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Principles of nasal framework reconstruction for complex nasal defects: review

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Summary

Background: Earlier nasal reconstruction techniques focused primarily on restoring the cutaneous envelope and the central portion of the nasal framework. Unfortunately, these approaches often produced results that were unstable over time, leading to secondary deformities and scarring of the reconstructed nose. Modern nasal reconstruction techniques rely on comprehensive restoration of all anatomical layers, with particular emphasis on rebuilding the structural support layer. This supportive framework is now routinely reconstructed not only in the central part as in the past, but also along the lateral nasal walls, using cartilage or (for reinforcement of the dorsum of the nose) thin bony grafts. **Evaluation of the topic:** The nasal framework implantation is typically performed in the first stage of nose reconstruction; in patients with thick soft-tissue cover, however, it may be postponed to the period after soft-tissue thinning in a second stage. It is essential to restore both the central supporting framework and the lateral nasal walls, including adequate alar support. Graft materials commonly used for this purpose include non-vascularized cartilage harvested from the auricular conchal bowl, the rib, or the nasal septum, and bone grafts from the skull (outer parietal cortex) or rib. **Conclusion:** The results of modern reconstruction dramatically improved after emphasis was put on the reconstruction of all layers of the nose. In particular, complete reconstruction of the nasal framework – both the rigid and cartilaginous components – is crucial for long-term stability, prevention of postoperative collapse of the reconstructed nose, and maintaining the patency and function of the upper airway.

Key words

reconstructive surgery – acquired nasal deformities – nasal surgery – nasal framework – supporting layer

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Background

In the past, nose reconstrucion technique typically focused on the reconstruction of the outer cutaneous envelope. Of the skeltal parts, only the central support was usually reconstructed, omitting the lateral nasal walls. Due to the postoperative edema and temporary tissue stiffness that initially masked structural deficiencies, this approach often led to aesthetically acceptable results shortly after surgery. Over time, however, the progressing healing and scarring led to irreversible deformities and soft-tissue retraction. The six fundamental principles of nasal reconstruction are summarized in Tab. 1.

First, the well-vascularized internal lining is reconstructed. Subsequently, the structural framework (composed of cartilage grafts harvested from the auricular conchal bowl, rib cartilage, or nasal septum, or non-vascularized bone grafts taken from the outer parietal cortex or rib) is positioned and secured onto this lining. To allow a proper integration of the structural framework, it needs to be covered with a well-vascularized external skin/soft tissue envelope [1].

The shape of the nose is primarily determined by the bone, cartilage, and compact fibroadipose tissues. The skin and lining, on the other hand, possess only minimal rigidity and tend to simply drape over the supporting structures. The newly reconstructed nose must be designed and positioned proportionally to the face, and the rebuilt framework must provide long-term stability. Reconstruction of the skeletal support is, therefore, an essential component of nasal reconstruction, ensuring the durability and structural integrity of the outcome over time [3].

During nasal reconstruction, the complete nasal framework needs to be created in both the vertical and horizontal dimensions. The cartilage must be implanted extra-anatomically into the alar region because without such reinforcement, soft-tissue contraction and retraction are bound to occur. It is essential to recognize that the structural framework of the reconstructed nose must be stronger and more ro-

Tab. 1. Fundamental principles of modern nasal reconstruction.

Year	Author	Principle
1970s	Millard Burget Menick	Reconstruction must address all three layers of the nose: internal lining, structural support, and external skin envelope [1–3].
1925	Blair	Thanks to its superior color and texture match, the forehead flap is the optimal donor flap for nasal skin replacement [4].
1974	Millard	For nasal reconstruction with a forehead flap, a three-stage approach should be used, with an intermediate thinning stage inserted after one month between the stages of flap construction and pedicle separation [5].
1956	Gonzales-Ulloa	When more than 50% of a nasal subunit is missing, the entire esthetic subunit should be reconstructed [6].
1966	Millard	Restoration of the structural framework must be an integral component of nasal reconstruction [3], rebuilding both central and lateral skeletal components must be rebuilt [7].
2006	Thornton	A well-vascularized intranasal lining is a critical element of nasal reconstruction, as it provides coverage and nourishment for the structural framework [8].

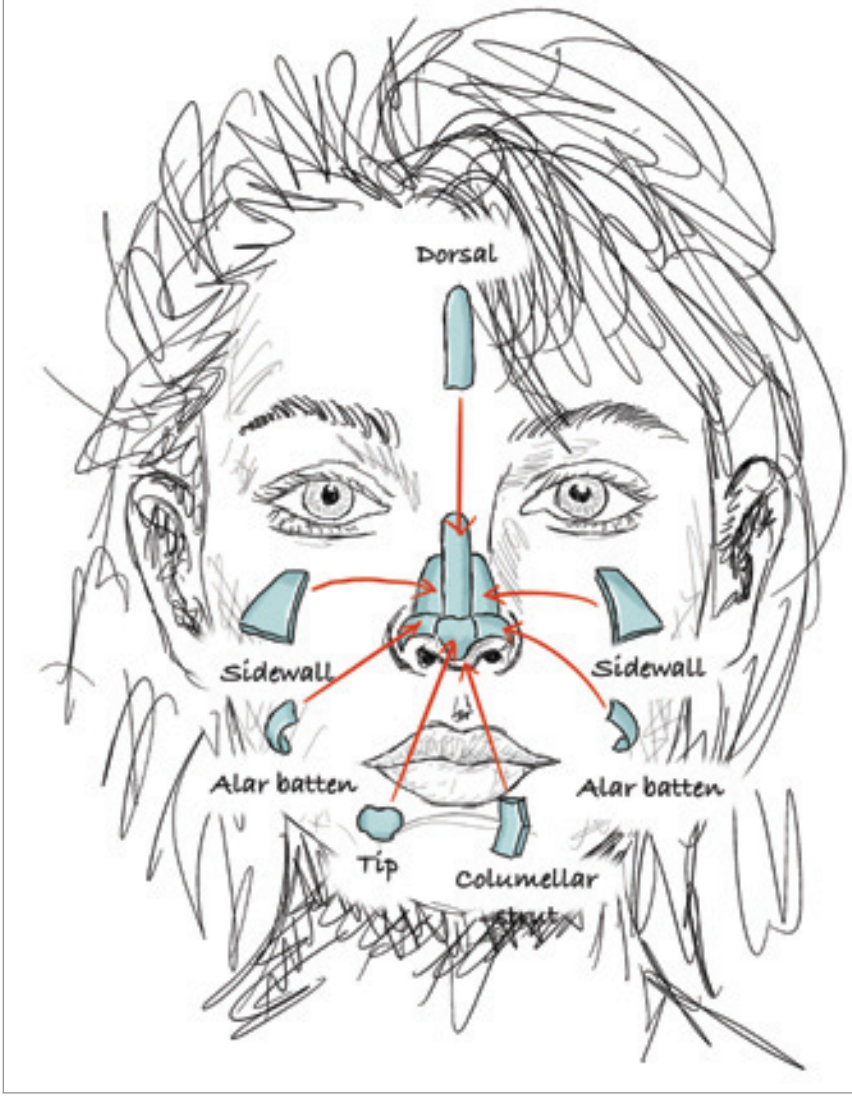


Fig. 1. Construction of individual parts of the nasal framework (support of nasal subunit).

bust than the native nasal skeleton (Fig. 1) [1].

Methods

A literature search was performed using the Discovery system of the Masaryk University Medical Faculty Library, employing the key words ALGORITHM and NASAL RECONSTRUCTION. This search yielded 34 publications. Additionally, cross-referencing was performed using reference lists of selected articles, and relevant monographs on nasal reconstruction were reviewed. Thirteen articles published between 1979 and 2021 were added in this way [9–21]. Papers with high risk of bias, institutional case summaries without methodological innovation, and works not bringing new options for reconstruction of the supporting framework were excluded. Ultimately, 37 works were selected as sources for this review.

Timing of nasal framework implantation

The primary reconstruction surgery is the ideal time for creating the nasal framework. In cases involving double-layered flaps or when bulky soft tissue obstructs the nasal cavity or nostril, the framework is, however, implanted during the second stage of reconstruction along with the thinning of both internal

and external layers. Typically, only intranasal mucosal flaps allow immediate primary implantation of the framework. For other flap types – local or free – the supporting layer is inserted only with thinning of the soft-tissue envelope [22].

Secondary implantation of the framework is no longer commonly performed due to the technical difficulty and suboptimal, compromised outcomes. The design of the nasal skeleton generally mirrors the intact contralateral structures [23]. Alternatively, the dimensions of the reconstructed nose may also be defined based on anthropometric measurements [24,25].

Materials and tissues for skeletal reconstruction

The choice of material is less important than the shape and structural design of the framework; the material must primarily provide sufficient rigidity. Still, however, alloplastic materials should generally be avoided because of the risk of extrusion, which may jeopardize the entire reconstruction.

The center of the septal cartilage can be used to harvest a 2–3 × 2–3 cm graft that is 2–3 mm strong and is suitable for multiple applications. The septal cartilage is firm, offers excellent support, and is useful for reconstructing the lateral nasal walls. Harvesting is performed similarly to open rhinoplasty. Importantly, a 1 cm L-strut always needs to be preserved to maintain nasal projection [26].

Auricular (conchal) cartilage is ideal for shaping the nasal tip and alae. It can be precisely contoured with sutures, but it does not provide adequate support for broader surfaces. Its harvest technique is shown in Fig. 2.

Costal cartilage is traditionally harvested from the submammary region at the synchondrosis of the 6th–8th ribs. Although the 9th and 10th floating ribs offer ideal curvature and length, the disadvantages of their use include prolonged donor-site pain and a higher scar visibility. When harvesting, a combined osteochondral graft (50% bone + 50% cartilage) is advantageous. Redundant material (if any) can then be stored subcutaneously in the scalp or within the thoracic subcutaneous pocket for potential secondary use [1,2,27,28].

Fixation of graft components during both primary and secondary construction is performed using Polydioxanone (PDS) or non-absorbable sutures. During secondary procedures, pockets preformed in the primary stage may be utilized. Creating a stable nasal framework requires reconstruction of the central support, while the lateral components may be formed from slightly more pliable materials [8].

It is essential to distinguish onlay grafts – used when residual structural support is present to smooth or enhance the projection – and cantilever grafts or L-grafts, which are used in the absence of such support. The latter are proximally secured to the nasal bones with screws or plates, or braced against them. The central nasal framework can be reconstructed using a composite septal pivot flap as well.

Reconstruction of the central nasal framework

The knowledge of the technical parameters of nasal bones (as described by Sullivan [29]) is crucial for anchoring graft materials to these bones. The nasal bones are approximately 12 mm wide at their free end, being widest at the frontonasal suture (14 mm) and narrowest at the nasofrontal angle (10 mm).

The thickness of the nasal bones decreases in the cranio-caudal direction: in men, it is approx. 6 mm in the upper part, decreasing to 3–4 mm at 5–10 mm below the nasofrontal angle. This thickness is still sufficient for screw fixation. Below that point, however, the application of osteosynthetic materials is not recommended due to the further decrease in thickness.

The four most widely used methods of central framework reconstruction include the L-graft, hinged septal flap, septal pivot flap, and cantilever graft.

L-graft

This graft consists of a long arm placed against the root of the nose and a short arm supported by the anterior nasal spine. It can be made of bone or cartilage. Ever since described by Gillies in 1920, it has been widely used (along with its modification). For example, Chait et al. (1980) used an osteochondral graft from the 5th rib. The downside of L-graft lies in the lateral instability of the result [30].

Hinged septal flap

The principle of this technique lies in the rotation of an L-shaped composite flap from the septum around a cranial pivot point (Fig. 3) [31]. The flap is vascularized by the anterior medial nasal branch of the anterior ethmoidal artery [32].

Septal pivot flap

In 1989, Burget and Menick [33] described rotation of the entire septum as a composite flap supplied by the septal branch of the superior labial artery. This was then followed by dorsal augmentation using a cantilever graft. The basic principle of this method is illustrated in Fig. 4.

Cantilever graft

Principally, this technique employs a long bone graft fixed to the nasal bones (which may sometimes require reduction; Fig. 4) [16]. The original idea by Converse and Millard was subsequently developed by other authors, who most commonly use an osteocartilaginous rib graft [30,34]. The rib bone is secured to the nasal bones, while cartilage is used to reconstruct the cartilaginous framework of the nose. Structural stability is typically achieved within 3 weeks.

Neu [35] combined a cantilever graft with an L-shaped cartilage strut to provide both the dorsal and tip support. In his technique, the cranial portion

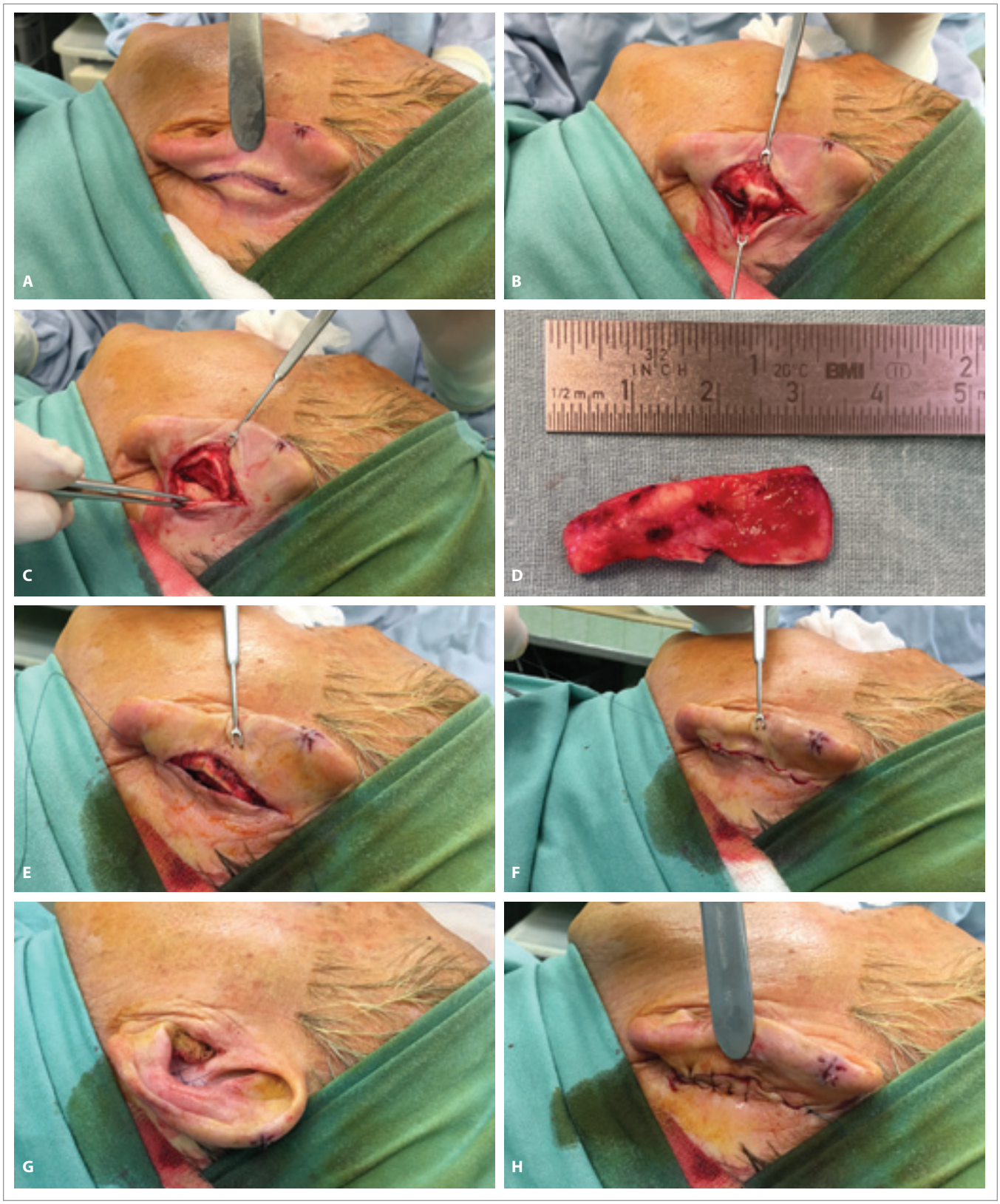


Fig. 2. Technique of harvesting a conchal cartilage graft from the auricle: A) drawing the design of the incision; B) exposure of the conchal cartilage; C) circumferential release of the conchal cartilage from its basal attachment and exposure of the ventral surface; D) the harvested conchal graft; E, F) closure of the dorsal surface of the auricle using non-absorbable sutures; G) placement of transdermal U-sutures for repositioning the skin of the concha onto the underlying structures; H) dorsal view of the final suture line. Source: author's archive.

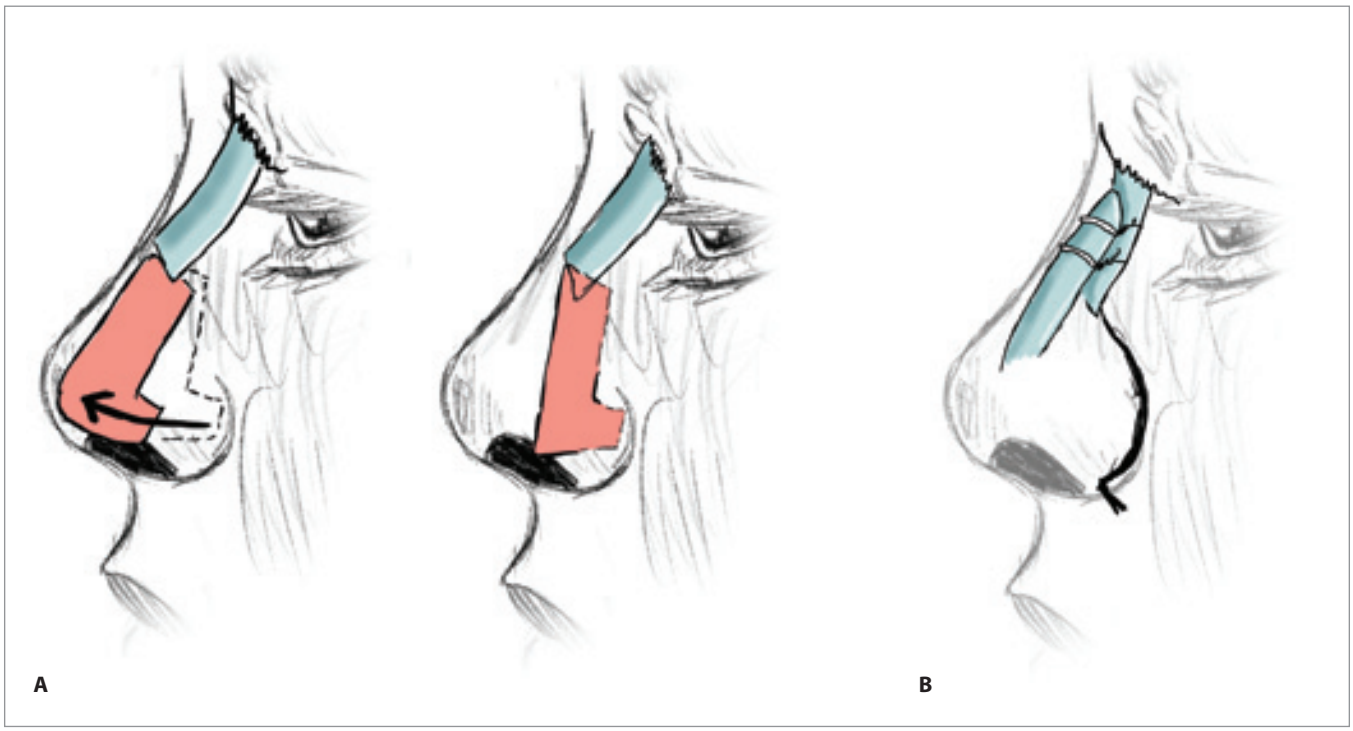


Fig. 3. Hinged septal flap (A) and cantilever graft (B).

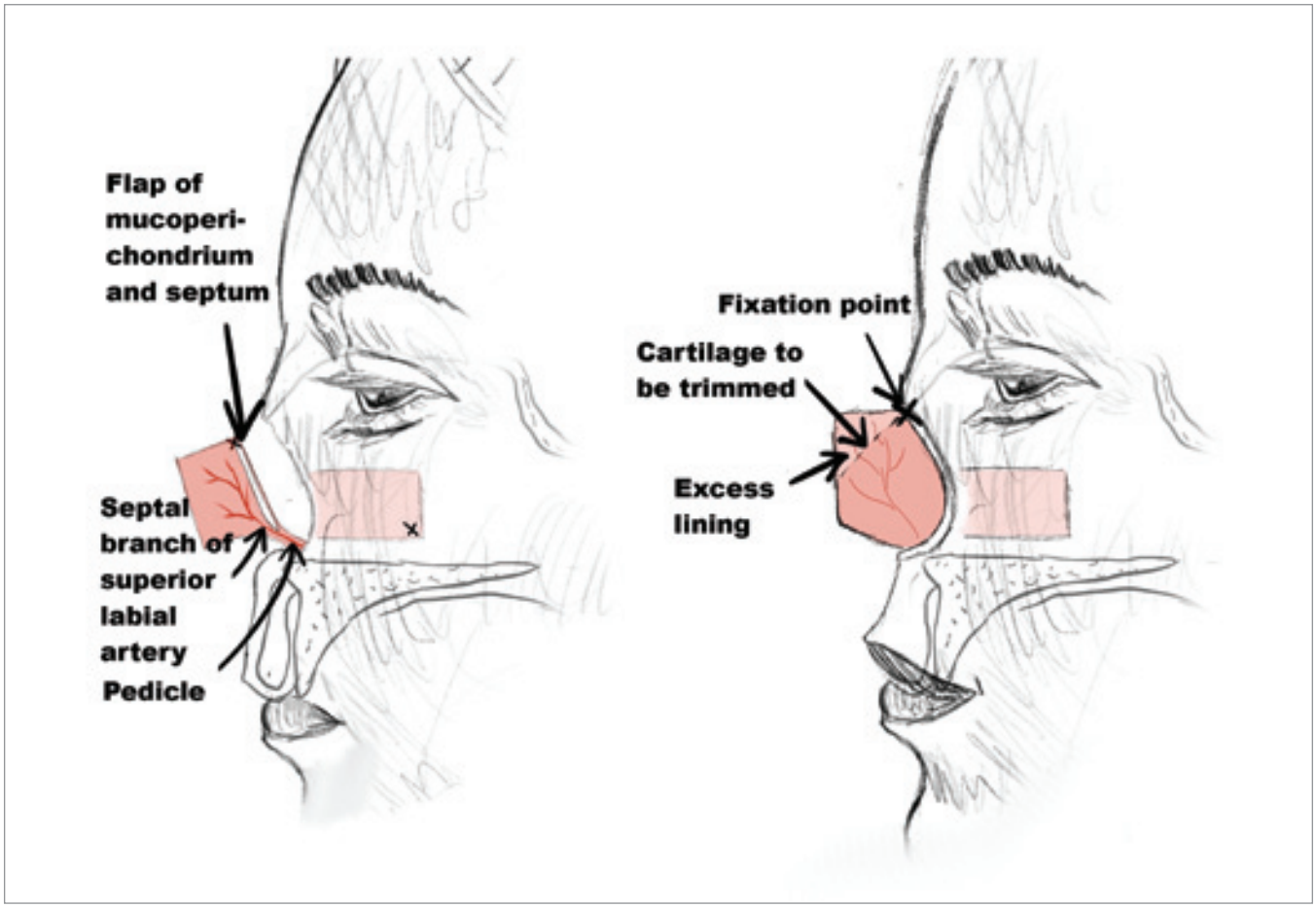


Fig. 4. Composite septal pivot flap.



Fig. 5. Examples of nasal skeleton reconstruction: A) nasal alas; B) reconstruction of half of the nose; C) reconstruction of the soft nose; D) total reconstruction of the nose.

was fashioned from the calvarial bone, whereas the caudal L-shaped segment was created from the septal or auricular cartilage.

Thomassin et al. [36] recommended constructing the L-graft from the calvarial bone – which is membranous in origin and, therefore, highly resistant to resorption – and fixing it using miniscrews and miniplates.

Shubailat used an osteocartilaginous cantilever graft (approximately 70% bone to 30% cartilage) harvested from the 10th rib. At 8–10 mm caudally to the nasal bones, the graft was perforated with a 1.5 mm drill and secured using 2 mm screws. In a cohort of 48 patients, the author reported excellent long-term stability without graft resorption [37].

Brackley and Jones [38] described a technique using a periosteal flap rotated from the forehead to reconstruct the central portion of the missing intranasal lining. On top of the flap, they placed auricular conchal grafts from both ears, and the structure was covered with a paramedian forehead flap. Conchal cartilage grafts were also used by Pirsig [39] for the reconstruction of the anterior septal segment in cases of full-thickness septal loss or saddle-nose deformity. During harvesting, the authors preserved perichondrium on one side, doubled the graft over it, and sutured it. This method employing an anterolateral approach led to the acquisition of a 2.5–3 cm graft demonstrating long-term stability without signs of resorption.

Reconstruction of the lateral nasal framework

The bony portion of the lateral walls can be fashioned not only from the calvarial bone [36], but (much more easily) from the rib bone, which can be split along one edge and opened to create a stable pyramidal construct [40]. Upper lateral cartilages are best reconstructed using septal cartilage or split rib cartilage, while the alar subunit is best supported

by the auricular conchal cartilage, as practically all authors agree [1,23,27,41]. Examples of nasal skeleton reconstruction for nasal defects of different sizes are shown in Fig. 5.

Discussion

The entire nasal skeleton must be reconstructed using well-vascularized tissue.

When reconstructing the intranasal lining, one should always aim to select the thinnest possible flap to prevent airway obstruction after an adequate structural framework is placed. In patients with extensive soft-tissue loss, microvascular free-tissue transfer is often the only viable option [42,43] but even here, the thinnest available flap should be opted for.

In 1974, Millard introduced a three-stage concept for nasal reconstruction using the forehead flap [5], inserting a procedure at 3 weeks after the initial transfer. During that procedure, the thick dorsal skin was thinned (by removal of the frontalis muscle) and the flap was then re-inset. This approach was later modified by Burget and Menick, who advocated against any initial thinning of the distal flap segments to prevent compromising the vascularity of the flap's peripheral portions and to perform any thinning exclusively during the second surgical stage, 3–4 weeks after the transfer [44].

Even a thin, well-vascularized soft-tissue envelope is able to nourish the implanted cartilaginous and bone grafts enough to prevent their extrusion or resorption. At the same time, using such a thin layer avoids obstruction of the nasal airway and allows clear expression of the aesthetic contours of the reconstructed nasal framework, thereby preserving the natural appearance of the nose.

The question of using alloplastic materials to replace the nasal framework appears repeatedly in the literature. In cases of total nasal loss, Bikhazi [45] used Vitalium or titanium mesh for dorsal support, which was then covered with an expanded forehead flap; the nasal tip was reinforced with conchal cartilage. The fact that no bony graft needs to be harvested, thus preventing any potential donor site morbidity is a clear benefit of this approach. On the other hand, disadvantages include a higher risk of infection and implant extrusion, as well as interference with radiography and CT imaging (which is especially relevant in oncologic patients).

Romo et al. [46] reported outcomes from a group of 187 nasal framework reconstructions using porous polyethylene implants (MEDPOR, Stryker, Minessota, USA), followed up for 6 to 42 months. They observed a 2.6% rate of infection requiring implant removal. Niechajev [47], using Medpor in 23 patients (primarily) with saddle-nose deformities, recorded two complications – one extrusion and one infection [47]. On the other hand, Burget and Menick consistently advise avoiding alloplastic materials in nasal reconstruction [2,27].

Conclusion

The stability of the reconstructed nose is directly proportional to the successful restoration of all nasal layers. Reconstruction of a well-vascularized intranasal lining and its overlay with a well-nourished forehead flap permits the implantation of avascular bone and cartilage grafts in complex nasal defects. A complete structural framework ensures long-term durability of the reconstruction, preventing collapse of the reconstructed nose and maintaining patency as well as functional integrity of the upper airway. Thus, the use of contemporary reconstructive principles allows excellent functional and aesthetic outcomes in nasal reconstruction.

Roles of the authors

Martin Kubát, Jan Menoušek, Ievgenij Polovko conducted the literature search, designed the flowchart and analysed the collected data. Andrej Berkeš drew the pictures. Zdeněk Dvořák and Ievgenij Polovko wrote the manuscript with the input from all authors. Richard Pink and Tomáš Kubek conceived the study and revised it critically for important intellectual content. All the authors approved the version to be published.

Disclosure

The authors have no conflicts of interest to disclose.

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