doi: 10.48095/ccachp202527

Possibilities of intranasal reconstruction in complex nasal defects

Z. Dvořák[1,2], M. Kubát[1], A. Berkeš[1], R. Pink[3], T. Kubek [3], J. Menoušek[1]

[1] Department of Plastic and Esthetic Surgery, St. Anne's Hospital and Faculty of Medicine, Masaryk University, Brno, Czech Republic
[2] Department of Oral and Maxillofacial Surgery, University Hospital and Faculty of Medicine, Palacký University, Olomouc, Czech Republic
[3] Department of Surgical Oncology, Masaryk Memorial Cancer Institute, Brno, Czech Republic

Summary

Background: Complex nasal defects most often arise due to oncological resection or severe trauma. Traditional methods of two-stage nose reconstruction using a forehead flap with a skin graft have often resulted in collapse and deformity of the nose with a very compromised outcome over time. These techniques were gradually replaced by new procedures consistently reconstructing the intranasal lining, most often with flaps from the nasal septum. These methods reconstruct the cartilaginous and bony support of the nose as well, while the skin cover of the nose is, nowadays, in large defects, reconstructed in three stages. **Evaluation of the topic:** The options for intranasal lining reconstruction are as follows: a composite graft, a turnover flap covered with a local flap, advancement of the residual lining (bipedicle vestibular mucosa flap), a folded forehead flap, a prelaminated forehead flap, the use of another local flap (a forehead, nasolabial, facial artery myomucosal flap), a hinged turnover flap, a septal mucoperichondrial hinged flap, a composite septal chondromucosal pivot flap, a turbinate flap and microvascular free flaps (a radial forearm flap, a helix free flap, a kite flap, a dorsalis pedis free flap, a temporoparietal free flap, a postauricular free flap). Thanks to the abundant vascular supply of the face, the risk of ischemia and infection is mitigated, allowing most complex nasal defects to be reconstructed by using local flaps to restore all layers of the nose. Local tissues retain ideal quality, coloration, and texture, are reliable, and usually result in esthetically acceptable morbidity of the donor area. If the inner lining defect is extensive, it must be reconstructed by free microvascular tissue transfer. If other than intranasal flaps are used in the reconstruction of the internal lining, it is preferable to postpone the reconstruction of the supporting framework until the second stage while thinning the flaps used; otherwise, there is a high risk of obturation of the nasal airways. **Conclusion:** The results of modern reconstruction dramatically improved after the introduction of three-stage nasal reconstruction and emphasizing the reconstruction of all layers of the nose. Therefore, a quality inner lining is the basis for the construction of the new nose.

Key words

reconstructive surgery – acquired nasal deformities – nasal surgery – intranasal lining

Dvořák Z, Kubát M, Berkeš A et al. Possibilities of intranasal reconstruction in complex nasal defects. Acta Chir Plast 2025; 67(1): 27–41.

Introduction

The original concepts of nasal reconstruction predominantly focused on the reconstruction of the external skin cover of the nose. The temporary postoperative stiffness and tissue swelling often ensured esthetically acceptable results early after surgery; these results, however, were unstable over time and irreversible deformations of the reconstruction occurred after further healing and scarring. Hence, new principles of quality and stable nasal reconstruction were accepted that can be summarized in the following points:

1) Reconstruction of all layers of the nose – nasal lining, supporting layer, and outer skin cover – needs to be performed [1–3].
2) due to the ideal color and texture quality, the forehead flap is the best donor flap to replace the skin cover of the nose [4]. The harvest site on the forehead is left for secondary healing [5,6].
3) Nasal reconstruction with a forehead flap is performed in three stages. First, the full-thickness forehead flap is moved into the position in the nose; 3–4 weeks later (surgical delay), the forehead flap is reelevated, thinned, and returned, and the pedicle is removed next 3–4 weeks later [7].
4) If more than 50% of the nasal subunit is missing, the entire regional esthetic subunit of the nose needs to be reconstructed.
5) Reconstruction of the supporting component (nasal skeleton) must be an integral part of the planned reconstruction in the first step before being covered with the soft tissue [3]. Both the central and lateral parts of the nasal skeleton need to be reconstructed [8].

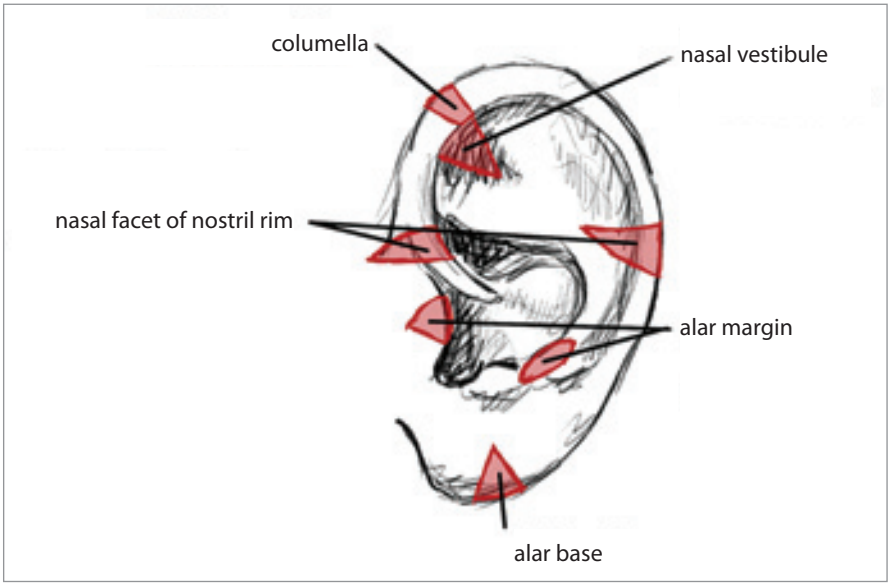

Fig. 1. Locations of harvesting composite chondrocutaneous grafts for individual parts of the nose. (Drawing by A. Berkeš according to [70]).

6) According to Thornton, an adequate well-vascularized intranasal lining is the most important element of nasal reconstruction as it provides overlay and nutrition to the supporting component [9]. Simply stated, a well-vascularized lining serves as a basis for the construction of a new nose.

Therefore, the well-vascularized inner mucosal lining of the nose is reconstructed first. Subsequently, the supporting layer of the nose is transferred and fixed on top of it. This layer consists of cartilage (transferred from the cavum conchae of the auricle, from the rib or nasal septum), and bone freely transferred from the skull (external cortices of the parietal region) or from the rib. For good healing of the supporting layer, its overlay with a well-vascularized outer layer of the skin and subcutaneous tissue is necessary [1]. Thus, the overall shape of the nose can be likened to a triangular pyramid made of cartilage and bone, which forms the center of the sandwich between the two layers of the soft tissues – the inner mucosal lining and external skin cover [10].

When transferring individual tissues for the purpose of nasal reconstruction, care must always be taken to ensure that they are adequately vascularized as only well-vascularized tissues are able to heal and fuse into new units. The necessary nourishment of the tissue can be ascertained either by a soft tissue bridge with a sufficient amount of capillaries (functional subdermal plexus) or by preserved vessels [11–13].

Assessment of the problem

The literature search of the MU Medical School Campus Library Discovery System using keywords „INTRANASAL LINING“ and „NASAL RECONSTRUCTION“ yielded 682 publications over the past 5 years. Subsequently, cross-referencing of the papers selected for thorough reading identified monographs on nasal reconstruction. From the resulting body of literature, we removed studies with apparent bias, studies that only described an overview of performed surgeries on an individual department, and those that did not specifically focus on the reconstruction of the intranasal lining. Finally, 70 papers were used as information sources for this review.

The reconstruction of well-vascularized inner lining seems to be the single most important point in modern nasal reconstruction as it serves as a basis for the entire supporting structure of the nose (which is then overlaid with a skin cover. Its importance is often underestimated, and its absence invariably results in the contraction and destruction of the reconstruction [14]. Below, we provide a list of reconstructive options:

1) composite skin graft;
2) advancement of residual lining;
3) prelamination of the forehead flap;
4) second flap (forehead, nasolabial, facial artery myomucosal flap, etc.);
5) hinged turnover flap;
6) folded forehead flap;
7) intranasal lining flap;
8) free flap.

Composite graft

Composite graft contains skin and cartilage, taken from various locations of the the auricle depending on the requirements of the target site (Fig. 1). This method is suitable for small defects of the soft triangle, nostril margins, or nostril base. The recipient wound bed must be well vascularized; if the transfer was preceded by extensive coagulation, it is better to postpone the procedure by 7–14 days. The full-thickness composite graft is fixed using simple skin stitches. Typically, the maximum width of the composite graft is 1.5 cm. The graft is initially white, grows blue within 24–72 hours and, after that, it starts to turn pink, reflecting an improvement in vascularisation [15].

Advancement of the residual nasal lining

In minor defects of the nostril margin, a bridge shift of the lining caudally can be performed along the margins of the nostrils. The position of the lining is secured by extraanatomically placed conchal cartilage grafts, covered externally with a local flap (Fig. 2).

Prelaminated forehead flap

In this technique, the reconstruction of the nose starts on the forehead. In the literature, this procedure is sometimes

incorrectly called prefabrication; the principle of prefabrication, however, lies in the manipulation of the vascular supply to create a new flap [16–18]. In principle, prelamination lies in the incorporation of new tissues or elements into the classic flap, thus changing its properties. If this is performed at the same time the flap is transferred, this procedure is called lamination [19].

During the preparatory surgery, a full--thickness skin graft is placed under the frontal muscle 1–1.5 cm from the „nostril" edge of the nostril and a bolus is inserted. Conchal cartilage grafts are inserted from the lateral approach as a reinforcement between the frontal muscle and the skin. After 6 weeks of healing, the entire construct is transferred into the nasal position (Fig. 3).

In the recipient site, the cranial lining is created by flipping the flap from the cheeks or nose dorsum; caudally, it is connected to the remnants of the nose wings and columella [2].

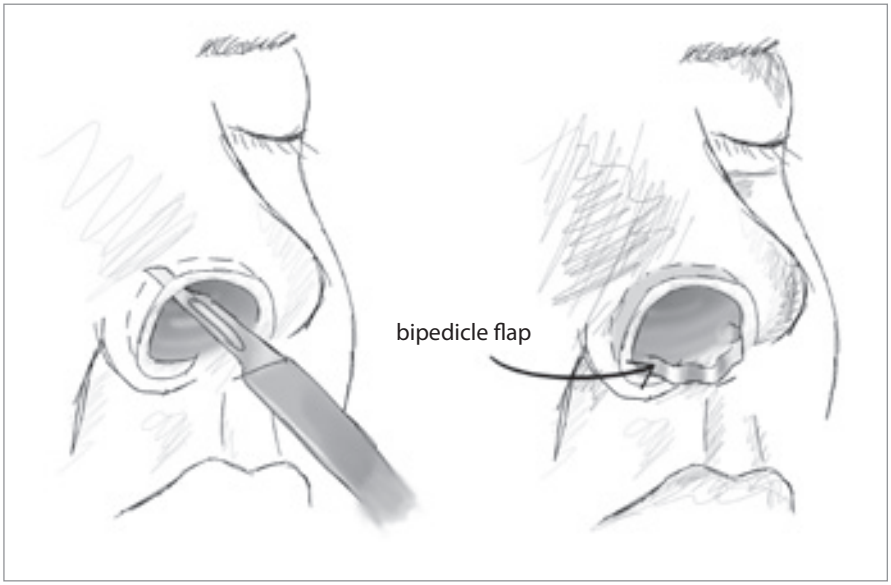

Fig. 2. Bridge vestibular flap. (Drawing by A. Berkeš according to [2]).

The limitations in positioning, shape, and size of the cartilage often result in an imperfect and unstable nasal skel-

Fig. 3. Prelaminated frontal flap and its transfer to the nose reconstruction. (Source: photo archive of the author).

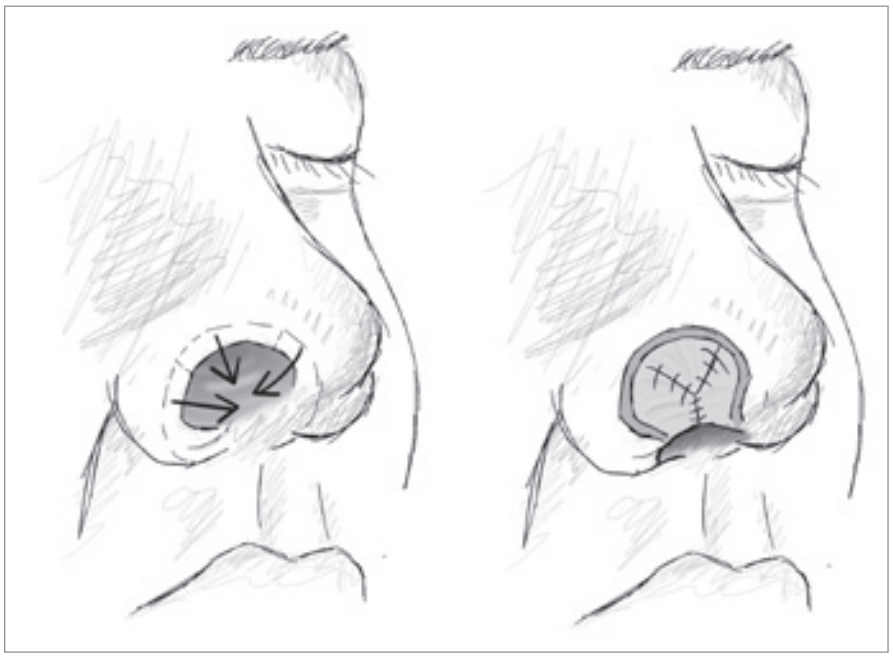

Fig. 4. Overlapping lining flap. (Drawing by A. Berkeš according to [2]).

eton. The indications for this method include:

- minor nose tip defects;
- elderly and frail patients (all steps of the surgery can be performed under local anesthesia);
- salvage surgeries (if other options are not available).

Turnover flap

After full healing, approx. 6–8 weeks after the surgery, continuity of the outer and inner lining is established. This allows turning the flap over along the defect margins. Flap nourishment is then provided through the capillaries in the scar (Fig. 4).

The maximum recommended width of these flaps is 1–1.5 cm. Care should be taken because the blood supply to the flaps unfortunately often fails and even a small loss of the blood supply can cause a major infection. Therefore, if the blood supply is problematic, the viability of the flaps can be improved by using a delay. The flap is elevated, turned over, and returned to its original position. The final turnover is performed approx. 1–2 weeks later [2].

Turnover flaps often suffer from greater scarification, contractibility, limited nutrition and mobility. Moreover, the aforementioned technique further prolongs the duration of the reconstruction. In general, the turnover flap is usually stiff, thick, and unyielding. The typical indications for this technique include:

- small defects;
- margins of the wings;
- salvage procedures – in cases of rhinoplasty failure, cocaine nose, reconstruction failure;
- pediatric nose reconstruction (reduction of the impairment of a growing nose; a composite flap should be considered as an alternative) [20].

Disadvantages of the turnover flap include:

- impossibility of use in fresh injuries – it is necessary to wait for 6–8 weeks;
- the result is thick, stiff, and non-pliable;
- if the flap covers a greater part of the nostril, a secondary contraction occurs [21].

In 2004, Lee et al. proposed a hinged turnover flap [22] facilitating a single-

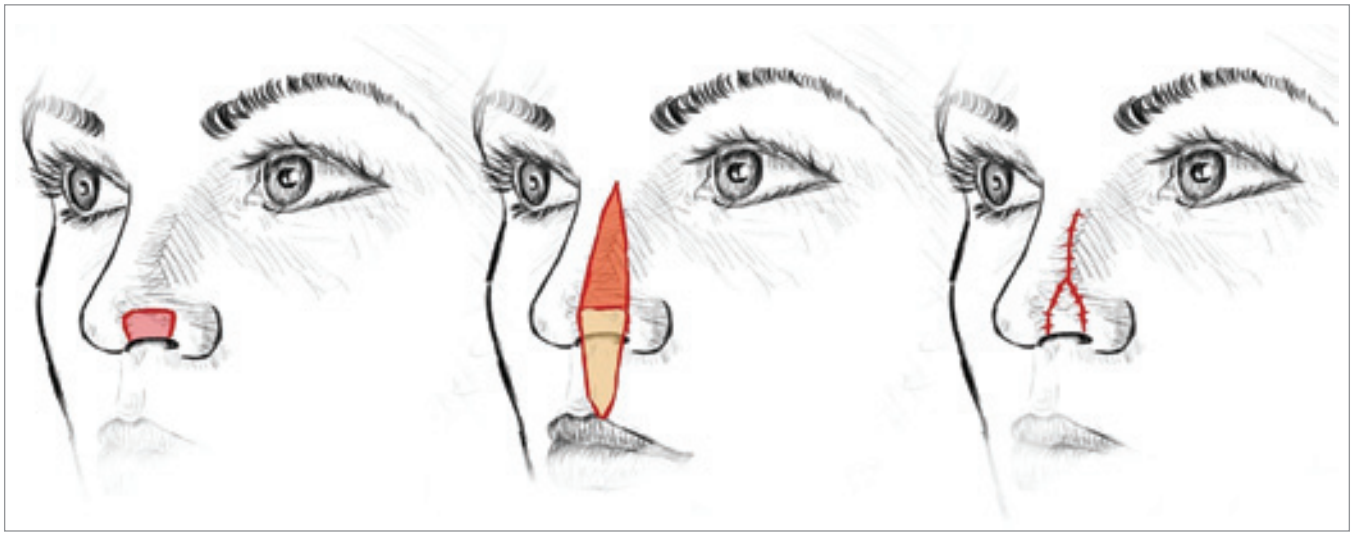

Fig. 5. Hinged turnover flap. (Drawing by A. Berkeš).

procedure resolution of minor defects of the wing. The principle of this modification is depicted in Fig. 5. In both situations, it is advisable to reconstruct the nasal wing skeleton with the conchal cartilage to prevent the retraction of the wing.

Use of a second flap for the inner lining

In this type of inner lining reconstruction, the defect is addressed by turning over an additional local flap with its own vascular supply. The nasolabial flap, the secondary paramedian forehead flap, and the facial artery myomucosal (FAMM) flap are the most commonly used flaps for this procedure.

Nasolabial flap

Millard used and popularized the randomly pedicled facial flap. When reconstructing the nasal lining of half of the nose, he usually flipped a flap of skin from the upper nose and used the nasolabial flaps from the cheek for the wings [23]. Nasolabial flaps were also used for the reconstruction of the nostrils and columella. However, the negatives of the nasolabial flap include:

- thickness and stiffness of the flap, it cannot be primarily thinned due to a high risk of compromising the vascular supply;
- it is impossible to apply primary cartilage grafts as this would lead to significant airway obturation with highly limited options of thinning the flap in the future;
- the need for later thinning of the flap to improve the nostril patency and modify its external contour.

Nowadays, this flap is rarely used as it has been largely replaced by the inner lining flaps.

Use of a second paramedian forehead flap

If this technique is considered, it is necessary to take into account the increased morbidity of the forehead and exhaustion of the material for the forehead flap for a potential additional reconstruction.

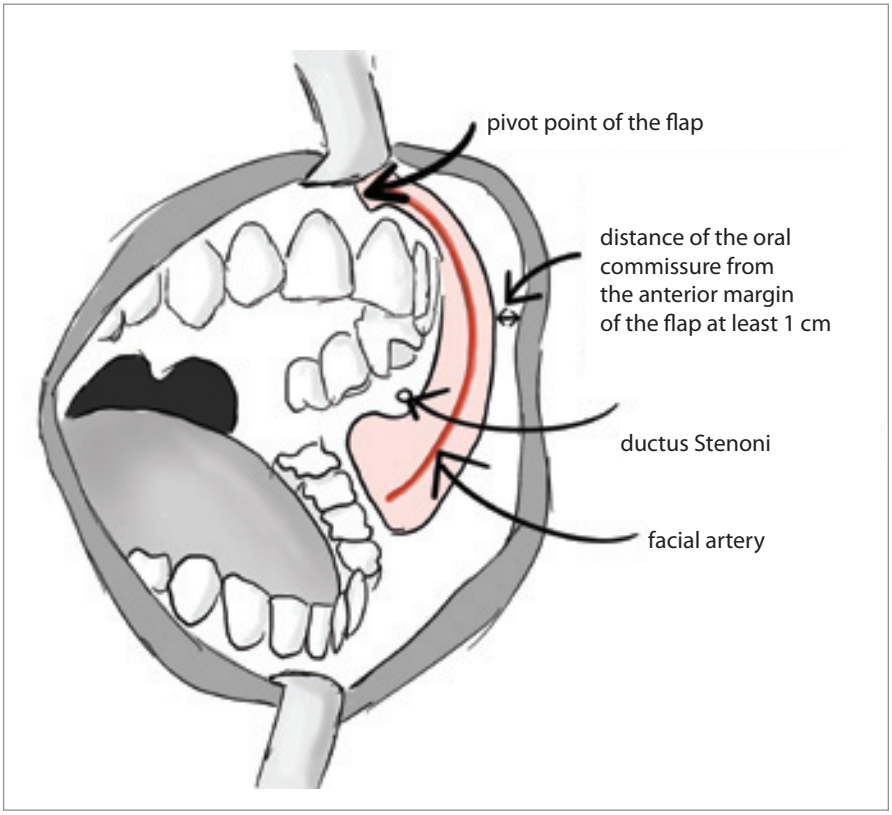

Fig. 6. Diagram of the oral cavity with drawing of the facial artery musculomucosal flap. (Drawing by A. Berkeš).

FAMM flap

The FAMM flap was first described by Pribaz et al. in 1992 [24]. Over the next years, several modifications have been developed and indications refined to make this intraoral musculomucosal flap even more universal.

The FAMM flap should not be mistaken for the buccal musculomucosal flap described by Bozola et al. (an intraoral flap pedicled on the buccal artery, a branch of the internal maxillary artery), which is pedicled more posteriorly, has greater width, and its rotation is more limited compared with the FAMM flap [25].

The FAMM flap consists of intraoral mucosa, submucosa, a part of the buccinator, the deep portion of the orbicularis oris muscle, the facial artery, and the venous plexus. In nasal reconstruction, this flap can be cranially pedicled and used with dimensions of 8–9 cm × 1.5–2 cm. The pivot point is located at the base of the adjacent nasal wing.

Positives of the FAMM flap include good vascularity, the absence of a facial scar after harvesting, and the possibility of bilateral elevation [2]. During preparation, care must be taken to preserve the terminal buccal branches of the facial nerve, the distance of the leading edge of the flap from the commissural line should be kept at 1 cm, and the parotid gland duct should not be included in the flap [26–28]. A sketch of this technique is shown in Fig. 6.

Lining flaps

The relevant ventral part of the nasal mucosa is perfused by:

- branches of the facial and angular arteries;
- the septal branch of the superior labial artery – running under the edge of the

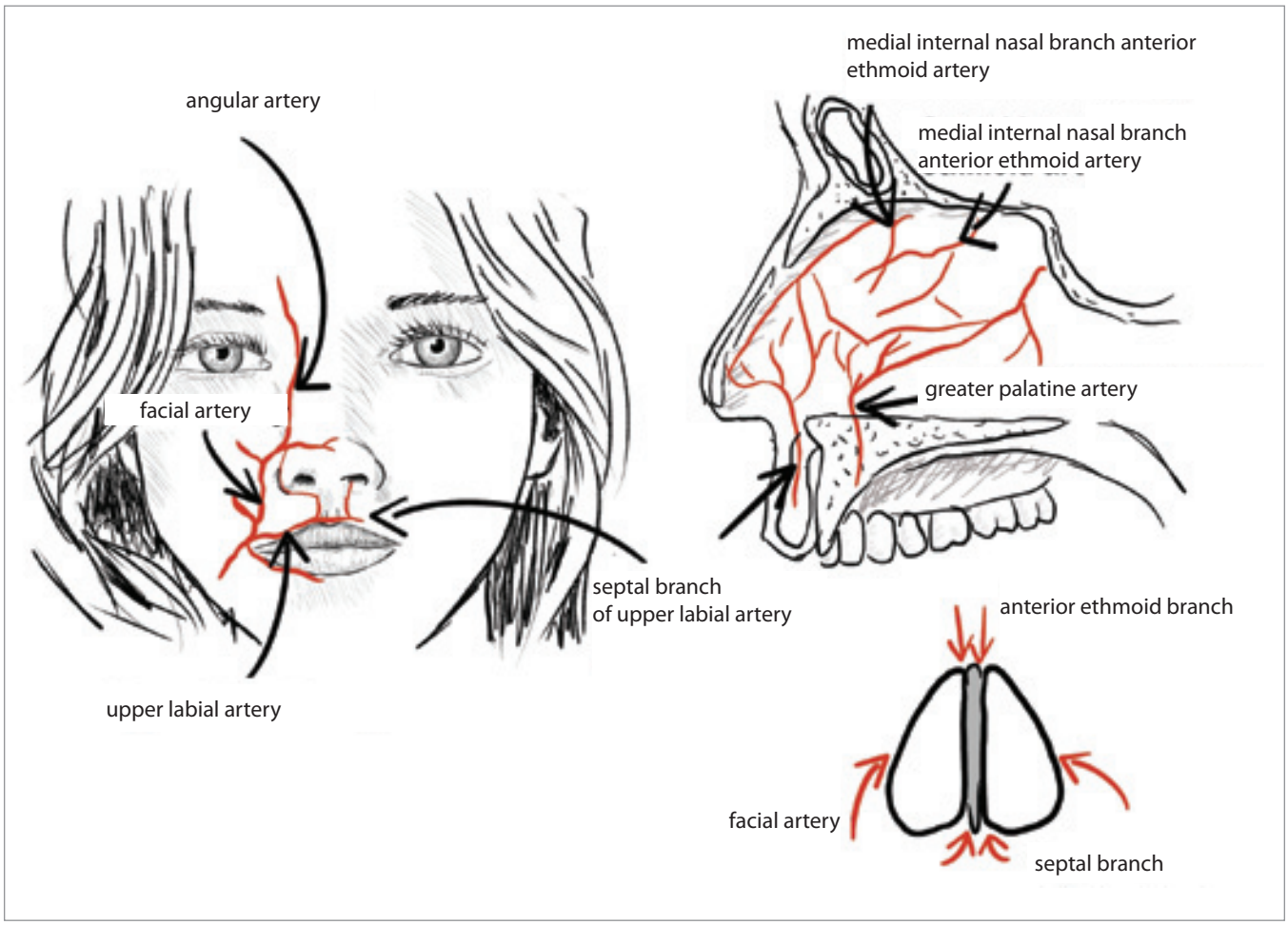

Fig. 7. Vascular supply to the septal mucosa. (Drawing by A. Berkeš according to [2]).

philtrum, lateral to the anterior nasal spine behind the base of the columella (approx. 1.0–1.2 cm behind the anterior nasal spine); this branch can supply the entire ipsilateral septum (Fig. 7);
- medial and lateral branches of the anterior ethmoidal artery [29].

Septal lining flaps were first described and used in various modifications by Burget and Menick [21,30–32]. They can be, however, unavailable after a previous surgery or trauma of the upper lip.

Bipedicle vestibular skin flap

It is indicated for marginal wing defects where the remaining vestibular lining of the nose can be moved caudally. The donor area may be covered with an ipsilateral septal flap, a skin graft, or a contralateral septal flap [31,32]. In all cases, however, the cartilaginous L-shaped septal rim must be preserved to maintain central support of the nasal skeleton (Fig. 2).

Ipsilateral septal mucoperichondrial flap

The ipsilateral septal flap is standardly used to reconstruct the nasal wing margin. It is pedicled on the septal branch of the facial artery, on which the flap is elevated from the entire equilateral surface of the septum and bent ventrocaudally (similarly as a quilt thrown over a window frame) to form the lining of the lower 1/3 of the caudal nose [31].

Contralateral septal mucoperichondrial flap

The contralateral septal flap is vascularly supplied from the cranial branch of the posterior septal artery and from both ethmoidal arteries. It is pedicled along the dorsum of the nose and turned over to the contralateral side through a cartilaginous window in the center of the septal cartilage (a "frame" arising after harvesting the central septal cartilaginous graft) [33,34]. This flap will form the central part of the inner lining of the lateral wall of the nose (it cannot reach the alar base or wing margin) (Fig. 8).

Composite septal pivot flap

A composite septal pivot flap (Fig. 9) is nourished by the septal branches of the superior labial artery. Thanks to this, the entire nasal septum can be rotated, allowing the reconstruction of the entire middle nasal support. Mucosal flaps, however, are not long enough to reach the base of the wings, necessitating

a combination of this technique with residues of the wings, nasolabial flaps, or turbinate flaps.

General properties of lining flaps

In general, lining flaps are thin, pliable, and well-vascularized. They enable the application of primary grafts, which brought significant progress in nose reconstruction. These flaps do not obstruct the airway; on the downside, their size is limited and their success in smokers is uncertain. They must always be reinforced by cartilage grafts. Lining flaps can be optimally used for isolated defects of the middle vault or unilateral complex defects (Tab. 1).

Unilateral nasal loss is resolvable with a contralateral septal flap. A transverse incision is made on the ipsilateral septal mucosa, the septum is exposed, and the central portion of the septal cartilage is removed while preserving an at least 7–8 mm wide cartilaginous rim. Subsequently, a dorsally pedicled contralateral septal flap is elevated and used to reconstruct the lining defect. After that, the harvested septal cartilage is implanted and the ipsilateral septal mucosa is sutured (or allowed to heal spontaneously). A forehead flap or another local flap is then used to reconstruct the skin cover [2].

If the alar defect is less than 1 cm in width, a bipedicled (bridge) vestibular flap may be used. It should be at least 8 mm wide. The bipedicled vestibular flap is then moved to the alar margin and the secondary defect of up to 3 × 3 cm in size is then covered with a dorsally pedicled ipsilateral septal flap or with a skin graft (Fig. 2).

In the case of a complete unilateral nasal defect, the ipsilateral septal flap can be used in the position of the lining at the alar margin (pedicled in the vicinity of the anterior nasal spina) and a dorsally pedicled contralateral septal flap can then be used to fill the defect above the previous flap. The ipsilateral flap may, however, partially obstruct the airway and needs to be subsequently transected [21].

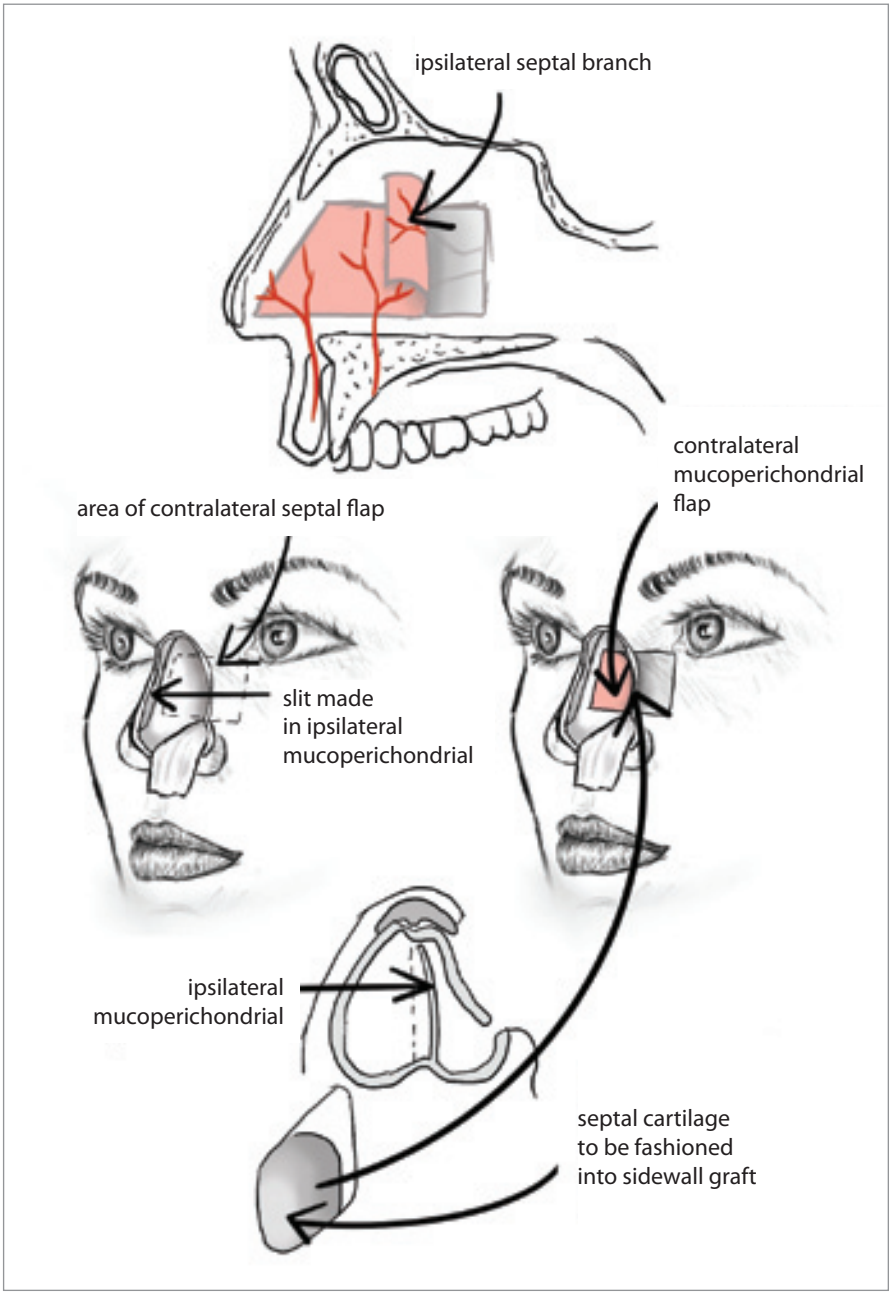

Fig. 8. Ipsilateral and contralateral septal flap in mid-nasal reconstruction. (Drawing by A. Berkeš according to [2]).

In the central nasal region, mucosal mobilization with a direct suture is often possible. It can be aided by the lowering of the dorsum of the nose, which is then re-established using a cartilaginous graft. Defects in the lower part of the nose can be classified into subtotal (soft nose missing) and total (loss of the entire nose including the septum and nasal bones). The septal pivotal composite flap is the ideal solution in all these cases; however, this solution may be unavailable in some cases. Where nasal bones are preserved, a cantilever graft can be applied. If the central part of the lining as well as the supporting structures were missing, Millard used preliminary surgery applying the following techniques:

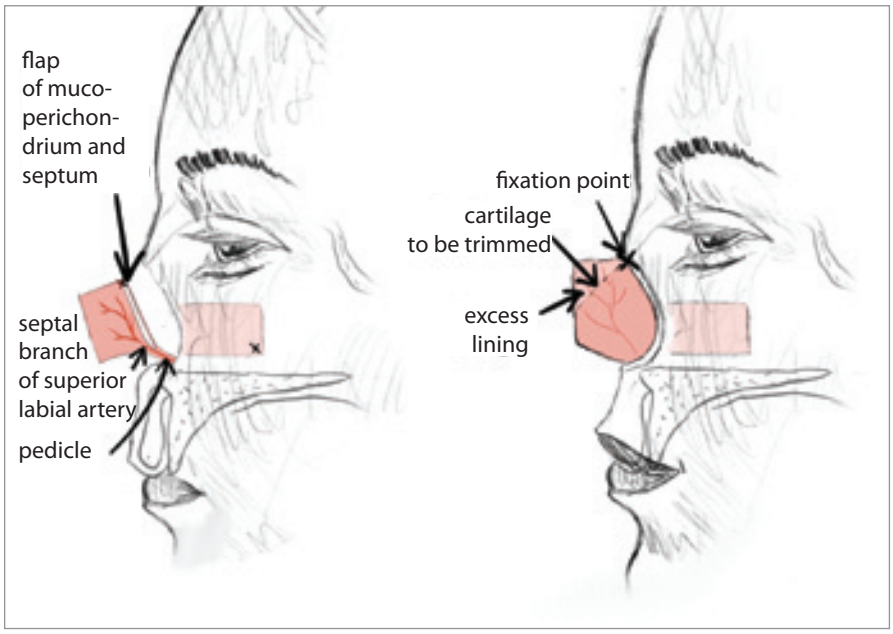

Fig. 9. Composite septal flap. (Drawing by A. Berkeš according to [2]).

1) turnover flap combined with bone grafts and forehead flap;
2) cranially pedicled composite L-graft from the septum;
3) local flaps (nasolabial, cheek) and a forehead flap with a cantilever graft [33].

Nowadays, however, all three of these techniques are considered unreliable. At present, the composite septal pivot flap is typically used (Fig. 9) with a graft from a rib anchored into the nasal bones (forming the base of the nose) or a costochondral L-graft [35]. When rotating the pivot flap, it is necessary to preserve approx. 2 cm of the tissue at the point of entry of the labial artery branches. After rotation, the septal cartilage is fixed to the upper lateral cartilages, and the entire reconstruction is then covered with the forehead flap. If the entire nose is missing, it is preferable to delay the surgery by 6–8 weeks (so that turnover flaps can be used if necessary) [36].

Turbinate flap

Flaps from the lateral wall of the nose can also be elevated to a limited degree. The turbinate flap comes from the mucosa of the inferior nasal concha. It can be pedicled ventrally on the anterior lateral branch of the anterior ethmoidal artery and the lateral nasal artery, or dorsally on the descending branch of the posterior lateral nasal artery [37]. This flap was originally proposed for the closure of septal perforations [38,39], of palatal fistulas in cleft defects [40], and for defects of the cranial floor [41]. In 1999, Mukarami et al. described nine cases in whom he used this flap as inner lining in the reconstruction of complex nasal ala and lateral wall defects (Fig. 10). In his small cadaveric study, he also defined the usable flap dimensions – usually 5 cm^2 with a length of 2.8 cm (1.7–4.0 cm) and a width of 1.7 cm (1.5–2.0 cm) [42]. The middle nasal concha can be used in a similar way, but the flap derived from it has a limited reach and size. The turbinate flap can be practically used in the reconstruction of the inner lining of the base of the ala [43].

Folded forehead flap

The folded paramedian forehead flap is used for the reconstruction of both inner lining and outer skin cover. It is a traditional reconstruction method; however, when used, the amount of available soft tissue is excessive, which necessitates a three-stage surgery [7]. In the first stage, the flap is extended by the inner lining at its end and a full-thickness forehead flap is elevated. Templates (made of e. g. tinfoil, packaging of the suture material, or canvas) can be easily used for planning the flap shape. To support the bending of the flap, a strip of at least 7 mm in width needs to be inserted between the inner and outer parts of the flap (Fig. 11).

The second stage comes a month later when the flap is transected at the site of

Tab. 1. Indication criteria for lining flaps.

Defect	Flap type
isolated medial vault defect	contralateral septal mucosal flap
unilateral lower 1/3 nasal defect	bipedicular vestibular flap + ipsilateral septal flap
unilateral defects up to ½ nose	bipedicular vestibular + contralateral septal flap
unilateral defects complete	ipsilateral + contralateral septal flap
central defect of the dorsum and tip	septal composite flap
central defect with wing defects	septal composite flap + nasolabial flap (or flap of wing remnants, turbinate flap)

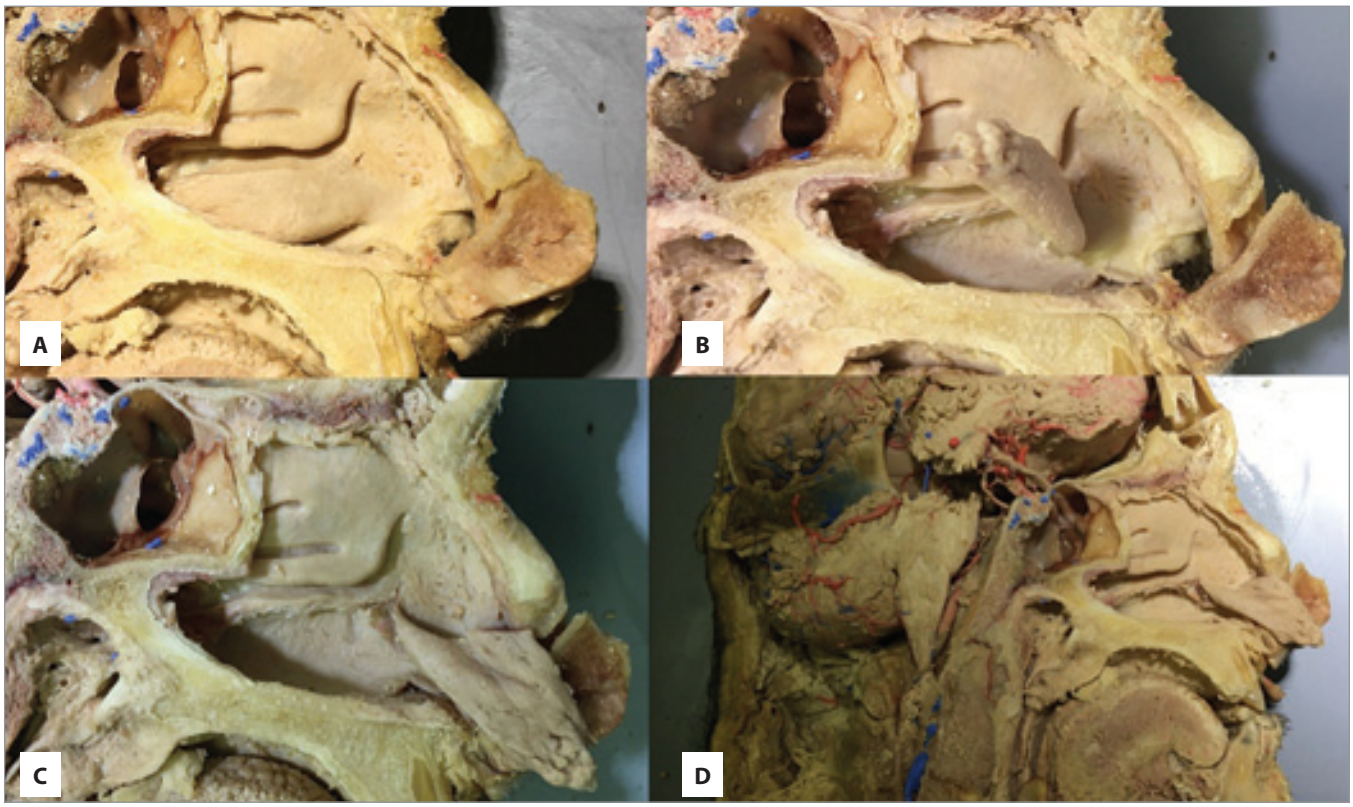

Fig. 10. Scheme of the elevation of the turbine flap. (Source: author's photo archive).

the future margin, layers are thinned to 2–3 mm (dermis and subcutaneous fat), and a cartilaginous conchal graft is inserted extraanatomically into the margins of the reconstructed nasal wing (a delayed primary graft). In the third stage, in another month, the pedicle is removed.

When using the folded forehead flap, it is necessary to adhere to the following rules:

- cartilaginous grafts are to be inserted only in the second stage;
- the frontalis muscle needs to be transferred as a part of the forehead flap, which preserves the softness and pliability of the flap, and prevents its contraction;
- it is suitable for defects of up to 3 cm in the full thickness of the ala;
- reconstruction of the nostril floor perpendicularly to the alar lining is also possible;
- thanks to the excellent forehead blood supply, this method is also suitable for using in smokers;

Fig. 11. First stage of nasal reconstruction with a duplicated forehead flap. (Source: author's photo archive).

- the individual surgical procedures are relatively short, making this technique suitable also for frail patients [21].

Microvascular free flaps

A microvascular free flap is indicated if the defect size is greater than a size that can be covered by local flaps. It serves to provide a sufficient amount of well-nourished tissue for primary healing. Most of the time, it is used in complex extensive injuries involving damage to tissues adjacent to the nose. Preparatory surgery is often necessary when using this flap.

Menick defined the principles of large defects reconstruction as follows [2,6,20,21]:

1) Establish the platform first with the primary reconstruction of the lips and cheeks.
2) The septum is usually not reconstructed, leaving an acceptable fistula.
3) The columella either hides part of the support system (strut graft) or is composed of soft tissue only.

4) Compared to the original lining area, the flap size is smaller (only approx. 7 × 8 cm). The columella must be long enough to maintain nasal tip projection and thin enough to maintain airway patency. The nasal floor can be likened to a platform on which the nose is placed caudally. It is often preserved or reconstructed in a preliminary surgery. It can also be reconstructed together with the nose, either applying a separate local flap or an extended free flap for the lining. The nasal floor defect following an excision or trauma must be reconstructed. Otherwise, scar retraction is likely to pull the upper lip and corners of the mouth up.
5) Nose reconstruction is performed in several stages. When free flaps are used, they are employed to reconstruct the intranasal lining, thus converting the defect to a skeletal and skin cover defect only.
6) The functions of the distantly transferred tissues:
   - filling in the dead space;
   - protecting vital structures;
   - creation of a barrier between the central nervous system and gastrointestinal tract;
   - formation of a stable platform.

The color and texture of the skin is, however, a downside of the use of free flaps, they resemble ugly pale patches. Flaps from the head and neck – the auricular helical flap, the retroauricular flap, and the submental flap (containing facial hair in males) are exceptions from this rule.

Free flaps ensure the presence of a well-vascularized tissue in the defect and can replace adjacent tissues. In large defects of the midface, the scapular and parascapular flaps are often used, along with the latissimus dorsi muscle and rectus abdominis muscle. All these flaps are of sufficient size to fill in the maxillary sinus. The reconstruction of the nose is then performed later, after a stable platform is established.

Radial forearm free flap

For reconstruction of central defects, the fasciocutaneous or osteocutaneous variant of the radial forearm flap is the most commonly used [44]. The principles of its use also apply to other flaps.

If the nostrils are preserved, it is advisable to turn the flap with the skin inwards and cover its surface with a skin graft. If the septum is preserved, the same procedure is followed.

If the nostrils are missing, the flap is bent around the future nostrils (in the ulnar or in the thinnest part) and immediately supported with a cantilever graft. In the next step, the outer skin is removed, the nose skeleton is added and the skin is replaced with a three-stage forehead flap.

If a part of the septum is primarily missing, it can be addressed using a composite septal pivot flap. Several modifications of this method have been described in the literature.

Burget and Walton [45] used multiple skin islands on the radial artery. They created three separate skin flaps – one for the columella, another one for the nasal entrance, and the last one for the lining (on the radial artery like beads on a string). The whole structure was covered with the skin graft (Fig. 12). Later, the flap was thinned, the nasal skeleton was applied, and a distally thinned three-stage forehead flap was applied. In all, at least six surgeries were needed for this technique. This technique allows a full reconstruction of the entire internal nasal surface. However, their approach came with downsides such as increased technical difficulty, a shortened pedicle length, the increased risk of pedicle injury due to multiple surgeries, and the fact that thinning the flap increases the risk of necrosis, potentially compromising the overall outcome of the reconstruction.

Menick and Salibian published their version of the use of the radial forearm flap in combination with a 3-phase forehead flap in 47 patients [46,47]. During the first surgery, an 8–10 × 6–8 cm flap is elevated with a 12–15 cm pedicle, which is then microanastomosed with the facial vessels on the neck (Fig. 13) or with the temporal superficial vessels. They fold the thin ulnar region of the lobe inward to form primitive nostrils. The septum is not primarily reconstructed. The thin ulnar region of the flap is folded inward to form primitive nostrils. In cases with a subtotal or total loss, an osteocartilaginous graft from the rib is implanted into the position of the cantilever graft, saving the remaining cartilage for the subsequent surgery. The second surgery takes place usually two months later. The position of the nostrils is measured and the outer skin covering the flap with a few millimeters of subcutaneous tissue is excised. Thus, the excess flap is excised and the neurovascular bundle is spared. The nose skeleton reconstruction is completed, fixing it to the previously applied grafts. Everything is covered with a three-stage forehead flap. A month later, a third surgery is performed, during which skin with 2–3 mm of subcutaneous tissue is elevated and, if needed, the cartilaginous supporting structures of the new nose are corrected. Another month later, during a fourth surgery, the pedicle is removed and if needed, nostrils are thinned. The final, fifth, surgery is performed four months later. In that surgery the scar on the forehead is corrected, the shape of the nose fine-tuned and, if required, the tip of the nose may be adjusted by implanting cartilaginous grafts. The entire reconstruction, therefore, takes eight months.

Advantages of the radial forearm flap include:
- thin, pliable skin;
- excellent blood supply;
- long pedicled;
- the flap is suitable for combined lining and columella defects.

Most authors use this flap for the reconstruction of the nasal lining [48–50]. However, other uses of this flap and its

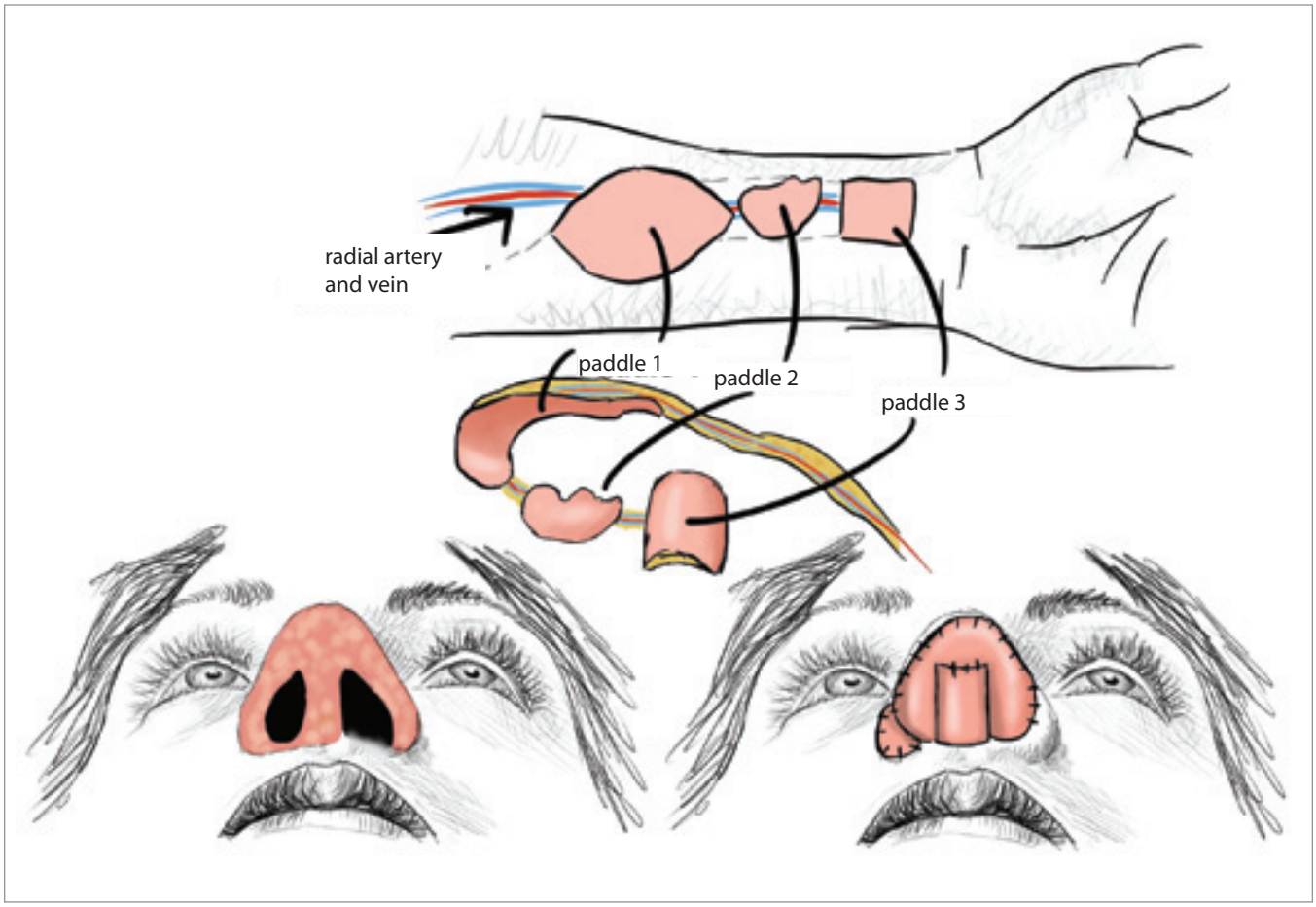

Fig. 12. Burget-Walton technique of Chinese flap nose reconstruction. (Drawing by A. Berkeš according to [2]).

modifications during nose reconstruction have been reported [51,52].

Prelaminated radial forearm flap

Prelamination was introduced by Pribaz and Fine in 1994, and since then, the radial forearm flap has been the most commonly prelaminated flap in facial reconstruction [18,49,53,54]. For example, Costa used a prelaminated osteocutaneous variant of this flap, modeling a nose with a central bony L-segment and nostrils created by folding the flap using reinforced nasal dilators. After 3 weeks, he transferred the prepared nose to the facial area [54].

Winslow et al. [55] reported an interesting modification, using the radial forearm fascial flap (radial forearm flap without skin, only vascularized fascia) to reconstruct the inner lining. On top of this, several remnants of nasal mucosa from the conchae were applied, the nasal frame was created from the calvarial bone, and the structure was covered with a three-stage forehead flap.

In 2019, Ahcan presented a case of a 52-year-old woman who underwent a two-stage reconstruction of the entire nose due to a complex nasal defect arising after the resection of invasive squamous cell carcinoma [56]. In the first stage, the osteocutaneous radial forearm flap innervated by the lateral antebrachial cutaneous nerve was elevated in the forearm using a 3D template. The bony L-graft was fixed using a plate. A skin island was used to reconstruct the inner lining, the future shape of which was ensured using a titanium mesh. The "supine" new nose was externally covered with the antebrachial fascia and covered with a skin graft. In the second stage, five weeks later, the well-vascularized "neo-nose" was transferred to the face and covered with a pre-expanded forehead flap.

Free flap of the first dorsal metacarpal artery (free kite flap)

Beahm et al. used this flap for columella reconstruction after the failure of a part of the radial forearm flap [57]. The donor site can be sutured or transplanted with a skin graft, depending on the extent of the flap. The thinness and the possibility to elevate two skin islands on a single vessel (Fig. 14) are the main advantages of this flap; the negatives are represented by the very short pedicle of the first metacarpal artery and the fact that the artery is very thin (diameter of 0.5–1 mm). To acquire a larger vessel diameter, the radial artery needs to be prepared up to the anatomical snuffbox.

Fig. 13. First stage of nasal reconstruction with Chinese flaps suitable for combined defects of the lining and columella. (Source: author's photo archive).

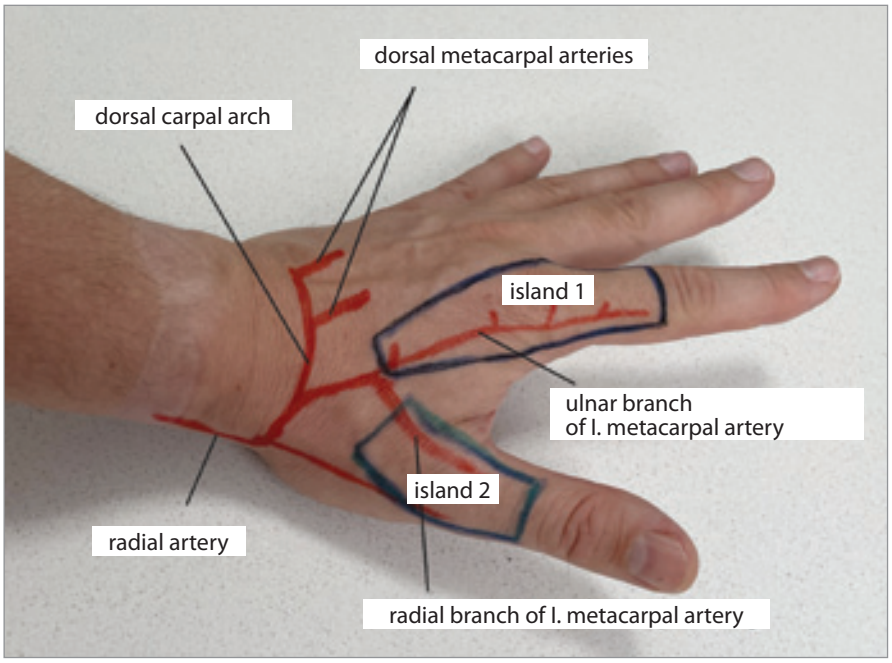

Fig. 14. Free flap of the first dorsal metacarpal artery. (Source: author's photo archive).

Dorsalis pedis free flap

The sufficiently thin skin cover is a crucial advantage of this flap [58–62]. Similar to the radial forearm flap on the forearm, the dorsalis pedis free flap can also be harvested as an osteocutaneous flap (with a part of the second metatarsal). However, there are also disadvantages when using this flap – in particular, the morbidity of the donor site with the need to cover the defect with a skin graft, which often causes problems when walking in shoes. Moreover, the collateral vascular supply to the distal limb is compromised, which can pose a problem in elderly patients.

Temporoparietal free flap

The temporoparietal free flap is flexible, thin, and well-vascularized. It reportedly perfuses the underlying calvarial grafts. Acikel et al. used this flap to cover the nose in combination with a skin graft from the supraclavicular region [63]. Although the authors achieved an acceptable nasal shape, the discoloration of the skin graft reduced the aesthetic result, compared with the outcomes of reconstruction when using the forehead flap. Still, the temporoparietal free flap is considered one of the alternatives to the radial forearm flap for reconstruction of the nasal mucosa.

Serratus anterior muscle free flap

Thomas and Harris reported a complex nasal reconstruction using a serratus anterior muscle free flap with a vascularized free rib [64]. The rib graft was anchored to the frontal bone using miniplates. The nostrils were shaped from the serratus muscle and lined with tubes enveloped with skin grafts. The graft, however, subsequently significantly contracted during healing (despite stenting) excessively narrowing the airway lumen down.

Postauricular free flap

The postauricular free flap represents a microvascular modification of the Washio technique. It was described and used by Swartz and it probably has a better vascular supply than if used in a pedicled variant [65]. The main disadvantage of this technique is the skin of the flap, which is smooth and thin, not resembling the thick sebaceous skin of the male nose.

Helix free flap

The auricular tissue was also reported to be transferred to the superficial temporal artery (Fig. 15). The full-thickness helix root is transferred to the nose as a composite free flap [66]. This method is particularly suitable for nasal wing reconstruction. Its advantages lie in the resistance to actinosis and the large diameter of the superficial temporal arteries. The main limitation, however, lies in the

maximum area of 3 × 3 cm that can be removed without disturbing the shape of the ear.

This method is particularly suitable for the reconstruction of alae. The actinic-resistant skin and large diameter of the superficial temporal vessels count among its advantages. The principal limitation lies in the maximum harvest area of 3 × 3 cm (harvesting a larger flap would compromise the shape of the ear). Zhang et al. used this technique in 63 pacients with various defects of the nose and reported very good results [67].

Free deltopectoral flap

Zhou and Cao presented a series of eight cases of nasal reconstruction using a free flap based on a cutaneous acromiothoracic arteriovenous system [68]. A skin flap of up to 8 × 9 cm can be obtained in this way. As for disadvantages, the small (1–2 mm) and short vascular pedicle of the flap, which often requires the use of vein grafts, is the main downside of this technique.

In general, we can say that there is currently a consensus that free flaps are primarily used to reconstruct the inner surfaces of the nose, and the outer nasal cover is reconstructed with a three-phase paramedian forehead flap [58].

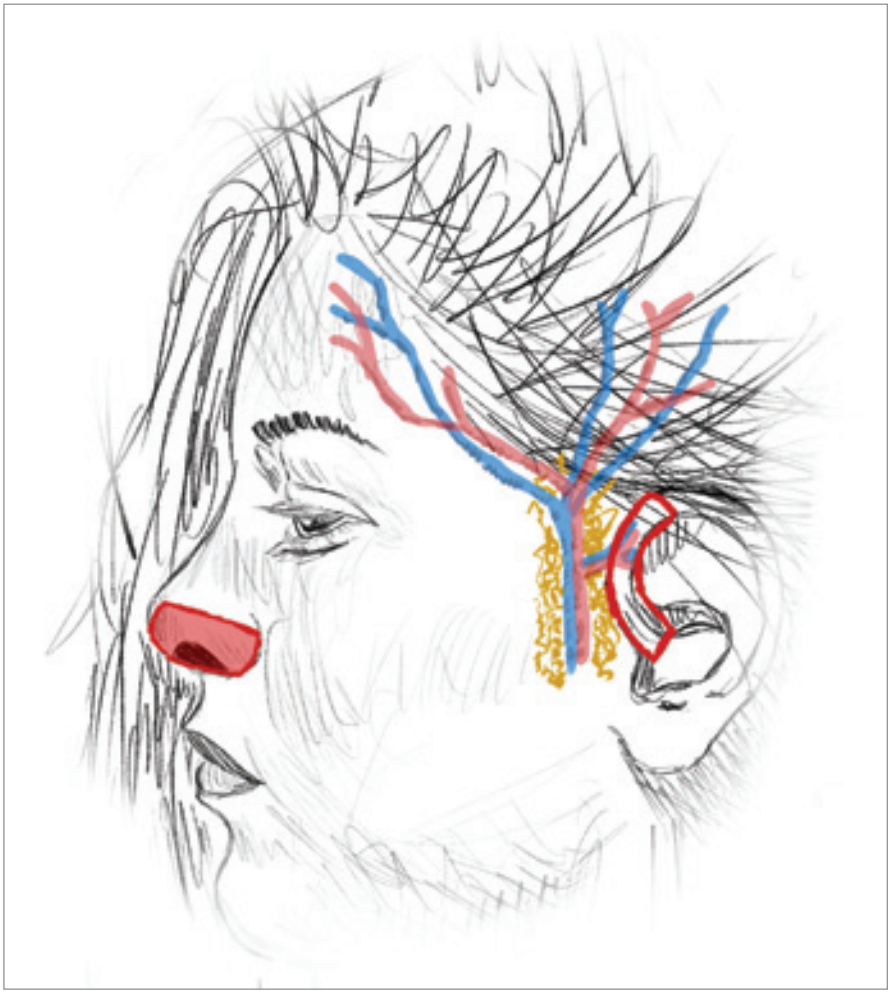

Fig. 15. Helix free flap to replace the missing nasal ala. (Drawing by A. Berkeš).

Discussion

For the reconstruction of the inner lining, the most readily available, well-nourished soft tissue should be generally used. The requirements include good vascularity, pliability, and, if possible, a sufficiently thin tissue that does not obstruct the airway. The simpler the principle and the shorter the facial scars, the better. When reconstructing large defects, free tissue transfer using a microvascular technique is often the only options [12,13].

In 1974, the eminent American plastic surgeon Millard proposed a three-stage concept of nasal reconstruction with a forehead flap [69]. In this concept, an additional step was added between the flap transfer and pedicle detachment (3 weeks after the transfer), in which the thick skin in the dorsum of the nose was thinned (by removing the frontalis muscle) and the flap was sutured back. Burget and Menick later modified this approach by omitting the initial thinning of the forehead flap before the transfer to the nasal region. This modification aimed to prevent any damage to the vascularization of the peripheral parts of the flap. In their modification, the thinning is performed only 3–4 weeks after the transfer during a necessary second surgery [7].

Of the various modifications of the forehead flaps, paramedian forehead flaps are the most commonly used. The current concept of reconstructing the skin cover of the nose with a forehead flap is illustrated in Fig. 16.

In complex nasal reconstructions, the entire external nose may be temporarily created from a free flap, which is inferior in appearance; such skin is then usually replaced with the skin of the forehead flap in the next surgical stage.

When reconstructing large defects, free tissue transfer using a microvascular technique is often the only option [12,13].

Conclusions

Even today, nasal reconstruction represents a great challenge for the reconstructive surgeon. The rich vascular supply of the face reduces the risk of ischemia, necrosis, and infection, allowing most large nasal defects to be re-

Fig. 16. Principle of three-phase nasal reconstruction with restoration of all layers of the nose and overlapping with the paramedian forehead flap thinned in the second period and with the vascular pedicle removed in the third period, before reconstruction on the left, final result on the right. (Source: author's photo archive).

constructed using local flaps. Local flaps retain ideal quality, coloration, and texture, are reliable, and usually result in esthetically acceptable morbidity of the donor area. If, however, the defect exceeds the possibilities of using local flaps, distant flaps need to be transferred, most often by free microvascular transport. The stability of the reconstructed result is directly proportional to the successful reconstruction of all layers of the nose. Reconstruction of a high-quality inner lining is an essential step in modern nasal reconstruction, allowing the exposure of additional nasal layers in complex nasal defects. Very good functional and esthetically acceptable results of nasal reconstruction can be achieved using the current concept.

Disclosure

The authors have no conflicts of interest to disclose. All procedures performed in this study involving human participants were in accordance with the ethical standards of the institutional and national research committee and with the Helsinki declaration and its later amendments or comparable ethical standards.

Funding

Supported by the internal project LF MU - MUNI/A/1610/2023.

Roles of the authors

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

References

1. Baker SR. Principles of nasal reconstruction. *Springer* 2011.
2. Menick FJ. Aesthetic nasal reconstruction. *In: Neligan PC (ed.). Plast Surg. Elsevier* 2013: 134–186.
3. Millard DR. Total reconstructive rhinoplasty and a missing link. *Plast Reconstr Surg.* 1966, 37(3): 167–183.
4. Dvořák Z., Novák P., Výška T., et al. Reconstruction of defects with forehead flap. *Acta Chir Plast.* 2015, 57(3–4): 46–48.
5. Menick FJ. Nasal reconstruction: forehead flap. *Plast Reconstr Surg.* 2004, 113(6): 100e.
6. Menick FJ. Practical details of nasal reconstruction. *Plast Reconstr Surg.* 2013, 131(4): 613e–630e.
7. Menick FJ. A 10-year experience in nasal reconstruction with the three-stage forehead flap. *Plast Reconstr Surg.* 2002, 109(6): 1839–1855.
8. Burget GC., Menick FJ. The subunit principle in nasal reconstruction. *Plast Reconstr Surg.* 1985, 76(2): 239–247.
9. Thornton JF., Griffin JR. Nasal reconstruction. *Sel Read Plast Surg.* 2006, 10(12): 1–39.
10. Bayramiçli M. A new classification system and an algorithm for the reconstruction of nasal defects. *J Plast Reconstr Aesthetic Surg.* 2006, 59(11): 1222–1232.
11. Veselý J. Plastická chirurgie pro lékařské fakulty a postgraduální výchovu. *Tisk centrum s.r.o.* 2007.
12. Veselý J., Dvořák Z., Binková H., et al. Rekonstrukce pooperačních defektů v dutině ústní a hltanu. In: Smilek P., Plzák J., Klozar J., et al. (eds.). Karcinomy dutiny ústní a hltanu. *Medicína hlavy a krku.* Tobiáš: 2015: 294–312.
13. Binková H., Hložek J., Kostřica R., et al. Volné laloky v rekonstrukci rozsáhlých defektů po onkochirurgických výkonech v oblasti hlavy a krku. *Otorinolaryngol Foniatr.* 2014, 63(2): 75–81.
14. Dvořák Z., Kubek T., Pink R., et al. Moderní principy rekonstrukce nosu. *Otorinolaryngol Foniatr.* 2018, 67(4): 100–106.
15. Argamaso RV. An ideal donor site for the auricular composite graft. *Br J Plast Surg.* 1975, 28(3): 219–221.
16. Pribaz JJ., Fine N., Orgill DP. Flap prefabrication in the head and neck: a 10-year experience. *Plast Reconstr Surg.* 1999, 103(3): 808–820.
17. Guo L., Pribaz JJ. Clinical flap prefabrication. *Plast Reconstr Surg.* 2009, 124 (Suppl 6): e340–e350.
18. Taghinia AH., Pribaz JJ. Complex nasal reconstruction. *Plast Reconstr Surg.* 2008, 121(2): 15e–27e.

19. Themes UFO. Prefabrication and prelamination. [online]. Dostupné z: https://plasticsurgerykey.com/prefabrication-and-prelamination/.
20. Menick FJ. Nasal reconstruction. *Plast Reconstr Surg.* 2010, 125(4): 138e–150e.
21. Menick FJ. Aesthetic nasal reconstruction: principles and practice. *Aesthetic Nasal Reconstruction Press* 2017.
22. Lee KK., Gorman AK., Swanson NA. Hinged turnover flap: a one-stage reconstruction of a full-thickness nasal ala defect. *Dermatol Surg.* 2004, 30(3): 479–481.
23. Millard DR. A rhinoplasty tetralogy: corrective, secondary, congenital, reconstructive. *Little Brown & Co* 1996.
24. Pribaz J., Stephens W., Crespo L., et al. A new intraoral flap: facial artery musculomucosal (FAMM) flap. *Plast Reconstr Surg.* 1992, 90(3): 421–429.
25. Bozola AR., Gasques JA., Carriquiry CE., et al. The buccinator musculomucosal flap: anatomic study and clinical application. *Plast Reconstr Surg.* 1989, 84(2): 250–257.
26. Ayad T., Xie L. Facial artery musculomucosal flap in head and neck reconstruction: a systematic review. *Head Neck.* 2015, 37(9): 1375–1386.
27. Ayad T., Kolb F., De Monès E., et al. The musculo-mucosal facial artery flap: harvesting technique and indications. *Ann Chir Plast Esthet.* 2008, 53(6): 487–494.
28. Rahpeyma A., Khajehahmadi S. Facial artery musculomucosal (FAMM) flap for nasal lining in reconstruction of large full thickness lateral nasal defects. *Ann Med Surg.* 2015, 4(4): 351–354.
29. MacArthur FJD., McGarry GW. The arterial supply of the nasal cavity. *Eur Arch Otorhinolaryngol.* 2017, 274(2): 809–815.
30. Burget GC. Aesthetic reconstruction of the nose. *In: Mathes SJ (ed.). Plast Surg Head Neck,* 2006: 573–648.
31. Burget GC., Menick FJ. Nasal support and lining: the marriage of beauty and blood supply. *Plast Reconstr Surg.* 1989, 84(2): 189–202.
32. Burget GC., Menick FJ. Nasal reconstruction: seeking a fourth dimension. *Plast Reconstr Surg.* 1986, 78(2): 145–157.
33. Millard DR. Hemirhinoplasty. *Plast Reconstr Surg.* 1967, 40(5): 440–445.
34. Westerveld GJ., Middelweerd RJ., Leemans CR. The hinged-door composite septal flap as structural support and lining of nasal reconstruction by a forehead flap. *Rhinology.* 2001, 39(1): 5–8.
35. Dvořák Z., Cheimaris A., Knoz M., et al. Three-stage paramedian forehead flap reconstruction of the nose using the combination of composite septal pivot flap with the turbinate flap and L-septal cartilaginous graft – a case report. *Acta Chir Plast.* 2021, 63(1): 6–13.
36. Baker SR. Local flaps in facial reconstruction. *Elsevier: Saunders* 2014.
37. Amit M., Cohen J., Koren I., et al. Cadaveric study for skull base reconstruction using anteriorly based inferior turbinate flap. *Laryngoscope.* 2013, 123(12): 2940–2944.
38. Vuyk HD., Versluis RJ. The inferior turbinate flap for closure of septal perforations. *Clin Otolaryngol Allied Sci.* 1988, 13(1): 53–57.
39. Kilty SJ., Brownrigg PJ., Safar A. Nasal septal perforation repair using an inferior turbinate flap. *J Otolaryngol.* 2007, 36(1): 38–42.
40. Rahpeyma A., Khajehahmadi S. Inferior turbinate flap for nasal-side closure of palatal fistula in cleft patients: technical note. *Plast Reconstr Surg Glob Open.* 2014, 2(12): e265.
41. Yip J., MacDonald KI., Lee J., et al. The inferior turbinate flap in skull base reconstruction. *J Otolaryngol Head Neck Surg.* 2013, 42(1): 6.
42. Murakami CS., Kriet JD., Ierokomos AP. Nasal reconstruction using the inferior turbinate mucosal flap. *Arch Facial Plast Surg.* 1999, 1(2): 97–100.
43. Dvořák Z., Pink R., Heinz P., et al. Rare syringoid eccrine carcinoma of the upper lip and nasal base treated with resection and subsequent innovative reconstruction using an Abbé flap, turbinate flaps and three-stage forehead flap: a case report. *World J Surg Oncol.* 2022, 20(1): 288.
44. Koshima I., Hosoda M., Moriguchi T., et al. Three-dimensional combined flaps for reconstruction of complex facial defects following cancer ablation. *J Reconstr Microsurg.* 1997, 13(2): 73–80.
45. Burget GC., Walton RL. Optimal use of microvascular free flaps, cartilage grafts, and a paramedian forehead flap for aesthetic reconstruction of the nose and adjacent facial units. *Plast Reconstr Surg.* 2007, 120(5): 1171–1207.
46. Menick FJ., Salibian A. Microvascular repair of heminasal, subtotal, and total nasal defects with a folded radial forearm flap and a full-thickness forehead flap. *Plast Reconstr Surg.* 2011, 127(2): 637–651.
47. Salibian AH., Menick FJ., Talley J. Microvascular reconstruction of the nose with the radial forearm flap: a 17-year experience in 47 patients. *Plast Reconstr Surg.* 2019, 144(1): 199–210.
48. Cannady SB., Cook TA., Wax MK. The total nasal defect and reconstruction. *Facial Plast Surg Clin N Am.* 2009, 17(2): 189–201.
49. Walton RL., Burget GC., Beahm EK. Microsurgical reconstruction of the nasal lining. *Plast Reconstr Surg.* 2005, 115(7): 1813–1829.
50. Moore EJ., Strome SA., Kasperbauer JL., et al. Vascularized radial forearm free tissue transfer for lining in nasal reconstruction. *Laryngoscope.* 2003, 113(12): 2078–2085.
51. Antunes MB., Chalian AA. Microvascular reconstruction of nasal defects. *Facial Plast Surg Clin N Am.* 2011, 19(1): 157–162.
52. Stamatopoulos C., Panayotou P., Tsirigotou S., et al. Use of free flaps in the aesthetic reconstruction of face and neck deformities. *Microsurgery.* 1992, 13(4): 188–191.
53. Pribaz JJ., Fine NA. Prefabricated and prelaminated flaps for head and neck reconstruction. *Clin Plast Surg.* 2001, 28(2): 261–272.
54. Costa H., Cunha C., Guimarães I., et al. Prefabricated flaps for the head and neck: a preliminary report. *Br J Plast Surg.* 1993, 46(3): 223–227.
55. Winslow CP., Cook TA., Burke A., et al. Total nasal reconstruction: utility of the free radial forearm fascial flap. *Arch Facial Plast Surg.* 2003, 5(2): 159–163.
56. Ahcan U., Didanovic V., Porcnik A. A unique method for total nasal defect reconstruction – prefabricated innervated osteocutaneous radial forearm free flap. *Case Rep Plast Surg Hand Surg.* 2019, 6(1): 11–19.
57. Beahm EK., Walton RL., Burget GC. Free first dorsal metacarpal artery flap for nasal lining. *Microsurgery.* 2005, 25(7): 551–555.
58. Yoleri L., Oztan Y. Total nasal reconstruction with free and local flaps: controversies and difficulties. *Ann Plast Surg.* 2000, 44(6): 687–689.
59. Ohmori K., Sekiguchi J., Ohmori S. Total rhinoplasty with a free osteocutaneous flap. *Plast Reconstr Surg.* 1979, 63(3): 387–394.
60. Shaw WW. Microvascular reconstruction of the nose. *Clin Plast Surg.* 1981, 8(3): 471–480.
61. Benmeir P., Neuman A., Weinberg A., et al. Reconstruction of a completely burned nose by a free dorsalis pedis flap. *Br J Plast Surg.* 1991, 44(8): 570–571.
62. Bayramiçli M. The distal dorsalis pedis flap for nasal tip reconstruction. *Br J Plast Surg.* 1996, 49(5): 325–327.
63. Acikel C., Bayram I., Eren F., et al. Free temporoparietal fascial flaps and full-thickness skin grafts in aesthetic restoration of the nose. *Aesthetic Plast Surg.* 2002, 26(6): 416–418.
64. Thomas WO., Harris CN. Subtotal midfacial/total nasal reconstruction following shotgun blast to the face employing composite microvascular serratus anterior rib, muscle, and scapular tip. *Ann Plast Surg.* 1997, 38(3): 291–295.
65. Swartz WM. Microvascular approaches to nasal reconstruction. *Microsurgery.* 1988, 9(2): 150–153.
66. Shenaq SM., Dinh TA., Spira M. Nasal alar reconstruction with an ear helix free flap. *J Reconstr Microsurg.* 1989, 5(1): 63–67.
67. Zhang YX., Yang J., Wang D., et al. Extended applications of vascularized preauricular and helical rim flaps in reconstruction of nasal defects. *Plast Reconstr Surg.* 2008, 121(5): 1589–1597.
68. Zhou LY., Cao YL. Clinical application of the free flap based on the cutaneous branch of the acromiothoracic artery. *Ann Plast Surg.* 1989, 23(1): 11–16.
69. Millard DR. Reconstructive rhinoplasty for the lower half of a nose. *Plast Reconstr Surg.* 1974, 53(2): 133–139.
70. Baker SR. Principles of nasal reconstruction (2nd ed.). London: Springer 2011.

Jan Menoušek, MD
KPECH FN U sv. Anny a LF MU Brno
Berkova 34, 612 00 Brno
jan.menoušek@fnusa.cz

Submitted: 3. 2. 2025
Accepted: 28. 3. 2025