



Endoscopic repair of septal perforation in children

Rusetsky Yuriy^a, Mokoyan Zhanna^{b,*}, Meytel Irina^a, Spiranskaya Olga^a, Malyavina Ulyana^a

^a Federal State Autonomous Institution "National Medical Research Center of Children Health". Moscow, Lomonosov Avenue, 2, 119991, Russia

^b Federal State Autonomous Educational Institution of Higher Education I.M. Sechenov First Moscow State Medical University of the Ministry of Health of the Russian Federation (Sechenov University), Moscow, Trubetskaya Street, 8, 119048, Russia



ARTICLE INFO

Keywords:

Nasal septal perforation
Pediatric otorhinolaryngology
Endoscopic rhinosurgery
Repair of septal perforation
Septal perforation in children

ABSTRACT

Objective: Being increasingly faced with the problem of pediatric nasal septal perforations, we have found that the surgical management of nasal septal perforations in children is not widely described in the literature. The objective of our study was to demonstrate the results of different surgical techniques, including two original endoscopic techniques, in the septal perforation repair in children.

Methods: 24 children, ranging between 6 and 17 years of age, with nasal septal perforations were operated using different endoscopic techniques from February 2015 to May 2019 at the special tertiary referral clinic. Apart from well-known techniques, such as anterior ethmoidal artery flap, intranasal bipedicle advancement flap, sublabial flap, free temporal fascia graft, we used two original techniques – inverted edges technique and cross-septal returned flap.

Results: The total rate of complete perforation closure was 79% (19 of 24 patients). Regarding the reduction of symptoms, the efficacy of surgery was approaching 100%.

The combination of inverted edges technique and anterior ethmoidal artery septal flap demonstrated the best results with no reperforations in all 10 cases. Using cross-septal returned flap, we achieved complete closure of perforation in 5 (83%) of 6 patients. The remaining techniques were performed rare and showed relatively low rates of success. There were 2 cases of complications (oronasal fistula), both developed in patients with sublabial mucosal flap.

Conclusion: Use of endoscopic assistance, vascularized mucoperichondrial flaps and bilateral closure demonstrates high effectiveness in septal perforation surgical repair in children.

Level of evidence: 4.

1. Introduction

While surgical management of nasal septal perforations is relatively well described in adult literature, pediatric publications are rather limited.

According to the literature, this pathology in children is mostly mentioned in the context of complications of nasal foreign bodies, in particular – batteries [1–3]. On the other hand, very few publications about surgical repair of septal perforations in children are available [4–6]. Furthermore, there are some published case series involving children together with adults [7].

Specific features of pediatric surgical repair of septal perforations have not been well established yet. The appropriateness and the optimal age for surgery and the most effective surgical technique are not clearly defined.

Furthermore, surgical treatment outcomes in children with septal

perforations are still controversial. According to few available publications, the effectiveness of this surgery in children is obviously less than in adults [5,6].

At the same time, surgical repair of septal perforations in adults is undergoing revival due to active use of endoscopes. Most of the new techniques and reports on the effective surgical repair of septal perforations refer to endoscopic approaches for dissection and adjustment of vascularized flaps [8–11].

Such an approach seems to be very promising due to its less invasiveness in pediatric practice. Moreover, the use of endoscope improves visualization and facilitates manipulations of surgeons in narrow children nasal cavities. Pediatric otorhinolaryngologists have not yet started extensive using of endoscopes for this field of surgery, probably due to intrinsic conservatism.

We successfully use endoscopic approaches for septal perforation surgical repair in children and report our experience with an assessment

* Corresponding author.

E-mail addresses: rusetski@inbox.ru (R. Yuriy), god_zhan@mail.ru (M. Zhanna).

<https://doi.org/10.1016/j.ijporl.2019.109817>

Received 16 September 2019; Received in revised form 9 December 2019; Accepted 10 December 2019

Available online 13 December 2019

0165-5876/ © 2019 Elsevier B.V. All rights reserved.

Table 1
List of patients.

Case	Age at the time of surgery	Sagittal diameter, mm	Vertical diameter, mm	Area, sq mm	Cause	Symptoms	Surgical technique	Follow-up (months)	Outcome
1	10	5	3	11.8	Probably because of nose-picking	Whistling, nasal obstruction	Bilateral IBAF	37	No perforation and no complaints
2	17	10	7	55	Probably because of decongestants	Nasal obstruction	IBAF + SLF	36	Residual perforation 3–4 mm, reduction of symptoms
3	17	7	4	22	Probably because of decongestants	Nasal bleeding, crusting	CSRF	31	No perforation and no complaints
4	16	3	2	4.7	Trauma	Nasal obstruction	Bilateral IBAF	30	No perforation and no complaints
5	11	10	10	78.5	Probably because of INCSs	Whistling, crusting, nasal obstruction.	IBAF + SLF	30	No perforation, oronasal fistula
6	15	20	20	314.2	Probably because of nose-picking	Whistling,	IBAF + SLF	29	No perforation, oronasal fistula
7	15	25	10	196.3	Treatment of juvenile arthritis, including methotrexate and tocilizumab	Crusting, nasal bleeding	TFG	12	Residual perforation, 15 by 10 mm, reduction of symptoms
8	16	15	10	117.8	Treatment of juvenile arthritis, including methotrexate and tocilizumab	Crusting	AEAF	18	Residual perforation, 10 by 8 mm, reduction of symptoms
9	6	10	10	78.5	Foreign body (battery)	Whistling, crusting, nasal obstruction	IBAF + SLF	28	Residual perforation 1–2 mm, reduction of symptoms
10	15	25	15	294.4	Probably because of nose-picking	Crusting	CSRF	24	No perforation and no complaints
11	17	25	15	294.4	Probably due to INCSs	Whistling	CSRF	24	No perforation and no complaints
12	17	5	5	19.6	Probably because of nose-picking	Nasal bleeding, nasal obstruction	CSRF	24	Residual perforation 3–4 mm, reduction of symptoms
13	9	15	10	117.8	Probably due to INCSs	Whistling, crusting	CSRF	14	No perforation and no complaints
14	14	15	15	176.6	Trauma	Whistling, crusting, nasal obstruction	CSRF	12	No perforation and no complaints
15	12	18	15	211.9	Probably because of nose-picking	Crusting	IET + AEAF	13	No perforation and no complaints
16	14	20	15	235.5	Probably because of nose-picking	Nasal obstruction	IET + AEAF	12	No perforation and no complaints
17	15	30	15	353.3	Probably because of INCSs	Nasal bleeding, whistling, crusting nasal obstruction	IET + AEAF	12	No perforation and no complaints
18	14	30	25	588.8	Spontaneous, probably due to decongestants	Whistling, crusting, saddle deformation, nasal obstruction	IET + AEAF	11	No perforation and no complaints
19	8	15	10	117.8	Probably because of nose-picking	Nasal bleeding	IET + AEAF	11	No perforation and no complaints
20	13	17	17	226.9	Coagulation due to bleeding	Nasal obstruction	IET + AEAF	9	No perforation and no complaints
21	11	8	8	50.3	Coagulation due to bleeding	Nasal bleeding, crusting	IET + AEAF	5	No perforation and no complaints
22	17	20	15	235.5	Probably due to decongestants	Nasal bleeding, crusting	IET + AEAF	5	No perforation and no complaints
23	9	20	20	314	Foreign body (battery)	Whistling, crusting, nasal obstruction	IET + AEAF	5	No perforation and no complaints
24	16	20	10	157	Probably because of nose-picking	Nasal obstruction	IET + AEAF	4	No perforation and no complaints

INCSs – intranasal corticosteroids; IBAF – intranasal bipedicated advancement flap; SLF – sublabial mucosal flap; TFG – temporal fascia graft; CSRF – cross-septal returned flap; IET – inverted edges technique; AEAF – anterior ethmoidal artery flap.

of the effectiveness of different techniques.

1.1. Patients and methods

24 children with nasal septal perforations were operated by the same surgeon using different endoscopic techniques and followed prospectively at the ENT department of National Medical Research Center of Children Health from February 2015 to May 2019 (Table 1). This Center is the leading national institution for children health in Russia, which delivers the specialized and highly qualified health care. Mean age of patients was 13,5 years, ranging between 6 and 17 years. In 7 patients (29%) no evident cause of septal perforation was found.

These perforations were possibly associated with nose-picking. In 8 patients (33.2%), septal perforations were caused by topical drug application: 4 cases were associated with active use of nasal decongestants and 4 cases – with intranasal corticosteroids. Although it is difficult to prove the strong association between use of these drugs and septal perforations. 2 patients had septal perforations after nasal trauma and 2 other patients had a history of nasal foreign body (battery). In 2 cases, perforations were caused by coagulation of blood vessels of the septum in patients with a history of nasal bleeding. In the last 2 cases (the same child was operated twice with an interval of 1 year), the perforation was due to juvenile arthritis and immunosuppressive treatment.

The most common complaints were nasal dryness and crusting (14 patients, e.g. 58%). Additionally, there were complaints of nasal obstruction (13.54%), whistling during nasal breathing (10.41%), nasal bleeding (6.25%).

Perforations were mostly localized at the anterior and middle portions of the septum, sizes of perforations range from 3 to 30 mm in the sagittal plane and 2–25 mm in the vertical plane (the mean size of 16.2 mm × 11.9 mm) (Table 1).

For more convenient comparative assessment of perforations' sizes, we have calculated the area (A) of each perforation. We used the formula for calculating the area of an ellipse, as the most common shape of perforation, $A = \pi SL$ (L - half of the longest diameter of perforation, S - half of the shortest diameter of perforation). The mean perforation area was 178 sq mm with a range of 4.7 sq mm to 588.8 sq mm (Table 1).

1.2. Surgical techniques

We used different surgical techniques, in most cases we were trying to combine several of them, to achieve more effective closure of perforation at both sides.

In 6 cases (2 – bilaterally, 4 – in combination with sublabial flap) we used intranasal bipediced advancement flap (IBAF). This technique with several variations was first described before the era of endoscopic surgery, later similar techniques have been provided with endoscopic assistance [8,9,11,12]. This technique is based on reducing of the tension of two mucoperichondrial flaps superior and inferior to perforation by making two horizontal incisions along the nasal floor and under the roof of the nasal cavity. Thus, the connection between flaps and remnant septal mucoperichondrium is preserved as two wide pedicles anterior and posterior to perforation, which gave a name to this technique. After adequate elevation of flaps due to releasing incisions and dissection, the perforation is closed with the advancement of flaps towards each other and suturing. This technique seems to be rather effective, but not suitable for large perforations repair. Furthermore, cases of columella retractions were reported in patients after such surgeries [8,9,11].

In 4 patients, we used sublabial mucosal flaps (SLF), combining it with IBAF in all cases. Sublabial mucosal flap technique has a long history [13]. This technique is based on the creation of the medial-based flap under the superior lip. Then this flap is guided through created midline sublabial-nasal tunnel to the nasal cavity and sutured after adjustment to perforation edges with endoscopic assistance. This approach allows to get a rather large vascularized flap located

adjacently to perforation, but has several disadvantages, described later (see results).

Plastic closure of perforation with free temporal fascia graft (TFG) have been used in 1 patient. We believe that the viability of this graft is very doubtful in case of such monolayer closure of perforation, although some publications demonstrate the contrary [14]. We provided this technique only once in the patient with a history of long-term use of Methotrexate and Tocilizumab for juvenile arthritis, who had higher risks of perforation enlargement after surgery. Considering severe comorbidity of the patient we decided to preserve the rest septum and chose free temporal fascia graft as a minimally invasive technique.

Anterior ethmoidal artery septal flap (AEAF) was one of the most preferable techniques, which we used in 11 patients, including only one case of unilateral closure and 10 cases of combination with inverted edges technique. Once Castelnovo described this flap in 2011, the technique soon has become popular among surgeons and has proven to be easily reproducible [10,11,15]. The main advantage of this technique is a possibility to create a large and mobile flap, supplied with the anterior ethmoidal artery branches. For preparing Castelnovo's flap we started with a vertical incision through mucoperichondrium of the septum at one side from the middle turbinate level to the nasal floor. Then the incision is continued along the nasal floor to the inferior meatus. After that, the incision turns anteriorly until it reaches the head of the inferior turbinate where it turns again towards the septal perforation. The flap was elevated within these boundaries, then turned anteriorly to close the perforation and sutured to the perforation margins along the perimeter.

Apart from well-known techniques we used successfully two original techniques, which will be outlined below.

Cross-septal returned flap (CSRf) is our modification Castelnovo's flap that allows to close perforation bilaterally (Fig. 1). The anterior ethmoidal artery flap prepared for this purpose should be larger than in traditional technique. Vertical incision of septum starts at the level of the midpoint of the middle turbinate and continues laterally to the inferior meatus almost reaching the basal lamella of the inferior turbinate. Once the flap is elevated we make the transfixion vertical incision of the septum 1–2 mm anterior to perforation. Then the flap is guided through this incision to the contralateral side of the nasal cavity, turned backward and sutured first to the posterior edge, then along the whole perimeter of perforation. In most cases, the size and mobility of flap are enough to close perforation bilaterally. We used this technique in 6 cases.

In 10 cases with complete epithelization of perforation edges, we provided the inverted edges technique (IET) (Fig. 2; Fig. 3). This surgery starts with a circular incision around the perforation at one side (usually at the left side). The distance between incision and perforation is about 5–7 mm. Then, mucoperichondrium around perforation is elevated towards the perforation edges and turned out to the contralateral side of the nasal cavity, leaving an “umbo”- like gap at the center of the flap. We put 2–3 sutures to close this gap. (Fig.2; Fig. 3). Due to this simple trick, small perforations are closed completely and large ones are closed partly. The additional advantage of the described technique is the creation of a wide strip of wound surface at the initial side of the septum. This wound surface will serve as a good bed for placement and fixation of the anterior ethmoidal flap, which we combine with inverted edges technique in all cases. Therefore, we reach the complete closure of perforation on both sides.

One of the common challenges of septal perforation surgical repair in children is the narrowness of the nasal cavity, that restrict endoscopic manipulations. It is particularly difficult in young children to make incision and dissection at the inferior meatus. To ease manipulations at inferior meatus we temporally cut off the inferior turbinate at its anterior and middle portions (Fig. 4). This useful maneuver significantly improves the visualization of the inferior nasal meatus and facilitates flap dissection. At the end of surgery inferior turbinate is freely fixed back into place with 1–2 absorbable sutures (Fig. 4).

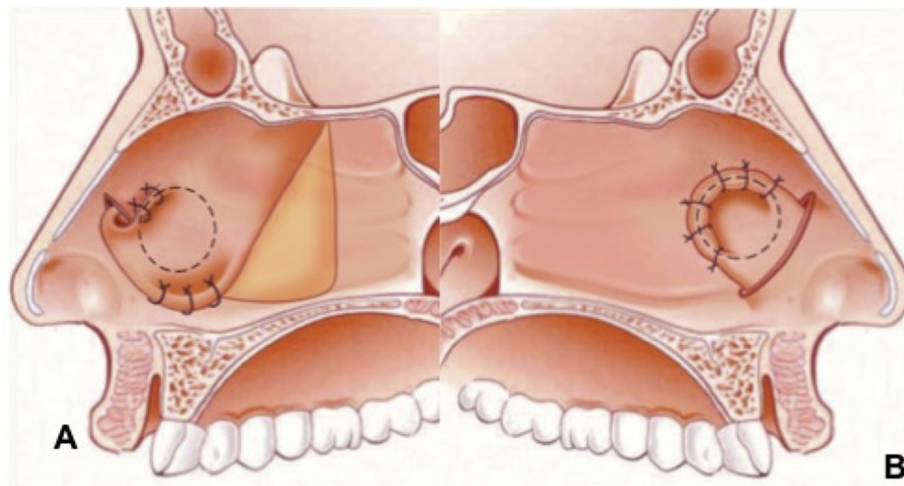


Fig. 1. A schematic view of the cross-septal returned flap from left (A) and right (B) nasal cavities. The anterior ethmoidal artery flap is passed through the transfixion incision of the septum and rotated backward to close the perforation bilaterally.

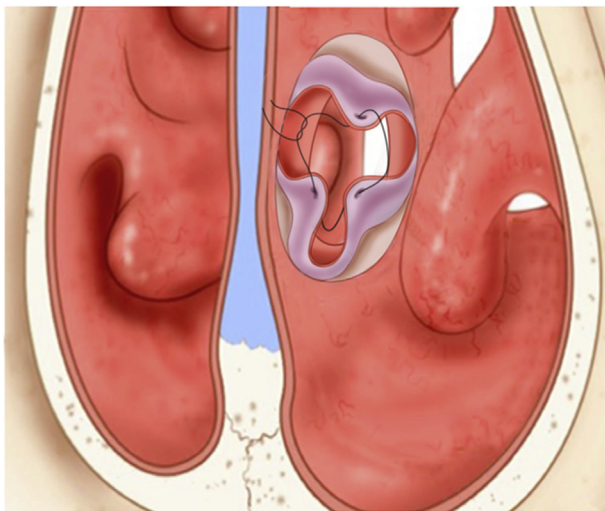


Fig. 2. A schematic view of the inverted edges technique (oblique angle view from the left nasal cavity). The flap was elevated at the left side. A gap in the center of the inverted flap is sutured.

1.3. Postoperative care

We prohibit the use of topical decongestants and intranasal corticosteroids for all patients during the postoperative period. Silicone splints were removed 12–14 days after surgery. Patients were recommended to use nasal saline irrigation, topical application of dexpanthenol ointments and use of oil nasal drops in the early postoperative period.

2. Results

During the early follow-up period, some patients complain of mild discomfort, but in general, silicone intranasal splints were well tolerated in children. In all cases, splints were removed without anesthesia as an outpatient.

After splints removal, we detected moderate edema and hyperemia of flaps, stable sutures and no visible perforations in all cases. The donor sites of the septum and nasal floor were covered partly with epithelium, partly with fibrin. There were no cases of reperforations in the early postoperative period.

Control examination in a month after surgery demonstrated no

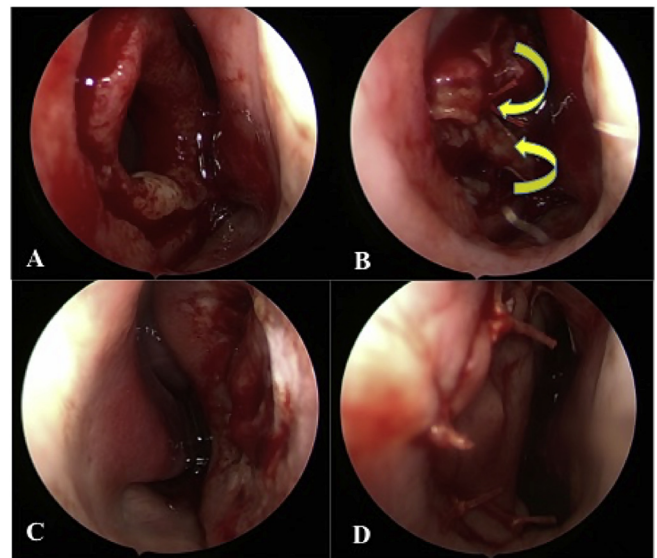


Fig. 3. Septal perforation repair with a combination of inverted edges technique and ethmoidal artery septal flap. (A) Circular incision of mucoperichondrium around the perforation. (B) Inversion of perforation edges to the opposite side (the direction of flap inversion indicated with arrows). (C) Endoscopic view from the right nasal cavity after the inversion and suturing. (D) Endoscopic view from the left nasal cavity after an adjustment and suturing of the anterior ethmoidal artery septal flap.

hyperemia, but minor swelling of the flap. The wound surface at the posterior part of the septum and nasal floor was completely epithelized.

Long-term results of each described techniques are presented in [Tables 1 and 2](#). The patients were followed up for a period of 4–37 months (median follow-up, 18.2 months).

The combination of inverted edges technique and anterior ethmoidal artery septal flap demonstrated the best results. In all 10 cases, perforations were completely closed with no recurrences up to 13 months of follow-up. In one patient with complaints of nasal dryness, we have found moderate crusting ([Fig. 5](#)).

Cross-septal returned flap also demonstrates a rather high rate of success. Using this technique, we achieved complete closure of perforation in 5 (83%) of 6 patients.

The remaining techniques were performed rare and showed relatively low rates of success. Thus, 2 of 4 patients with sublabial mucosal flap had residual perforations (success rate 50%). Furthermore, in 2

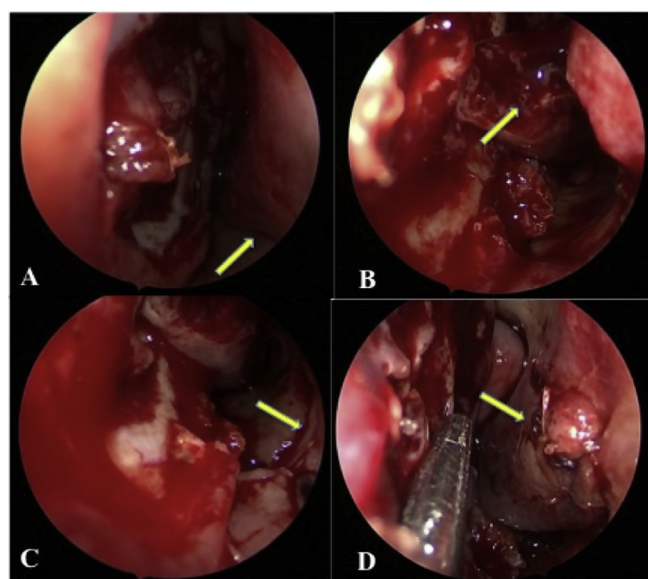


Fig. 4. Temporal cut off the inferior turbinate in 8 years old patient. Left nasal cavity. (A) Following inverted edges maneuver, the anterior ethmoidal artery septal flap is going to be prepared, but the inferior nasal meatus cannot be visualized with endoscope due to its narrowness (arrow). (B) The inferior turbinate is cut off (arrow) the lateral nasal wall 2–3 mm behind the head of the turbinate. (C) The inferior meatus is available and the incision for flap elevation is performed (arrow). (D) After elevation of the ethmoidal artery septal flap, the inferior turbinate is fixed back into place with 1–2 absorbable sutures (arrow).

other patients, we have found oronasal fistula, which requested additional surgery. It should be noted that all 5 cases of reperforations have been found during 3 months after surgery.

Regarding septal perforation closure, the total rate of success was 79% (19 of 24 patients), whereas 2 residual perforations occurred in the same patient treated with Methotrexate and Tocilizumab for juvenile arthritis. Nevertheless, these residual perforations were smaller than before surgery and a significant decrease of symptoms severity has been achieved.

Excluding this patient, the rate of complete perforation closure was 86% (19 of 22 patients).

If the reduction of symptoms is to be considered as a criterion for surgical treatment efficiency instead of complete perforation closure, the success rate is approaching 100%.

3. Discussion

Review of the literature shows that the rates of success in surgical repair of perforations in children and adults significantly differ. Thus, Jennings et al. using external rhinoplasty technique with vascularized

nasal septal flaps achieved complete closure of septal perforations only in 50% of pediatric cases [6].

Trying to improve outcomes of septal perforation surgery in children Chua used auricular cartilage graft [4]. In 1 patient Chua had to repeat the surgical procedure 3 times to achieve complete closure.

Chang described factors that should be considered prior to surgery, such as etiology of septal perforation, comorbidity, patient compliance, availability of local tissues and grafts, the potential effect on nasal growth [5]. However, despite careful consideration of these factors, the authors reported that successful closure was limited to 4 of 6 patients (66,7%) who were offered repair.

At the same time, there are some trends in surgical repair of septal perforations in adults, such as obligatory endoscopic assistance, use of vascularized flaps with clear understanding of supplying blood vessel and seeking for techniques providing full-thickness septal repair [7,10,11,16–20].

An “endoscopic era” in septal perforation surgical repair starts with the first published reports of Hier et al., in 2002 [21]. Since that time, the endoscopic approach gradually becomes prevailing in septal perforation surgical repair with increasing amounts of publications reporting high success rates. In 2012 Cassano reported interesting data about trends in septal perforation surgical approaches for the last three decades [20]. During the last decade, a wide prevalence of open approach has been changed with a predominant advantage of endonasal techniques and increase of publications on endoscopic approaches (N = 12). Since that time for the last two years, the number of publications additionally increase [7,11,22].

According to Cassano, the advantages of the endoscopic approach are minimal invasiveness without external incisions, optimal exposure of the operative field with better visual control of perforation edges [20].

Opinions about the appropriate number of layers in the flap are rather controversial. On the one hand, Castelnuovo et al. popularized monolayer closure of septal perforation using vascularized flap pedicled by the anterior ethmoidal artery [10].

On the other hand, many authors try to recover both mucoperichondrial layers, or even all layers of the septum, including cartilaginous support. Thus, Kaya et al. proposed for septal perforation repair the three-layer interlocking technique under endoscopic assistance [19]. Ozdek et al. reported that bilateral intranasal flaps are more effective than unilateral ones, especially when combined with autogenous connective tissue graft and open septoplasty technique [18]. Schultz-Coulon, André, Park, Cassano also prefer bilateral or full-thickness repair of septum [8,15,20,23].

Trying to reverse the trend of a certain delay in surgical repair of septal perforations in children, during 5 years we actively performed these operations under endoscopic assistance using vascularized flaps techniques.

Etiology of septal perforations in our patients differs from data in the publication of Jennings, who reported about 40% cases of

Table 2

Comparative assessment of different techniques used for surgical closure of children septal perforations.

Surgical technique	Number of patients	Maximum size of perforations, mm	Maximum follow-up (months)	Number of residual perforations	Number of complications	Efficiency (complete perforation closure), %	Efficacy (symptoms relief), %
IET + AEF	10	30 by 25	13	0	0	100	100
CSRF	6	25 by 15	24	1	0	83	100
IBAF + SLF	4	20 by 20	36	2	2 (ornasal fistula)	50	100
Bilateral IBAF	2	5 by 3	27	0	0	100	100
TFG ^a	1	25 by 10	12	1	0	0	100
AEAF ^a	1	15 by 10	18	1	0	0	100
All techniques	24	30 by 25	36	5	2 (ornasal fistula)	79	100

IBAF – intranasal bipediced advancement flap; SLF – sublabial mucosal flap; TFG – temporal fascia graft; CSRF – cross-septal returned flap; IET – inverted edges technique; AEF – anterior ethmoidal artery flap.

^a – both techniques were consequently used in the same patient with juvenile arthritis without effect.

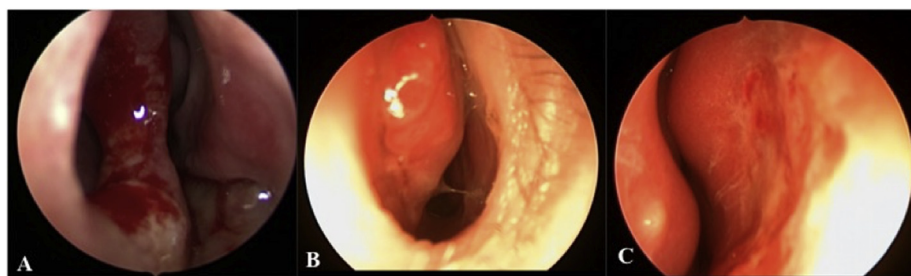


Fig. 5. Endoscopic view of nasal septum of 8 years old child (N 19 according to the list of patients). (A) Preoperative view of septal perforation from the left nasal cavity. (B) Postoperative view of the left nasal cavity 11 months after surgery. (C) Postoperative view of the right nasal cavity 11 months after surgery.

iatrogenic perforations, 40% caused by a nasal foreign body (battery) [6]. Most of our cases were idiopathic, including 4 perforations in patients using intranasal corticosteroids. Only 2 children had a history of nasal foreign body (battery). We had no cases of perforations caused by the previous septoplasty in our cohort of children.

The median age of our patients was 13.5 years (range 6–17), similar to Jennings reported data (167.5 months, range 1.5–221.0) and Chang's data (10.8 years, range 2 months–17 years) [5,6].

The success rate in bilateral repair techniques was 86% (19 of 22 patients), which was higher than in unilateral closure.

All cases of residual perforations have been found no later than 3 months after surgery. There were no cases of additional enlargement of the residual perforations during the further follow-up. According to this, control examination at the period of 3 months after surgery may be considered as a critical in patients' follow-up.

Since we had no cases of perforations due to previous septoplasty, there was a possibility to dissect a vascularized flap in subperichondrial and subperiosteal layers in almost all cases. It is a great advantage of the pediatric population.

It is particularly noteworthy that 2 of 5 residual perforations consequently occurred in the same patient with a history of long-term use of Methotrexate and Tocilizumab for juvenile arthritis. This clinical case combines several risk factors. Juvenile arthritis has been reported as a rare cause of septal perforation [24]. Another paper indicated that one of the side effects of Methotrexate was the perforation of nasal septum [25]. Also, according to the prescribing information the use of Tocilizumab may lead to gastrointestinal perforations.

This patient was operated twice with a one-year interval using different techniques. The first time we performed insertion of free temporal fascia graft, at the second - we used Castelnovo's anterior ethmoidal artery septal flap. Both surgeries were performed during the remission stage with approval of the rheumatologist. In both cases, septal perforations have been completely closed intraoperatively and remained closed after splints removal. However, at the control examination in one month after surgery reperforations have been found.

It is natural to ask whether surgery is relevant in such cases. On the one hand, two surgeries with two different techniques have failed to close the perforation completely, but at the same time, each surgery leads to perforation's size reduction and decrease in the severity of symptoms. Juvenile arthritis should be probably considered as a relative contraindication, that required an individual decision in each clinical case after discussion with parents and consultation with a rheumatologist.

In general, even considering this patient with poor prognosis, the effectiveness of endoscopic approach in our case series was 79%, which is significantly higher than in reports of Jennings (50%) and Chang (66.7%), while perforation sizes and age of patients were not substantially different [5,6].

The best results were achieved using bilateral closure techniques. Both the combination of inverted edges technique with Castelnovo's flap and the cross-septal returned flap have proven to be the most effective. It is important not to oppose these techniques, considering

different indications to each of them. Inverted edges technique may be used only in cases with complete epithelization of perforation margins, the cross-septal returned flap is preferable in cases of ulceration of one of the perforation's edge.

4. Conclusion

Use of endoscopic assistance, vascularized mucoperichondrial flaps and bilateral closure demonstrates high effectiveness in septal perforation surgical repair in children.

Performing endoscopic approach in rather narrow nasal cavities some additional tricks, such as temporal cut off the inferior turbinate, will be useful.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ijporl.2019.109817>.

References

- [1] C. Brown, Intranasal button battery causing septal perforation: a case report, *J. Laryngol. Otol.* 108 (7) (1994) 589–590, <https://doi.org/10.1017/s0022215100127513>.
- [2] A. Zanetta, Perforación septal en niños debido a una pila botón alojada en nariz. Serie de casos, *Arch. Argent. Pediatr.* 110 (5) (2012) 430–434, <https://doi.org/10.5546/aap.2012.430>.
- [3] T. Huang, W. Li, Z. Xia, J. Li, K. Rao, E. Xu, Characteristics and outcome of impacted button batteries among young children less than 7 years of age in China: a retrospective analysis of 116 cases, *World J. Pediatr.* 14 (6) (2018) 570–575, <https://doi.org/10.1007/s12519-018-0188-9>.
- [4] D. Chua, H. Tan, Repair of nasal septal perforations using auricular conchal cartilage graft in children: report on three cases and literature review, *Int. J. Pediatr. Otorhinolaryngol.* 70 (7) (2006) 1219–1224, <https://doi.org/10.1016/j.ijporl.2005.12.021>.
- [5] D. Chang, A. Irace, K. Kawai, C. Rogers-Vizena, R. Nuss, E. Adil, Nasal septal perforation in children: presentation, etiology, and management, *Int. J. Pediatr. Otorhinolaryngol.* 92 (2017) 176–180, <https://doi.org/10.1016/j.ijporl.2016.12.003>.
- [6] J. Jennings, A. Shaffer, A. Stapleton, Pediatric nasal septal perforation, *Int. J. Pediatr. Otorhinolaryngol.* 118 (2019) 15–20, <https://doi.org/10.1016/j.ijporl.2018.12.001>.
- [7] S. Dayton, N. Chhabra, S. Houser, Endonasal septal perforation repair using posterior and inferiorly based mucosal rotation flaps, *Am. J. Otolaryngol.* 38 (2) (2017) 179–182, <https://doi.org/10.1016/j.amjoto.2017.01.001>.
- [8] H. Schultz-Coulton, Three-layer repair of nasoseptal defects, *Otolaryngology-Head Neck Surg. (Tokyo)* 132 (2) (2005) 213–218, <https://doi.org/10.1016/j.otohns.2004.09.066>.
- [9] H. Lee, D. Ahn, J. Park, et al., Endoscopic repairment of septal perforation with using a unilateral nasal mucosal flap, *Clin. Exp. Otorhinolaryngol.* 1 (3) (2008) 154, <https://doi.org/10.3342/ceo.2008.1.3.154>.
- [10] P. Castelnovo, Anterior ethmoidal artery septal flap for the management of septal perforation, *Arch. Facial Plast. Surg.* 13 (6) (2011) 411, <https://doi.org/10.1001/archfacial.2011.44>.
- [11] I. Allobid, Endoscopic approach for management of septal perforation, *Eur. Arch. Oto-Rhino-Laryngol.* 276 (8) (2019) 2115–2123, <https://doi.org/10.1007/s00405-019-05490-w>.
- [12] W. Goodman, V. Strelzow, The surgical closure of nasoseptal perforations, *The Laryngoscope* 92 (2) (1982) 121–124, <https://doi.org/10.1002/lary.1982.92.2.121>.
- [13] M. Tardy, Practical suggestions ON facial plastic surgery: how I do it???. Sublabial mucosal flap: repair of septal perforations, *The Laryngoscope* 87 (2) (1977)

- 275–278, <https://doi.org/10.1288/00005537-197702000-00015>.
- [14] A. Goh, S. Hussain, Different surgical treatments for nasal septal perforation and their outcomes, *J. Laryngol. Otol.* 121 (5) (2007) 419–426, <https://doi.org/10.1017/s002221510700566x>.
- [15] J. Park, D. Kim, H. Jin, Nasal septal perforation repair using intranasal rotation and advancement flaps, *Am. J. Rhinol. Allergy* 27 (2) (2013) e42–e47, <https://doi.org/10.2500/ajra.2013.27.3878>.
- [16] M. Shikowitz, Vascularized mucoperiosteal pull through flap for closure of large septal perforation: a new technique, *The Laryngoscope* 117 (4) (2007) 750–755, <https://doi.org/10.1097/mlg.0b013e318030ac77>.
- [17] H. Foda, The one-stage rhinoplasty septal perforation repair, *J. Laryngol. Otol.* 113 (8) (1999) 728–733, <https://doi.org/10.1017/s0022215100145049>.
- [18] A. Özdek, Closure of nasal septal perforations using bilateral intranasal advancement/rotation flaps, *Turkish J. Ear Nose Throat* 24 (3) (2014) 123–128, <https://doi.org/10.5606/kbbihtisas.2014.20092>.
- [19] E. Kaya, C. Cingi, Y. Olgun, H. Soken, Pinarbasli Ö, Three layer interlocking, *Ann. Otol. Rhinol. Laryngol.* 124 (3) (2014) 212–215, <https://doi.org/10.1177/0003489414550859>.
- [20] M. Cassano, Endoscopic repair of nasal septal perforation, *Acta Otorhinolaryngol. Ital.* 37 (6) (2017 Dec) 486–492, <https://doi.org/10.14639/0392-100X-1313>.
- [21] M. Hier, A. Yoskovitch, W. Panje, Endoscopic repair of a nasal septal perforation, *J. Otolaryngol.* 31 (5) (2002) 323, <https://doi.org/10.2310/7070.2002.29958>.
- [22] A. Santamaria-Gadea, M. Lopez-Chacon, C. Langdon, et al., Modified nasal floor and inferior meatus flap for septal perforation repair. Extension and limits, *Rhinol. J.* (2018), <https://doi.org/10.4193/rhin18.036> 0(0).
- [23] R. André, P. Lohuis, H. Vuyk, Nasal septum perforation repair using differently designed, bilateral intranasal flaps, with nonopposing suture lines, *J. Plast. Reconstr. Aesthet. Surg.* 59 (8) (2006) 829–834, <https://doi.org/10.1016/j.bjps.2005.11.010>.
- [24] T. Avcin, E.D. Silverman, V. Forte, R. Schneider, Nasal septal perforation: a novel clinical manifestation of systemic juvenile idiopathic arthritis/adult onset Still's disease, *J. Rheumatol.* 32 (12) (2005 Dec) 2429–2431.
- [25] S.L. Lee, D. Neskey, J. Mouzakes, Potential predisposition for nasal septal perforation with methotrexate use: report of 2 cases and literature review, *Ear Nose Throat J.* 88 (8) (2009 Aug) 12–16, <https://doi.org/10.2165/00128415-201012830-00208>.