sal spine and vomer intact. Once the resection is completed and the preadapted hardware is replaced along the medial and lateral buttresses, two 1.5-mm transosseous tunnels are drilled through the anterior spine. Through these tunnels are then passed nonresorbable sutures (3.0 caliber). This allows the caudal septum and base of the medial crura to be reset in their normal anatomic position by affixing it to the spine. Intranasal resorbable packing is used for a period of 1 week to allow the nasal floor and posterior nasal mucosa to maintain their position during the early postoperative period.

All 4 subsets of patients undergo a common nonsurgical postoperative regimen, including avoidance of nose blowing for a period of 4 weeks after surgery. In addition, a first-generation oral cephalosporin is prescribed for the first postoperative week and nasal saline spray is used a minimum of 4 times daily for 1 month.

In all cases, it is important to note that all bone grafts are covered both externally by skin and internally by either a mucosal flap or an extension of the pericranial flap.

RESULTS

A total of 47 patients undergoing nasal reconstruction during skull base surgery were available for this review. In the subset of patients undergoing anterior craniofacial resection, all underwent placement of positioning plates and had reasonable restitution of their premorbid nasal structure. Healing was uneventful in all patients except for a single diabetic smoker who developed delayed (1 year postoperatively) soft tissue osteoradionecrosis overlying the dorsum, necessitating partial graft removal and secondary reconstruction. No other patients in this group required nasal surgery during the follow-up period.

In the subcranial group of patients, all underwent nasal reconstruction as described earlier with no evidence of long-term resorption. In addition, 3 of these patients who had premorbid deviation of the nasal root underwent intraoperative adjustment of the nasomaxillary miniplates. Each of these had amelioration of the position of the dorsum postoperatively. This is a difficult procedure to perform secondarily.

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Fig 7. Preoperative view of patient undergoing anterior craniofacial resection for esthesioneuroblastoma.

In the midfacial disassembly and maxillotomy group, we noted that the first 8 patients who did not undergo primary dorsal augmentation each developed resorption of the dorsum to some degree when followed for at least 1 year postoperatively. Four of these patients underwent secondary dorsal augmentation with calvarial grafts with good long-term stability. Our study population underwent planned primary dorsal augmentation with excellent maintenance of dorsal height in the follow-up period in each case. A single patient developed delayed graft fracture and displacement, necessitating secondary corrective surgery with a repeat graft.

In the Le Fort osteotomy group, septal positioning was judged to be excellent in all but a single patient, who later underwent secondary septoplasty. No evidence of submucosal hematomas, septal perforations, or nasopalatine nerve dysesthesia was noted in the postoperative period.

DISCUSSION

Although the primary goal in skull base surgery remains optimizing exposure to neoplasms in the area to allow for maximal safe removal, aesthetic concerns should not be ignored. In fact, it is our experience that most patients presenting for skull base surgery are concerned as much with their postoperative appearance as they are with the potentially much more serious complications of surgery at the base of the brain.

Many of the techniques described herein use calvarial bone grafting to a significant degree. Certainly, in experienced hands, the incidence of

Fig 8. One year postoperative result of patient in figure 7.

complications in calvarial bone harvest is low.[15] There is little evidence of resorption of this material long term, and certainly our patient population seems to support this.[16]

Traditionally, dorsal augmentation with calvarial bone grafts for treatment of entities such as saddle nose deformity has been performed by extending a long graft from the radix to the nasal tip region, where it is secured deep to the lower lateral cartilages.[17] Although we have routinely used this technique for secondary reconstruction in our skull base population who underwent dorsal bone resorption (not grafted initially), it is associated with the development of certain unfavorable sequelae. These patients have an immobile nasal tip as the placement of the graft along the entire dorsal length of the nose does not reproduce the normal nasal anatomy. In nonoperated noses, the lower one half to two thirds of the nasal dorsum is cartilaginous. This provides the lower nasal framework with mobility and a relatively softened appearance compared with bone. With the use of positioning plates and upper lateral cartilage suspension to the undersurface of the nasal constructs, we attempt to reproduce this form to a certain degree. In addition to a more natural appearance, it appears to enable relatively simple primary alteration of the position of the cartilaginous lower nose to enable the surgeon to effect changes in nasal tip rotation if he or she determines this to be necessary.

Primary dorsal augmentation of the nasomaxillary disassembly and maxillotomy patients is similarly performed with a thin short onlay single-

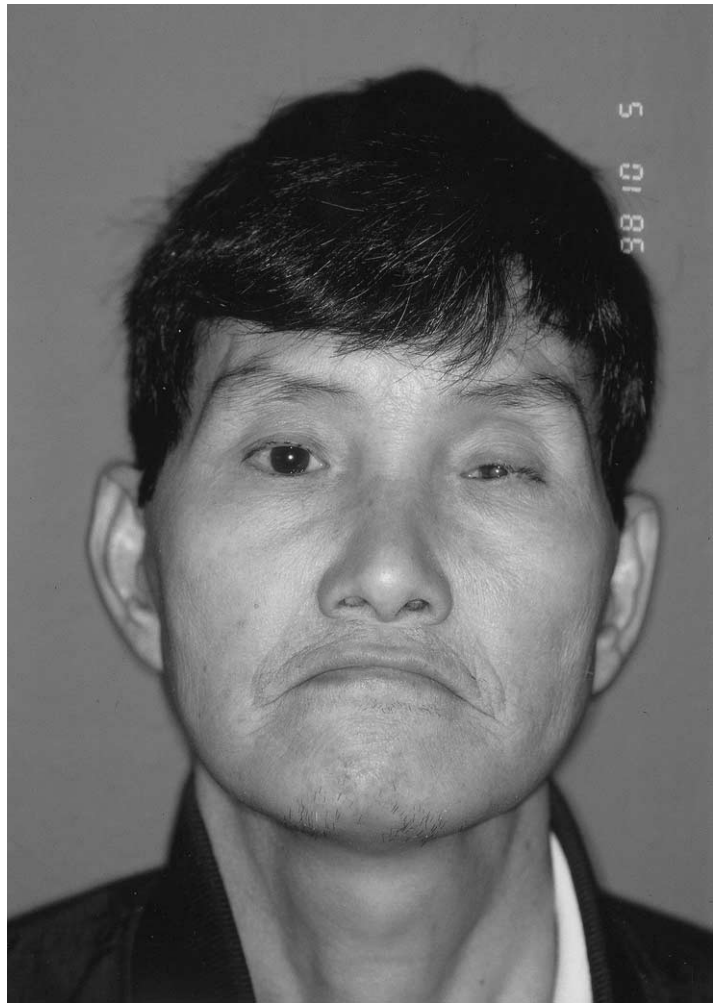

Fig 9. Preoperative frontal view of patient undergoing Lefort I osteotomy and anterior craniofacial resection for radiation induced skull base carcinoma.

layer bone graft extending to the upper lateral cartilages, which are also secured to the graft. We believe that the resorption we were seeing before routine grafting no longer is a problem. Whether the graft compensates for underlying native nasal bone resorption over time or somehow lessens the potential for resorption of the underling graft is not known and requires further study, which we are undertaking. Certainly it is interesting that resorption is not an issue when the nasal bones are removed in conjunction with the frontal bar region and becomes more significant when it is removed in conjunction with the orbital and/or maxillary segments (or pedicled with these segments). Not all of this latter group developed saddle nose deformities, but all of the initially nongrafted individuals do develop some element of resorption and reduction in height of the dorsum compared with their nonoperated state.

CONCLUSION

The skull base surgeon's primary goal remains the safe exposure and removal of neoplasms at the craniovertebral junction and base of skull region. The goals of reconstruction remain separation of the intracranial from extracranial compartments and maintenance of the 3-dimensional form of the maxillofacial skeleton. The nose is a prominent aesthetic highlight of the face. Use of the relatively simple maneuvers outlined in this article will facilitate rewarding long-term results (Figs 5-10).

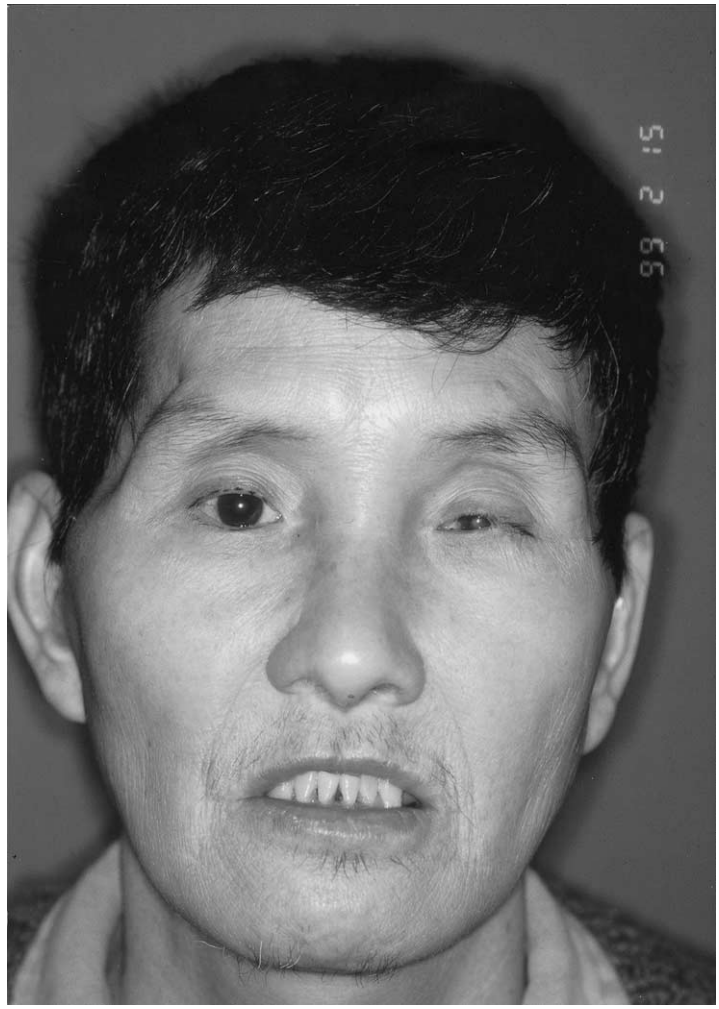

Fig 10. Postoperative frontal view of patient in figure 9 following nasal root calvarial bony reconstruction and upper lateral cartilage resuspension.

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