Closure of Nasal Septal Perforations Using a Diced Cartilage in Fascia Graft

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Abstract

The spectrum of surgical techniques in the repair of nasal septal defects is wide. The objective of this study was to assess the feasibility of using a diced cartilage in fascia (DC-F) graft for successful closure of nasal septal perforations and to evaluate symptom reduction. This was a retrospective study of 18 patients undergoing surgical repair of symptomatic nasoseptal perforations of different etiologies using a DC-F graft from 2020 until 2021. The procedure was feasible in all of the 18 patients. Reconstruction of septal defects with a DC-F graft led to reduction of crust formation, reduction of epistaxis, and improvement of nasal breathing in 13 out of the 18 patients when seen for their 2-month follow-up. Reperforation occurred in three cases, leaving defects of 1, 7, and 5 mm in diameter. In one case, the reperforation was symptomatic. A DC-F graft proved to be a reliable and reproducible method for the closure of nasoseptal perforations of variable sizes, of different locations, and of different etiologies.

Keywords
- costal cartilage
- nasal septal perforations
- rhinologic procedures
- diced cartilage
- fascia graft

Even though the prevalence of nasoseptal perforations has decreased, therapeutic approaches for closure are repeatedly in the focus of research. For a long time, closure of nasoseptal defects has seemed like squaring the circle as countless methods have been attempted and described. As early as 1929, Jackson recommended enlarging small perforations in order to reduce whistling and crusting by moving the posterior edge of the defect farther posterior where humidification of the inhaled air is higher.[1] In the following decades, ear nose throat (ENT) and plastic surgeons described intranasal muco (perichondrial) flaps, including rotational and advancement mucosal flaps (combined with reduction rhinoplasty) as well as lateral nasal wall and inferior turbinate flaps.[2–4] Due to the shortage of nasal mucosa in large perforations, multistage labial sulcus flaps combined with skin grafts were suggested.[5–7]

Also, there exist advocates of external rhinoplasty and midfacial degloving, approaches that allow complete exposure of the septum and enable different repair options.[2,8] Moreover, nonsurgical methods such as customized obturator buttons have been described and are still in use today.[9,10] At about the same time, connective tissue autographs and their combination with local mucosa flaps have been experimented with, including free septal, auricular and costal cartilage grafts, vomerine bone, and mastoid periosteum.[2,3,11] It was in 1980 that Fairbanks introduced temporalis fascia for septal reconstruction, a graft offering various amenities, especially when combined with cartilage.[12,13] When in 2000 diced cartilage was brought back into use by the work of Erol and his colleagues, diced cartilage in fascia (DC-F) grafts became an essential tool in corrective rhinoplasty.[14–17] However, DC-F grafts have not yet been used for closure of septal perforations.

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Even though the surgical toolbox seems limitless, every approach has its pitfalls, and we are still facing difficulties including flap ischemia, nasal obstruction due to the volume of the graft, as well as remaining or reperforations with loss of support and saddling of the nose, necessitating revision surgery. Many patients wearing septal prostheses complain of discomfort, crusting, and movement of the button and finally ask for surgical closure. Having in mind the positive characteristics of a diced or crushed cartilage in fascia graft as proven on extranasal application (no limitations due to graft size or thickness, no absorption due to foreign body reaction, and sufficient stability, independent of a vascular pedicle), we believe that this might also be an adequate procedure for the closure of septal defects.

In the following, we describe and prove the feasibility of closing septal perforations in what we call the "German ravioli technique" on 18 patients from three cooperating institutes.

Materials and Methods

In cooperation with the otorhinolaryngology departments of three hospitals, we performed surgical repair of nasoseptal perforations using either an autogenous diced cartilage combined with human fibrin glue or crushed cartilage in fascia graft (DC-F) in 18 patients from 2020 until beginning of 2022. We included patients independent of the size and site of the defect. When an inflammatory etiology was suspected, a histopathologic exam of the septal mucosa was performed to rule out specific inflammatory processes such as granulomatosis with polyangiitis. These cases were excluded from our study as well as patients having undergone radiation including the midface or nasal region. Patients mainly presented with crust formation, recurring epistaxis, and nasal blockage. In some of the cases, cartilaginous and/or osseous nasal deformity was present in addition to the septal pathology. The group consisted of nine males and nine females with a median age of 43.9 years and age range from 24 to 73 years. For further patient characteristics see ►**Table 1**.

Preoperative

Using nasal endoscopy, the defect was measured in its antero-posterior and cranio-caudal dimensions and classified as small (up to 1 cm diameter), medium sized (1 to 2 cm diameter), and large (more than 2 cm in diameter).[18] The site of the defect was documented according to the commonly used anatomic areas I to V.[19] Additionally, further information on previous treatment measures (nasal irrigation, moisturizing, and occlusion) or previous surgery involving the nose, paranasal sinuses, and midface was obtained. Potential risk factors such as previous and ongoing nicotine abuse and impaired wound healing due to medication and/or systemic disease were documented. After presenting the technique to be used in detail, informed consent was obtained, specifically clarifying the experimental character of the method as well as determining the surgical approach and donor site for the fascia (temporalis fascia or fascia lata) and cartilage grafts (auricular, septal, or costal; see ►**Table 2**). In patients with a low hairline or long hair temporalis fascia was preferred due to cosmetic reasons. Preference was independent of the size of the graft needed for septal repair.

Intraoperative

The procedure was performed under general anesthesia as an inpatient procedure. Generally, an endonasal approach was chosen and all relevant septal pathologies were corrected. However, when relevant deformity or deviation of the external nasal framework needed to be addressed, an open rhinoplasty approach was performed. Either a right-sided transfixion incision or a transcolumellar inverted-V-incision (combined with an intercartilaginous incision) was used. Via upper and lower tunneling, the mucoperichondrium was dissected from the underlying cartilage to expose the septal defect. This design facilitated a correct placement of the graft.

Depending on the patient's hairline position, the fascia graft was harvested either in the temporal or the distal lateral thigh region as reported several times.[20–22] The cartilage graft was harvested either from the posterior septum, the auricular region, or the rib as described previously[23–26]. Dicing or crushing of the cartilage was performed as recommended in previous publications and blended with human fibrin glue.[27–29] The diameter of the cartilage dices measured about 1 to 1.5 mm. The crushed cartilage segments were adapted to the individual septal defect. The strip of fascia was folded into the form of a pad. This pad was filled with the diced or crushed cartilage in fibrin glue, resembling a "ravioli." The amount of cartilage used corresponded to the diameter of the defect in order not to produce obstruction. The open sides of the fascia graft were closed by a continuous suture with 5.0 Vicryl or 6.0 Prolene. The obtained DC-F pad graft was then placed into the defect with a fascia overlap of approximately 5 mm and fixed on to its edges in an underlay technique using 5.0 or 6.0 Vicryl or 4.0 Monocryl mattress sutures penetrating two layers of fascia and two layers of mucoperichondrium at the edge of the defect (see ►**Fig. 1a–d**).

Finally, individually adapted septal splints were placed on either side, ensuring full coverage of the graft on all sides (see ►**Figs. 2a–d** and **3a–d**). They were fixed with mattress sutures. The used incisions were closed in the usual manner. We used hemostyptic gelatin tampons (Gelita by B. Braun Melsungen AG) for nasal packing.

Postoperative

The procedure was performed as an inpatient procedure. Analgesics were administered following the departments standard protocol. In our institute, no prophylactic antibiotic therapy was conducted. In the cooperating hospitals, patients were started on prophylactic antibiotic therapy with either ampicillin/sulbactam 3 g or ceftriaxon 2 g intravenously while hospitalized, continued orally with amoxicillin/clavulanic acid 875/125 mg or cefuroxim 500 mg after dismissal for a duration of 7 days in total. The drainage from the lateral thigh and the thoracic region was removed after 2 days. The gauze swabs on the auricle were removed after 5 days. Patients were specifically counseled on nasal irrigation using saline solution and moisturizing measures using soft nasal ointments. Also, we

Table 1 Patient characteristics

Patient	Age	Sex	Etiology	Symptoms	Previous surgery	Risk factors
1	51	f	Decongestive NS	Epistaxis, crusts, blockage	None	Diabetes mellitus, 10py nicotine
2	32	m	Iatrogenic	Epistaxis, crusts, blockage	Septoplasty, nasal bone reposition	Colitis ulcerosa, MTX
3	25	f	Frequent cauterization	Epistaxis, crusts, blockage	None	None
4	24	m	Iatrogenic	Crusts, blockage	Septoplasty, FESS	None
5	25	f	Unknown	Blockage, saddle nose	None	None
6	51	m	Posttraumatic iatrogenic	Blockage	Undetermined procedure involving the nose	Factor-V-Leiden
7	58	m	Iatrogenic	Blockage crusts	Rhinoplasty septal prosthesis	Diabetes II, coronary bypasses
8	35	m	Iatrogenic	Blockage, epistaxis	Septoplasty	None
9	73	m	Iatrogenic	Blockage, crusts, epistaxis, whistling sound of breath	Septoplasty	None
10	56	f	Unknown	epistaxis	None	None
11	34	m	Posttraumatic	Blockage, epistaxis saddle nose	None	None
12	33	f	Posttraumatic iatrogenic	Blockage, crusts, epistaxis	None	None
13	55	f	Unknown rhinitis sicca	Blockage	None	None
14	47	f	Unknown	Blockage	None	None
15	29	f	Iatrogenic	Crusts	Septoplasty	None
16	33	m	Unknown	Epistaxis	None	15py nicotine
17	58	f	Privinism	Crusts, epistaxis	None	Diabetes II
18	71	m	Iatrogenic	Crusts	Septoplasty	None

recommended temporary partial or complete nasal occlusion using a semipermeable 3M Micropore fleece tape (3M, St. Paul, Minnesota,) as previously published by Wirsching et al.[30] The sutures or skin staples in the harvesting site were removed after 7 to 10 days in the auricular and temporal region as well as after 10 days in the lateral thigh and the thoracic region. The septal splints were removed after an interval von 20 to 49 days (mean of 33.1 days), depending on the postoperative aspect of the graft.

Results

The procedure was feasible in all of the 18 patients and was performed by four surgeons with comparable skill levels and experience in rhinologic procedures (two surgeons being chief of department and two being experienced ENT, head and neck attendings). The operating time ranged from 80 to 145 minutes. No relevant postoperative complications, necessitating acute revision surgery resulting from (septal) hematoma, abscess formation, or postoperative bleeding, occurred. Analgetic medication following standard protocol was sufficient. Most of the patients merely complained of nasal blockage due to swelling of the mucosa, the gelatin tampons, and the splints. When patients were dismissed, they were again counseled on postoperative care using nasal irrigation to clean out mucous and the gelatin tampons, moisturizing soft nasal cremes, and protection measures for the fascia and cartilage harvesting site. The sutures in the harvesting sites (auricular, temporal, and thoracic region) were to be removed by the patients general practitioner. The fascia and cartilage harvesting sites in all patients showed good wound healing with cosmetically acceptable scarring.

First follow-up was set 7 to 10 days after dismissal. The remaining gelatin tampons and the septal splints were removed after 20 to 49 days after surgery (mean 33.1). After splint removal, subsequent follow-up intervals were set to 3, 6, 9, and 12 months postoperatively (see ►**Figs. 4a, b** and **5a–c**).

In all cases, at first follow-up endoscopy showed vital grafts and complete closure of the septal perforation, even in the subtotal defect in patient 3. After the splints were removed and the nasal cavity was cleaned, all patients reported comfortable nasal breathing. The volume of the graft did not seem to disturb the nasal airflow. However, in three patients (patient 3, 4, and 9), a septal reperforation has occurred over time. In patient 3, a perforation of 7 mm in diameter was observed when seeing her for second follow-up and splint removal 20 days postoperatively. In this case, the remaining graft itself was vital but must have

Table 2 Surgical specifications

Patient	Defect size (cm)	Defect localization (area)	Surgical approach	Splints (days)
1	1 × 1	II–III	Open	20
2	4 × 4	II–V (complete cartilaginous septum)	Closed	20
3	0.8 × 0.8	I–II	Closed	20
4	1 × 1	II–III	Closed	20
5	2.5 × 2.2	II–III	Open, combined rhinoplasty	25
6	1 × 1	I–III	Open, combined rhinoplasty	42
7	3 × 4	II–IV	Open, combined with nasal valve reconstruction	42
8	3 × 4	I–III	Open, combined with nasal tip graft	42
9	1 × 1	II–III	Closed	21
10	2 × 1.5	II–III	Closed	49
11	2 × 1	II–III	Open, combined rhinoplasty	36
12	4 × 2	II–III	Open, combined rhinoplasty	39
13	0.5 × 0.5	I–II	Open, combined rhinoplasty	47
14	2 × 1	II–III	Closed, septal exchange	42
15	1.8 × 1.2	II–III	Closed	21
16	4 × 4	II–IV	Closed	28
17	1 × 1	II	Closed	21
18	1.5 × 2	I–II	Closed	42

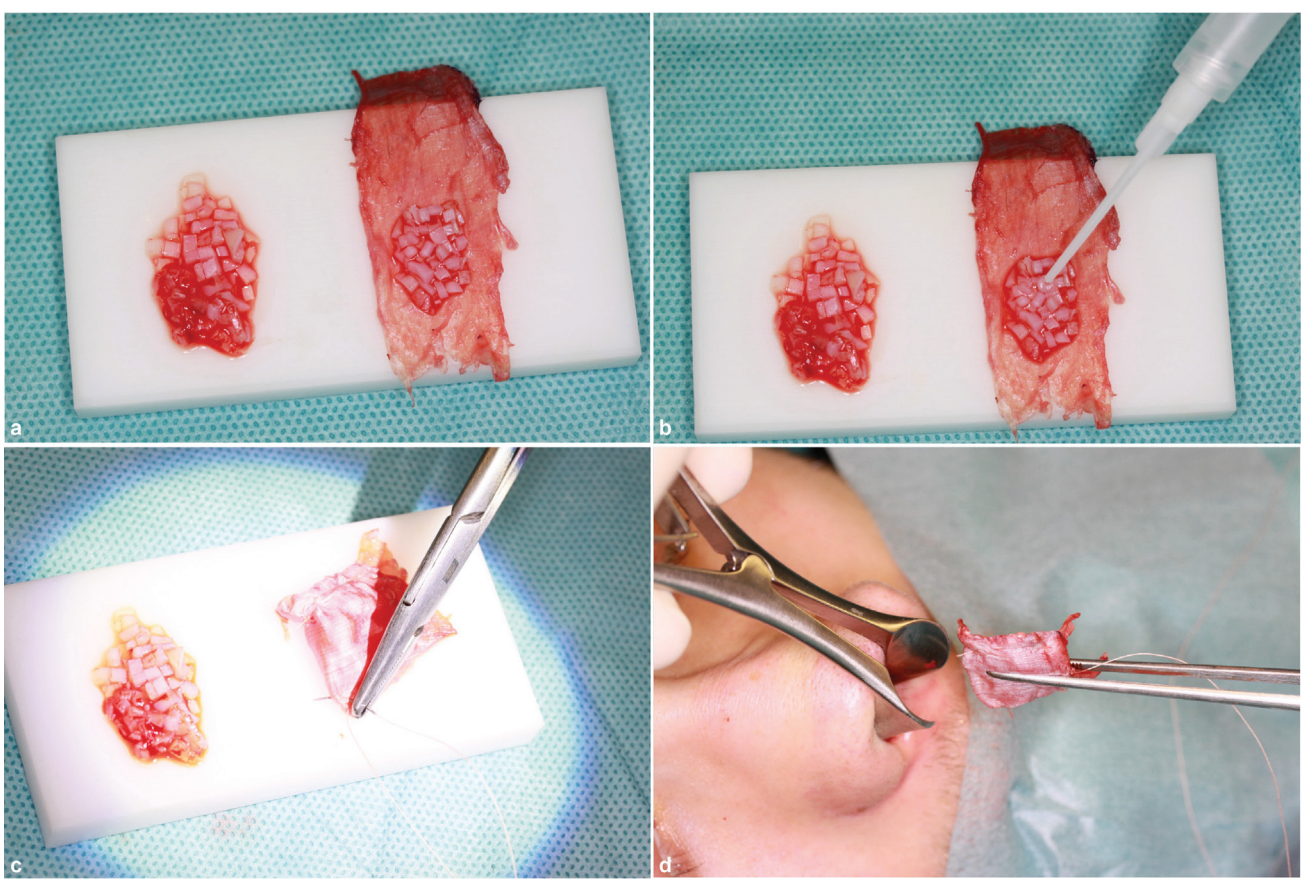

Fig. 1 (**a**) Diced cartilage. (**b**) Diced cartilage in fascia with fibrin glue. (**c**) Suturing of the DC-F graft ("ravioli"). (**d**) Placing of the DC-F graft.

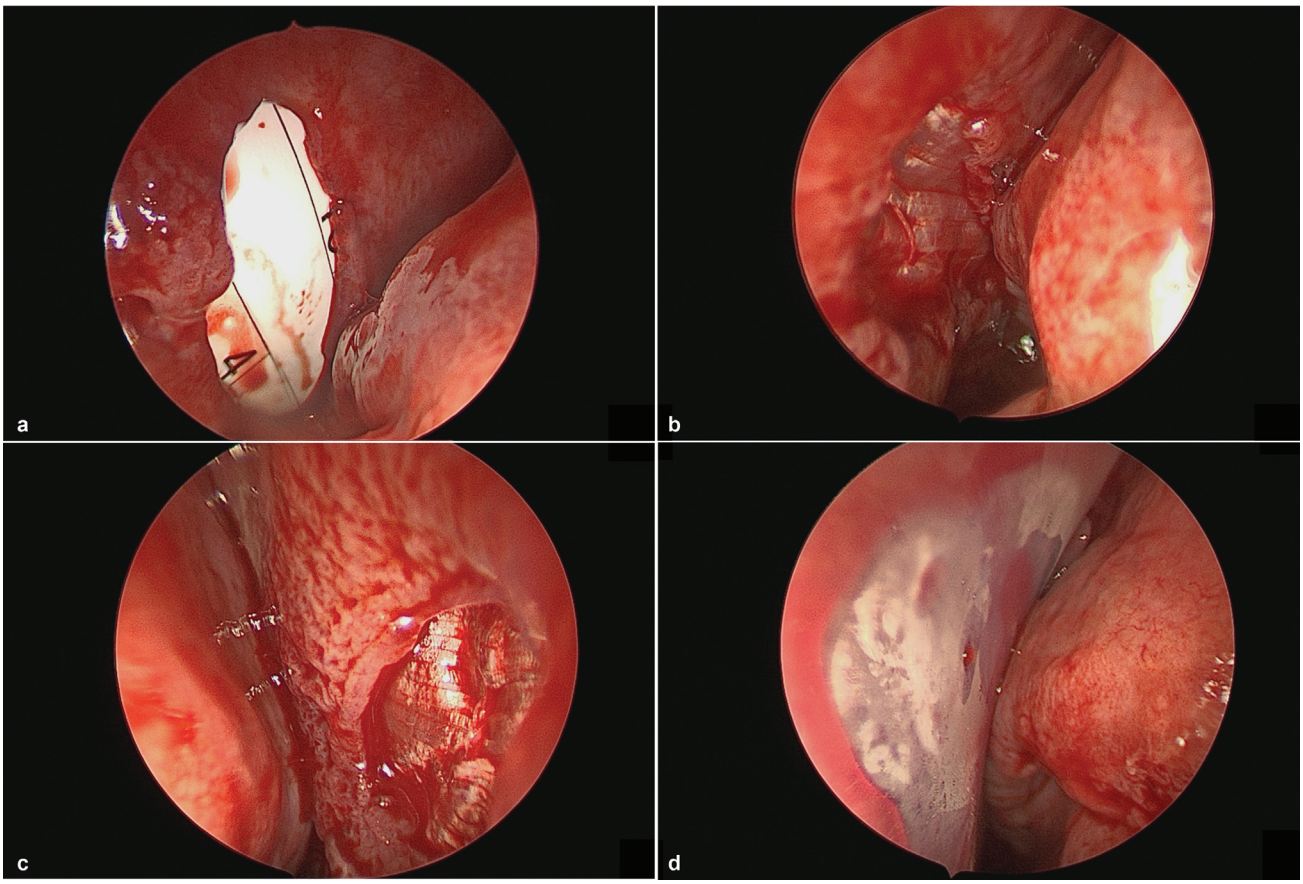

Fig. 2 (patient 4). (**a**) Septal defect in area II–III (*left lateral view*). (**b**) DC-F graft (*left lateral view*). (**c**) DC-F graft (*right lateral view*). (**d**) Septal splint covering the graft.

detached from the fragile cranial edge of the initial defect zone which had already shown advanced mucoperichondrial atrophy before surgery. We will further follow-up in this case and potentially consider revision surgery depending on the symptoms. On the 3-months follow-up of patient 4, a reperforation of less than 1 mm in diameter was observed in the posterior septum, the graft being vital and showing no signs of infection. The patient has not reported any symptoms so far. Also, in this case, we will further follow-up to evaluate a potential progression of the defect size and reoccurrence of symptoms.

In patient 9, a bulging in the lower portion of the DC-F graft was observed underneath the splints on the 1-week follow-up after surgery. When the splints were removed after 21 days, the cranial portion of the graft was still attached. However, the cartilaginous part (in this case crushed septal cartilage without fibrin glue) had presumably slipped off to the nasal floor, leaving the abovementioned bulge in the inferior portion. When seen again 6 weeks later, a reperforation of 5 mm in diameter had occurred in the cranial portion of the graft. Obviously, the mattress suture was not stable enough to hold the cartilaginous part of the graft in place. In addition, as according to the surgical procedure report, the overlap of the DC-F graft was less than 5 mm in the cranial portion, which may be ultimately responsible for its detachment. Revision surgery is planned due to the reoccurrence of symptoms.

So far, we can conclude that reconstruction of septal defects with a DC-F graft leads to long-term reduction of crust formation and reduction of epistaxis in 16 out of the 18 patients when seen for their 12-month follow-up. Also, all 16 of these patients report significant improvement in nasal breathing. Only in two out of three patients, the reperforation became symptomatic over time.

Discussion

When addressing nasoseptal perforations, one is confronted with several problems and tasks.

First, in the narrow space of the nasal cavity, the radius of operation is limited which requires a surgeon's dexterity and attention to detail, especially in placing and suturing delicate pedicled flaps or grafts of any sort. This may be one of the reasons for the high variability in the success rates of closing septal defects.

Against the common view, in 1994, Meyer claimed that with his two techniques that he would reliably close defects of any size.[11] Depending on the size and localization of the defect, he performed either a one-step procedure including bi-pedicled mucoperichondrial advancement flaps or a three-step procedure including a composite buccal flap. In 52 out of 55 patients, perforations, including those over 4 cm in diameter, were closed successfully. However, the sole use

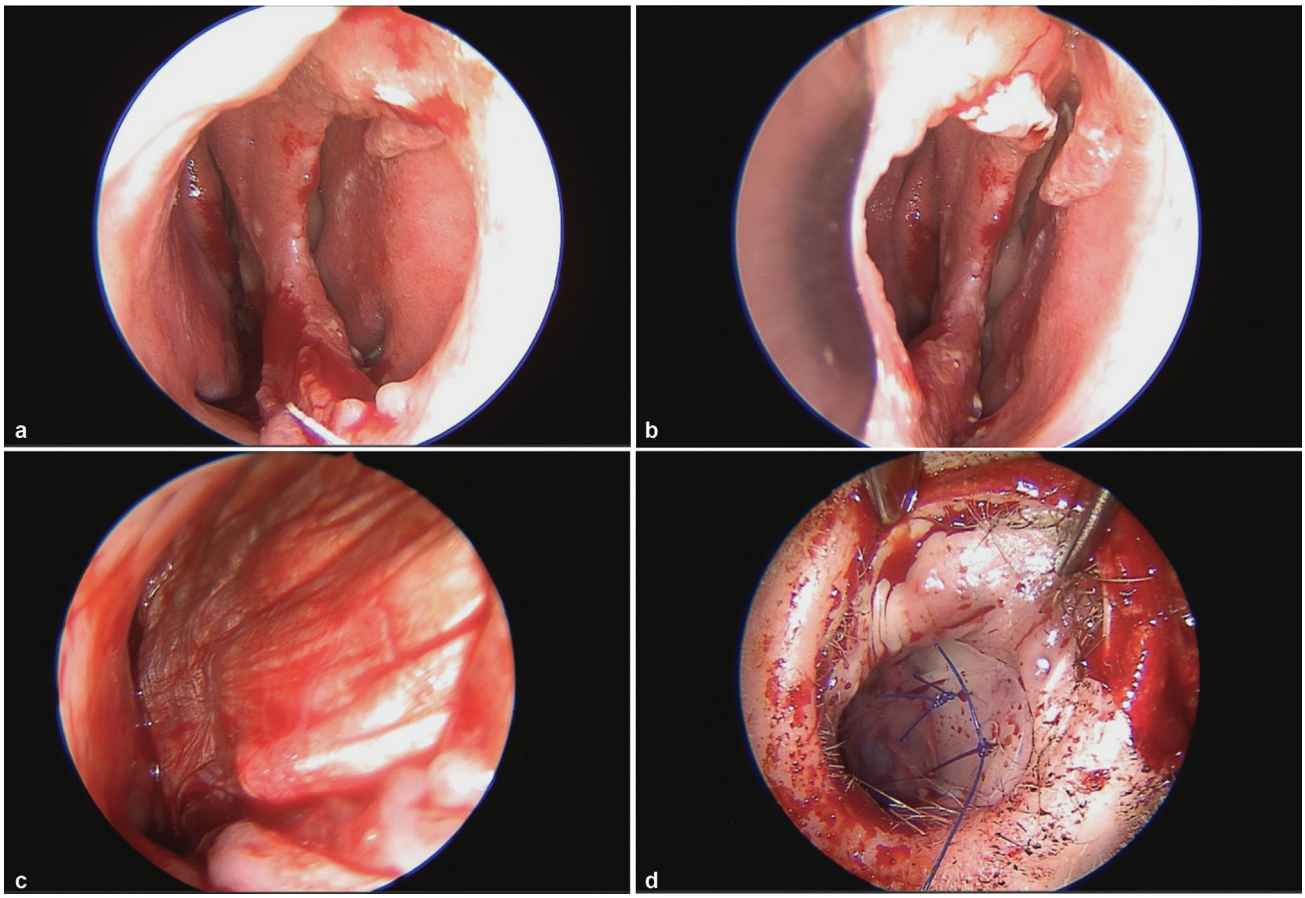

Fig. 3 (patient 7). (**a**) Septal defect in area II–IV (*right lateral view*). (**b**) Septal defect in area II–IV (left lateral view). (**c**) DC-F graft (*right lateral view*). (**d**) Septal splint covering the graft.

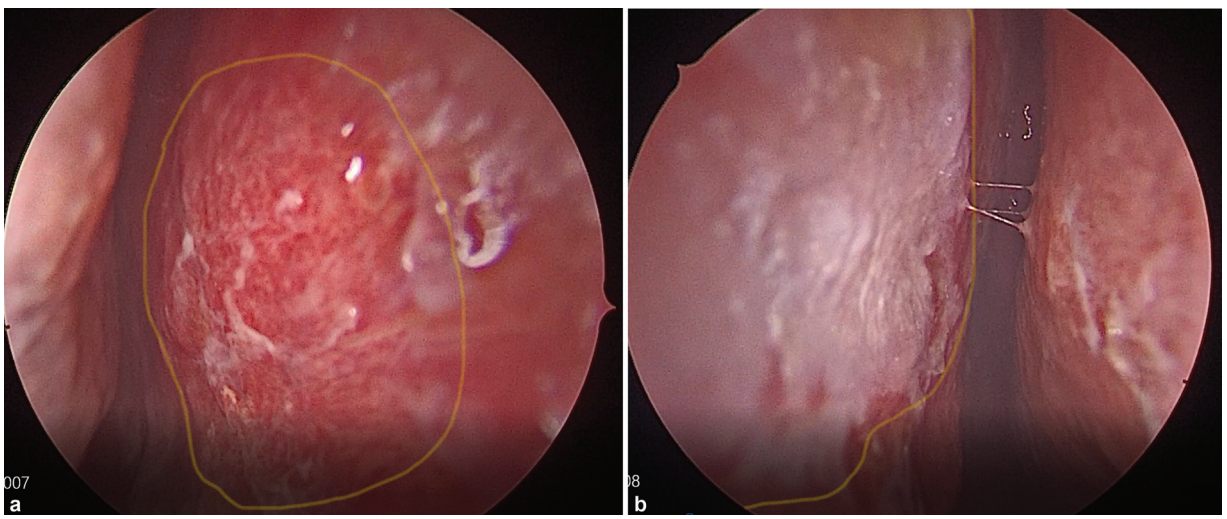

Fig. 4 (patient 5). Graft region marked in yellow. (**a**) Follow-up endoscopy right lateral view (6 months after surgery). (**b**) Follow-up endoscopy left lateral view.

of any local intranasal tissue is prone to flap ischemia due to tension on the suture lines in the margins of the defect zone, resulting in reperforation over time. Moreover, many of these procedures are multistep procedures requiring general anesthesia and hospitalization each time, reducing patient comfort. Accordingly, interpositional grafts (materials that are placed in between two mucosal flaps) have proven to act as an interface for vascular ingrowth and mucosal repair.[31,32] Contrary to the traditional model of wound healing, fascia has the exceptional ability to provide a matrix for revascularization and regeneration of original tissue in a wound area.[33] This approach allows the advancement of regenerated ciliated mucosa across imperfections in the repair zone instead of replacing it with collagenous scar tissue. For

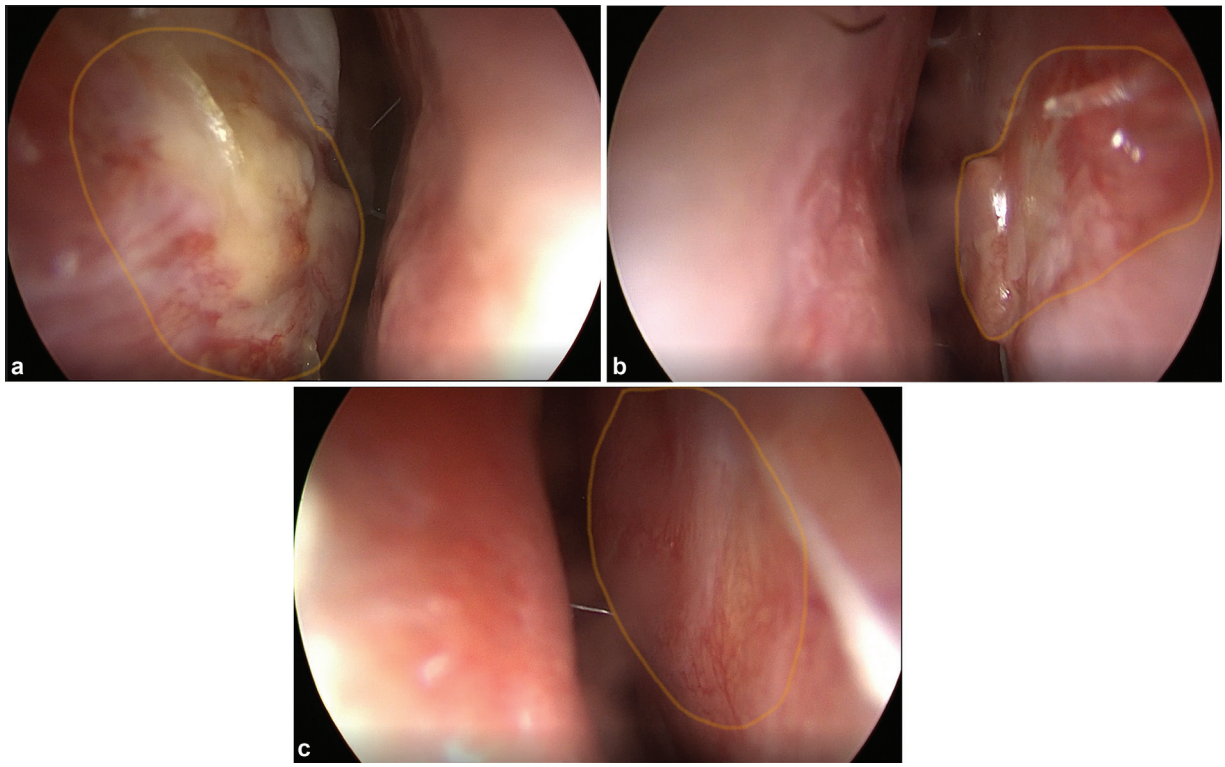

Fig. 5 (patient 18). Graft region marked in yellow. (**a**) Follow-up endoscopy right lateral view (3 months after surgery). (**b**) Follow-up endoscopy left lateral view. (**c**) Follow-up endoscopy right lateral view (6 months after surgery).

decades, there has been disagreement on the role of cartilage in nasoseptal repair. The general opinion was that adding cartilage would not contribute to the stability of the repair if both mucoperichondrial layers were intact. Today, it is commonly understood that the use of cartilage in septal defects increases stability in any repair technique and reduces the risk of reperforation. As observed in patient 9, where the cartilaginous component of the graft had detached, leaving a mere double layer of fascia, re-perforation reoccurred in exactly this area 6 weeks after splint removal. This underlines the importance of adding cartilage to the graft.

In their work, Toriumi and colleagues successfully use costal perichondrium as an interpositional graft, emphasizing its strategic role when septal defect reconstruction is combined with rhinoplasty.[32] In our opinion, in patients with a need for moderate to none correctional measures on the septum or exterior nasal framework, one would avoid harvesting cartilage or perichondrium from the coastal region due to higher donor site morbidity (more painful, more obvious scarring) and associated risks (pneumothorax). Only in 1 patient (patient 5) costal cartilage was necessary to ensure sufficient graft material for all pathologies (closure of large septal defect, septal extension, augmentation of the dorsum, and augmentation of the supratip break).

Second, understanding the complexity of nasoseptal defects is crucial to their successful closure. The repair requires stability in order to support the soft tissue and cartilaginous framework of the outer nose and it must sustain the continuous airflow through the nasal cavity while not impairing it and must not interfere with maintaining the intranasal environment.

Looking back at many years of experimentation with fascia and cartilage grafts for different kinds of indications in the nasal region, their advantages as compared to standalone local intranasal flaps become again apparent in this context. With its low vascular requirements and its framework for fibroblast growth, fascia is a viable graft.[34] In combination with cartilage, volume and stability are increased. In 1997, Hussain and Murthy published their work on a modified tragal cartilage-temporoparietal and deep temporalis fascia sandwich graft claiming a 100% success rate in closing defects up to 4 cm in diameter.[13] The limitations to their technique are the defined size of tragal cartilage, the thickness, and the low malleability of the graft possibly impairing intranasal airflow.

In order to address the limitations of a full-thickness cartilage graft (either coming from the septal, auricular, or costal region), diced cartilage grafts have been investigated for soft-tissue reconstruction since the mid-20th century.[35–37] In the following decades, however, the method had been abandoned, until brought back to our attention by the results published by Erol in 2000.[16] It was assumed that significant absorption of the diced cartilage in the preantibiotic era and the trend to allograft materials might have been the reason for the draw back.[38] In 2003, Daniel and Calvert showed that the absorption of cartilage can be prevented by wrapping it into a sleeve of autogenous fascia.[17] Meanwhile, the diced cartilage in fascia graft (often combined with human fibrin glue) has become a standard

surgical procedure, especially in relining and smoothing of the nasal dorsum or in revision rhinoplasty.[14,15,39] We have used crushed instead of diced cartilage in three of our patients. In two of these patients, reperforation has occurred over time. Histopathologic studies have shown that crushing of cartilage compromises chondrocyte viability to a greater extent than dicing.[40,41] We agree with other works that dicing the cartilage, adding fibrin glue, and wrapping it in fascia is crucial for graft survival in this method. In this context, we used cartilage dices of approximately 1.0 to 1.5 mm in diameter due to their high viability and stability as shown by experimental work of Dong et al.[42]

Third, to restore the integrity of the septum using a free graft, wound healing and graft survival are the most important factors.

The approach of leaving the splints for the abovementioned intervals follows the principle of reducing air flow along the septal repair. This results in a significant reduction of crust formation as well as less vascular trauma, caused by a strong airflow, allowing better restoration of the intranasal lining. The principle has been shown in previous studies on patients with hereditary hemorrhagic telangiectasia where nasal occlusion creates a humid and warm chamber.[30] It is hypothesized that the healing after tympanoplasty using the cartilaginous palisade technique follows the same mechanism.[43] However, we cannot give any recommendations on a definite time interval for keeping the splints in place since some of our follow-up intervals are yet too short to evaluate for long-term results. As demonstrated by Bertlich et al, a 4-week interval of septal splints seemed to have been sufficient to ensure graft viability. However, again, the follow-up interval in their clinical trial has been rather short to allow for a direct conclusion on long-term success rates.[44] Furthermore, the patient number in this study is too small to allow reliable conclusions. Also, the study design is not intended to compare the three small patient groups from three institutes. So far, we can report about successful closure and good healing of the graft after 12 months in 11 out of 14 patients. In this context, longer follow-ups using the same follow-up method (e.g., videoendoscopic visualization of the graft) over defined time intervals will provide a more realistic statement on the success rate of nasoseptal closure.[45]

Furthermore, one must consider that any synthetic material may be the substrate of selective bacterial growth causing inflammatory processes that might impair wound healing. The current Sk2 guideline on functional and aesthetic rhino surgery gives no general recommendation on perioperative systemic antibiotic therapy. Elimination or prevention of bacterial growth in the nasal cavity may imbalance the physiological mucous membrane flora causing selective overgrowth of facultative pathogenic bacteria. This is the reason why our institution dispensed from perioperative systemic antibiotics. At our cooperating institutes antibiotic therapy was administered a priori because septal splints were kept in place for longer time intervals. In our experience, in patients with hereditary hemorrhagic telangiectasia where splints may be left for an even longer period (even more than 6 weeks) to prevent recurrent epistaxis prophylactic antibiotic therapy is not necessary. The necessity of this regime should be discussed in further studies.

Finally, our experience from these cases shows that it is crucial to ensure a sufficient size of the harvested fascia in order to ensure a tension-free suture. As shown by Calvert and Kwon, the fascia graft tends to shrink over time.[22] In accordance with our patient collective the overlap of the DC-F graft over the edge of the defect zone should not be any less than 5 mm to facilitate a stable suture. This may be especially true in cases of large perforations and advanced atrophy in the edge area as observed in patient 3.[22] Also, reperforation seems to occur especially in the portion of the graft lacking cartilage. It is our understanding that it is the cartilaginous portion of the graft providing stability for the fascia. The fascia itself serves as a framework for fibroblast growth from the surrounding mucoperichondrium and as a durable attachment for the graft.[34] In patient 9, the crushed cartilage had slipped off to the nasal floor with the fascia still being attached to the cranial edge of the defect zone. Over time reperforation occurred in the cartilage-free portion of the graft. A common factor of all three cases of reperforation was the iatrogenic etiology of the initial nasoseptal defect. This may explain the atrophic nature of the mucoperichondrium and its high vulnerability to suture dehiscence. Also, all three defects were localized in the anterior septum, an area prone to high turbulences in the nasal airflow a priori.

Conclusion

A DC-F graft following the "German ravioli" technique proved to be a reliable and reproducible method for the closure of nasoseptal perforations of variable sizes of different locations and of different etiologies. Patient age, previous surgery, and comorbidity do not appear to influence the outcome of the procedure significantly. A sufficient size of the DC-F graft with a minimum overlap of 5 mm allowing a tension-free fixation within the defect seems to be crucial. Also, dicing of the cartilage seems to be superior to crushing. Adding fibrin glue not only improves graft survival but also optimizes adherence of the cartilaginous portion within the fascia sheets. However, due to the small number of cases and relatively short postoperative observation period, the results should be considered preliminary. Further studies should be performed to evaluate long-term results on a larger patient collective.

Conflict of Interest
None declared.

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