Nasal septal perforation repair: predictive factors and systematic review of the literature

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Purpose of review
Although numerous surgical techniques have been introduced thus far in order to achieve the surgical closure of nasal septal perforation, the repair of nasal septal perforation is still challenging for surgeons and operative techniques are not standardized. Furthermore, predictive factors for successful closure have not been elucidated. This review aimed to investigate predictive factors for complete closure of nasal septal perforation.

Recent findings
The size of perforation was the most significant factor for complete closure. Surgical failure occurred more frequently in patients with large perforation (>2 cm) than those with small-to-moderate perforation (<;2 cm). The bilateral coverage over the perforation with vascularized mucosal flap also helped complete closure. Interposition of grafts appeared to assist complete closure, although it was statistically insignificant.

Summary
This review provides information for surgeons on how to predict surgical outcomes of the repair of nasal septal perforation and which surgical techniques to choose in order to obtain better results.

Keywords
management, nasal septum, perforation, predictive factor, surgical

INTRODUCTION

Nasal septal perforation (NSP) can occur by numerous causes including previous septal surgeries, trauma, inflammatory diseases, and the use of nasal spray [1]. Although most patients with NSP remain asymptomatic, a significant minority suffer from debilitating symptoms such as nasal obstruction, crusting, epistaxis, and postnasal drip [2]. Conservative managements including nasal irrigation with isotonic saline, application of antibiotic ointment, or prosthesis such as a septal button can diminish problematic symptoms, yet surgical repairs are required for patients who do not respond to conservative treatments [3,4&&]. Many surgical techniques, approaches, flaps, and interpositional grafts have been reported. However, surgical techniques have not been standardized and the keys for successful closure have not been completely elucidated [5]. The objectives of this systematic review were to assess available literature on the surgical repair of the NSP and to search for the predictive factors for successful repair.

SYSTEMATIC LITERATURE REVIEW

We performed a systematic literature search of MEDLINE via PubMed, SCOPUS, Web of Science, and the Cochrane Ear, Nose and Throat Disorders Group Trials Register (The Cochrane Library, Issue 6, 2011) without language restriction except for articles in which English translation was not available for the period of January 1960 to June 2011. The search was conducted by both authors (K.S.-W. and R.C.-S.) independently to identify suitable articles for review. Medical subject headings (MeSH) and main keywords used in the database searches were nasal, septal, perforation, management, surgical, repair, and predictive factor. We also scanned the references in the retrieved articles.

No randomized prospective controlled studies dealing with the management or predictive factors

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KEY POINTS

- Repair of nasal septal perforation is challenging for surgeons and operative techniques are not standardized.
- Large perforations greater than 2 cm significantly increase the surgical failure rate.
- Bilateral coverage of the defect with intranasal vascularized mucosal flaps helps to improve complete closure of nasal septal perforation.
- Interpositional grafts seem to assist successful repairs, although this was not statistically significant.

of the NSP existed in the literature and, thus, formal meta-analysis was impossible. Most articles that were included were nonrandomized retrospective studies. Although there was a prospective study, it was impossible to confirm the prognostic factors for successful closure because no control group existed therein [2]. Inclusion criteria for obtaining the full-text article included original studies, case series, animal studies, systematic reviews, or meta-analyses reporting on outcomes of the surgical repair of the NSP. Exclusion criteria included reviews and articles focused on epidemiology, symptomatology, or causative factors of NSP. Any disagreement between the two authors was resolved by consensus. Of the initial 84 identified articles, 59 were suitable for further review.

Each study was evaluated for outcomes of the repair of NSP and predictive factors for favorable outcomes. Data suitable for extraction were defined by both authors and collected by the junior author (K.S.-W.). The number of patients, surgical approaches and techniques, graft materials, the size of NSP, follow-up periods, and surgical outcomes were entered into a computer database (Microsoft Excel 2007, Microsoft Corp., Redmond, Virginia, USA). After data extraction was completed, they were initially evaluated for the completeness of the datasets. For a dataset to be considered 'complete' and eligible for further review, the study required detailed description of the surgical repair as well as outcomes checked for at least 3 months postoperatively. If these data were included entirely in the database, the dataset was considered eligible for final analysis.

PREDICTIVE FACTORS FOR SUCCESSFUL OUTCOMES

Through the exhaustive review of the literature, we were able to identify three determinants for the successful repair of NSP: the size of the perforation, bilaterality of flap coverage, and interposition of graft materials (Table 1) [2,4[&&],6[&&],7,8[&],9[&],10–34]. Pearson's x^2-test was used to compare surgical outcomes among patients according to the identified three determinants. All statistical analyses were conducted using the statistical software package SigmaStat for Windows SPSS version 18.0 (SPSS, Chicago, Illinois, USA). A P value of less than 0.05 was considered statistically significant. As the postoperative symptom changes were fairly varied among the patients, surgical outcomes were assessed on the basis of closure rates of NSP. However, it may happen sometimes that nasal obstruction remains postoperatively despite the successful closure of NSP and, thus, should be included in assessing treatment outcomes of patients individually. Remaining nasal obstruction is assumed to be due to several factors such as the thickness of applied flaps and the decrease in normal respiratory mucosa [4[&&]].

THE SIZE OF THE PERFORATION

In fact, there is no consensus on the classification of the perforation size. Therefore, it is quite difficult to assess surgical outcomes according to the size of perforation by taking the individual studies together [5]. Although defects larger than 2 cm in length are generally accepted as large size, the upper limit of small size differs between authors, up to 5 mm or 1 cm [1,15,19,24,35]. Small-to-moderate perforations can be repaired with local advancement flaps alone or combined with interposition of grafts. Although various surgical techniques, including mucosal tissue expansion, diverse local, regional or free flaps, and allografts or xenografts, have been employed to close large perforations, it is still challenging for surgeons to deal with large perforations [16,36–38].

Success rates reported by oriental surgeons were lower than those from westerners [4[&&],11]. Considering ethnic differences, the relative size of NSP compared with the whole septum is thought to be more important than the absolute size. In this regard, classification of the size according to the involved ranges in three even parts of vertical height of the septum can be an alternative, as suggested by Islam et al. [10]. Despite the difficulties of size-wise comparison, large perforations have been recognized as a significant risk factor for incomplete closure because the size of NSP is inversely proportional to the amount of mucosa available for perforation closure [4[&&],37]. Collectively, the surgical success for large perforations was approximately 78%, whereas small-to-moderate perforations were

Table 1. Closure rates of nasal septal perforation repair according to the different methods

Authors	Bilaterality	Flap	Approach	Graft	Patients (n)	Perforation size (mm)	Follow-up period (months)	Closure rate (%)
Teymoortash et al. [6&&]	Unilateral	Wide nasal mucosal flap	Endonasal	None	55	23 (11–38)	4.4 (3.3–18)	94.5
Moon et al. [4&&]	Unilateral/ bilateral	Variable: mainly bipedicled advancement flap	Variable (external 51.4%)	Variable (allograft 47.2%)	35	12 (2–40)	26 (3–96)	52
Mansour [7]	Unilateral	None	Endonasal	Inferior turbinate mucosa	6	5–15	6–24	83
Li et al. [8&]	Unilateral	Rectangular nasal mucosal flap	Endonasal	Autogenous (cartilage or bone)	28	10–20	28	92.9
Giacomini et al. [9&]	Bilateral	Bipedicled advancement flap	Endonasal	Autogenous auricular cartilage	14	20–40	12–36	71.4
Wong and Raghavan [2]	Bilateral	Bipedicled advancement flap	External rhinoplasty	Acellular porcine collagen	28	22 (10–35)	16 (6–24)	96.4
Islam et al. [10]	Bilateral	Reciprocal mucoperichondrial flap	Endonasal	Autogenous (cartilage/ bone/fascia)	10	11 (8–13)	16 (5–26)	70
Lee et al. [11]	Bilateral	Mucoperichondrial flap	Endonasal	Allograft	11	6.5 (2–20)	15	91
Lee et al. [12]	Unilateral	Advancement flap	Endonasal	Temporalis fascia	14	15 (7–20)	8 (3–24)	85.7
Shikowitz [13]	Unilateral	Mucoperiosteal pull through flap	External rhinoplasty	Variable	10	20 (16–27)	15	90
Ribeiro and da Silva [14]	Bilateral	Mucoperiosteal/mucoperichondrial advancement flap	Endonasal	Autogenous cartilage/deep temporoparietal fascia	258	10–35	12	99
Pedroza et al. [15]	Bilateral	Mucoperichondrial flap	Endonasal	Autologous fascia/cartilage/ bone with periosteum	68	<20	12–120	100
			External rhinoplasty			>20–30	12–120	91
Ceylan et al. [16]	Unilateral	Mucoperichondrial flap	External rhinoplasty	None	24	14 (4–30)	28 (6–45)	79.2
Andre et al. [17]	Bilateral	Variable intranasal flaps	Mainly external rhinoplasty	Autogenous fascia, periosteum/ dermal allograft	43	Unspecified	29 (3–138)	93
Schultz-Coulon [18]	Bilateral	Bipedicled advancement flap	Endonasal	Autogenous cartilage	403	5–50	6	92.5
Stoor and Grénman [19]	Unilateral/ bilateral	Inferior turbinate flap	Endonasal	Bioactive glass	23	Unspecified	28 (5–70)	95.6
Newton et al. [20]	Unilateral	Bipedicled flap	External rhinoplasty	Autogenous septal bone/ temporalis fascia	12	<;20	10 (6–22)	90.9
Friedman et al. [21]	Unilateral	Inferior turbinate flap	Endonasal	None	10	10–20	18–36	70
Ambro et al. [22]	Bilateral	Bipedicled advancement flap	External rhinoplasty	Porcine small intestinal submucosa	10	10 (4–20)	3–12	100

Table 1 (Continued)

Authors	Bilaterality	Flap	Approach	Graft	Patients (n)	Perforation size (mm)	Follow-up period (months)	Closure rate (%)
Woolford and Jones [23]	Unilateral	Intranasal mucosal flap	Mainly endonasal	Autogenous conchal cartilage	11	22 (10–40)	19.8 (3–37)	72.7
Sarandeses-Garcia et al. [24]	Bilateral	Backwards extraction – reposition of quadrangular cartilage	Endonasal	None	25	<10	24	92
Foda [25]	Bilateral	Intranasal mucosal advancement flap	External rhinoplasty	Temporal fascia/dermal allograft	20	10–40	16–36	90
Kridel et al. [26]	Bilateral	Bipedicled advancement flap	External rhinoplasty	Acellular human dermal allograft	12	26 (5–45)	9.6 (3–14)	91.7
Nunez-Fernandez et al. [27]	Unspecified	Mucosal flap (details unspecified)	Endonasal	Temporalis fascia/bone	9	8 cases <3; 1 case >3	18–48	88.8
Hussain [28]	Unspecified	Mucoperiosteal/mucoperichondrial flap	Unspecified	Tragal cartilage – deep temporal fascia sandwich graft	15	10–30	6–24	100
Mina and Downar-Zapolski [29]	Unilateral	Mucoperichondrial/mucoperiosteal rotational flap	Endonasal	Temporalis fascia graft on contralateral side	14	5–30	6–120	92.9
Teichgraeber and Russo [30]	Bilateral	Bipedicled flap/contralateral posteriorly based flap	External rhinoplasty	Autogenous temporalis fascia/ mastoid periosteum	22	5–40	12	86
Arnstein and Berke [31]	Bilateral	Bipedicled mucoperichondrial flap	External rhinoplasty	Temporalis fascia	9	20–35	12–36	88.9
Kridel et al. [32]	Unilateral/ bilateral	Bipedicled mucosal flap	External rhinoplasty	Mastoid pericranium/ethmoid bone/cartilage	22	<40	12–36	77
Belmont [33]	Bilateral	Posteriorly based mucoperichondrial/ mucoperiosteal flap	Endonasal	Temporalis fascia	6	20–30	12	100
Fairbanks and Fairbanks [34]	Unilateral/ bilateral	Bipedicled mucosal flap	Endonasal	Temporalis fascia/mastoid pericranium/septal bone	24	10–30	12–84	95.8

Studies that have following conditions were excluded for statistical comparison: insufficient information about detailed surgical approaches and methods; short (<3 months) or unspecified follow-up period; case reports of three or fewer cases; the use of regional or free flap; and midfacial degloving approach that is not widely used at the moment. If the same authors' work dealt with the same techniques, only the last study was included in order to avoid overlapping of cases.

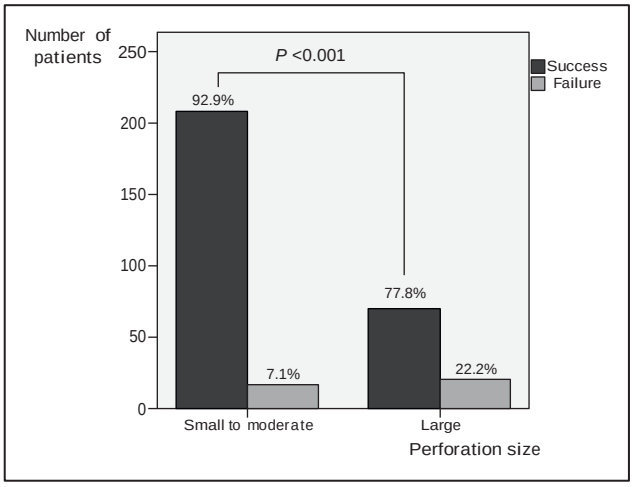

FIGURE 1. Closure rates according to the size of perforations. Repair of large nasal septal perforations (>2 cm) showed definitely higher failure rate than that of small-to-moderate ones ($P < 0.001$, Pearson's x^2-test).

completely closed in about 93% of patients ($P < 0.001$, Pearson's x^2-test) (Fig. 1).

With respect to the location of NSP, on the contrary, posterior perforations are known to be difficult to repair. However, as most of the articles did not assess surgical outcomes according to the location of NSP, location-wise differences could not be analyzed. Fortunately, patients with the posterior perforation rarely have symptoms and, thus, do not usually undergo surgical repairs [16].

PEDICLED MUCOSAL FLAP COVERAGE

Up to now, a multitude of local or regional flaps have been documented: unipedicled or bipedicled advancement flap, inferior turbinate flap, nasolabial flap, labiobuccal flap, and skin flaps.

Among various flap designs described in the literature, application of the inferior turbinate flap has shown a significantly high failure rate; thus it is not recommended as a first-line treatment. Although, in theory, it has some advantages, such as an abundant vascular supply, a wide arc of rotation, and the ability to preserve cartilaginous blood supply, unaccountably high failure rates have been reported by several authors [39]. Moreover, it can easily cause nasal obstruction due to its bulk [5,21]. On the contrary, advancement of mucoperichondrial or mucoperiosteal tissue from the septal wall or nasal floor has been widely utilized [8▪,18,40]. In the study involving a large series of patients, the bipedicled advancement flap was proven to be effective in complete closure of NSP, particularly with the concurrent use of interposed cartilage graft. Even in patients who redeveloped the perforation, the defect was considerably smaller than the original one and those patients were also asymptomatic [18,41].

With regard to the necessity for bilateral flap provision, unilateral flap coverage was advocated by some authors, as it limits the donor area to one side of the nose and, thus, preserves more nasal respiratory mucosa while achieving favorable closure rates [12,20,23,42]. Even in patients with moderate-to-large perforation, complete closure could be obtained by applying unilateral well vascularized mucoperiosteal flap [13]. Nevertheless, according to other articles including our previous study, bilateral mucosal flap coverage was of great importance; the advantage of it was presumably ascribed to increased vascularization, as suggested by some authors [4▪▪,40,43]. Furthermore, the principle of three-layer repair, which was advocated by Kridel [43], is widely accepted for successful closure [9▪,14]. Three layers indicate both right and left septal mucoperichondrial flaps and the intervening cartilage. All three layers must be separated from each other and repaired individually [43]. In terms of complete surgical closure, collectively, bilateral flap coverage was superior to unilateral coverage (84.5 vs. 73.4%, P ¼ 0.017, Pearson's x^2-test) (Fig. 2). Some other factors were, on the contrary, also indicated as important factors for complete closure, such as nonopposing suture lines of bilateral flaps, tension-free approximation of perforation margins, and the use of vertical mattress sutures that help flaps keep the margins everted [2,17]. Although these opinions seem

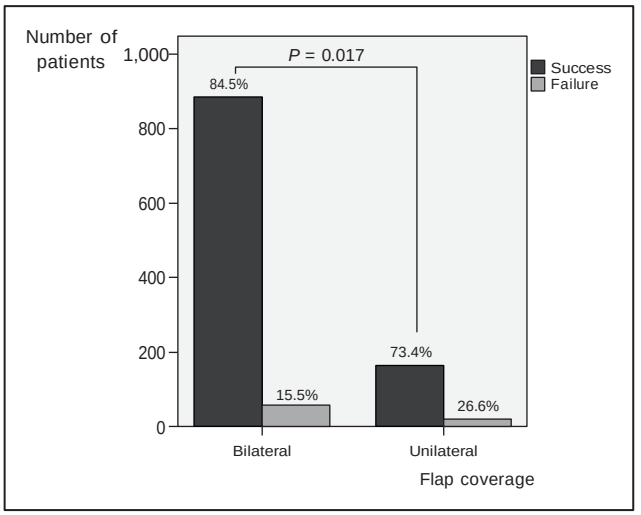

FIGURE 2. Closure rates according to the bilaterality of flap coverage. Bilateral coverage with mucosal flaps showed significantly higher success rates than unilateral coverage (P ¼ 0.017, Pearson's x^2-test).

reasonable, their significance for successful repair is difficult to prove by statistical analyses.

The critical limitation of the pedicled nasal mucosal flap is the insufficient size in the case of large perforation. Therefore, the radial forearm-free flap as well as several regional flaps outside the nose, such as pericranial, sublabial mucosal flaps, and facial artery musculomucosal flap, were introduced by several surgeons [38,44–50]. However, those flaps do not consist of mucus-producing ciliated respiratory epithelium; thus, the patients had persistent crusting and dry nose postoperatively, despite the fact that the perforations were successfully closed. Moreover, complications such as considerable donor site morbidity, oronasal fistula formation, and flap necrosis sometimes occurred. Therefore, those free or regional flaps have not been widely utilized [35].

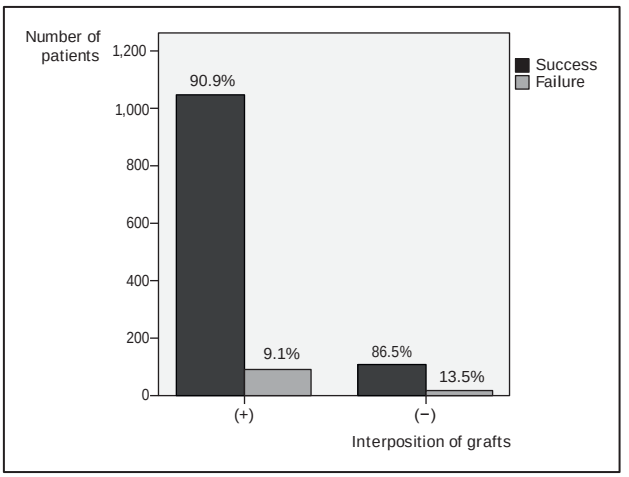

FIGURE 3. Closure rates according to the use of interpositional grafts. Complete closures were achieved more frequently by the use of interposing grafts compared with mucosal flap coverage alone, yet the difference was not statistically significant (P¼0.16, Pearson's x^2-test).

INTERPOSITION OF GRAFTS REGARDLESS OF THE TYPE OF GRAFT MATERIALS

High success rates with interposition of grafts have been repeatedly documented and opinions on the beneficial effect of each graft material did not differ from each other [4&&,5,28,51,52]. Despite exhaustive elevation of the mucosal flaps, viable mucosal lining can be frequently deficient, particularly in patients with large perforation, resulting in excessive tension on the perforation closure suture line. Excessive tension can be avoided by the incorporation of grafts, preventing distal flap ischemia and anastomosis breakdown that results in reperforation of the septum [36]. Moreover, grafts serve as a template for mucosal migration during the healing process and help prevent mucosal flaps from shrinking after rotation [23,53]. In our analyses, although the difference was not statistically significant, complete closures were achieved more frequently in the use of interposing grafts compared with mucosal flap coverage alone (P¼0.16, Pearson's x^2-test) (Fig. 3).

Among various graft materials, remnant of septal cartilage is considered the best intervening material because it can be obtained easily with minimal donor site morbidity [40,43]. Furthermore, it is preferred over other autologous grafts such as fascia and periosteum, as it provides greater support for the regenerating mucosa [23]. In patients with large perforation or with previous history of extensive septal trauma or surgery, however, cartilaginous remnants are usually insufficient and the quality of them can be quite low. Autologous auricular cartilage can be a good second option in such cases [9&,54]. The flattest part of auricular cartilage is usually utilized, but the curved areas can be used after flattening when a larger piece is required [40,55]. Although success rates between various graft materials are known not to differ from each other, some authors advocated the advantages of the dermal allograft, as it is thicker and, thus, easier to handle than autologous fascia or periosteum and readily available, thus saving operation time and eliminating donor-site morbidity [11,26,37,42]. Moreover, dermal allograft was proven to be biocompatible next to autologous cartilage by experimental animal study; proteoglycan in an allograft dermal matrix is known to provide a reservoir for growth factors, which guide collagen assembly and promote angiogenesis [11,56,57]. On the contrary, titanium membrane was applied to cases of large perforation in which remnant septal cartilage was lacking and outcomes appear to be satisfactory [58]. Similarly, there were articles on the successful closure by interposing bioactive glass or acellular soft tissue graft derived from porcine small intestinal submucosa [19,22]. In addition, bovine pericardium was also tested as interpositional graft by experiment with pigs, yet its biocompatibility has not been verified in humans [59].

Unlike previous studies, a recent case series suggested that NSP can be successfully repaired with no use of interposing grafts [6&&,60]. A newly devised wide local mucosal flap was introduced, which included mucosa of the nasal floor, the lateral wall in the inferior meatus, and the lateral surface of inferior turbinate. It was pointed out that the continuity of the flap in the area of perforation and the tension-free approximation of the flap, not the use of interposing grafts, were considered

as the critical factors for complete closure. In fact, even with incorporation of grafts, surgical outcomes can vary according to the types of flap utilized for the repair. For example, although cross-stealing technique was attempted by some surgeons, the closure rates were limited even with the use of interposing grafts [10,61]. Despite these controversies concerning the effectiveness of interpositional grafts, however, it is generally accepted that a high success rate can be achieved by incorporating graft materials [5].

SELECTION OF AN APPROACH

The external rhinoplasty approach showed a statistically higher surgical failure rate than the endonasal approach. However, the difference was ascribed to the confounding effect of the perforation size because the external rhinoplasty approach was more frequently employed for the repair of large perforation. The most distinguishable benefit from an endonasal approach over an external approach is that skin scars can be avoided. External skin scars are definitely unacceptable for some patients [9&]. Furthermore, articles showing favorable outcomes of NSP repair via an endonasal approach have recently increased despite its technical difficulties, particularly in cases of small-to-moderate perforations by the benefit of the endoscopic technique [14,40,62,63]. The highest success rate that has been reported to date is 100% via an endonasal approach [15]. In that study, all the patients with small-to-moderate perforations were successfully repaired via an endonasal approach and an external rhinoplasty approach was used only in cases of large perforation. The authors concluded that the repair of NSP can be easily accomplished by a well experienced surgeon by utilizing bilateral mucoperichondrial flaps and achieving tension-free closure via an endonasal endoscopic approach.

In practice, however, despite the aesthetic superiority of an endonasal approach, an external rhinoplasty approach is often utilized even in small-to-moderate perforations [4&&]. It appears that selection of an external approach often depends on the patient's desire for the correction of external nasal deformities as well as the size of the perforation. It allows full visualization of operative fields and bimanual manipulation and correction of the external nasal deformities which are frequently combined with NSP [4&&,37]. Furthermore, repair of NSP can be facilitated by using some of the routine rhinoplasty maneuvers such as medial osteotomies and dorsal lowering by providing more mucosal redundancy [16,37]. Accordingly, tension-less closure of the defect, which is crucial for the successful surgical outcome, could be more easily achieved by an external rhinoplasty approach. For beginners who lack surgical experience in unimanual manipulation, which is needed for an endonasal endoscopic approach, an external rhinoplasty approach will be a better choice in order to achieve complete closure.

On the contrary, the midfacial degloving approach was formerly used to repair septal perforations larger than 2 cm [64]. However, it appears not to be used any more due to its significant drawbacks, such as unparalleled exposure, intraoperative blood loss, long operation time, potential infraorbital nerve injury, vestibular stenosis, and asymmetry [36,65].

CONCLUSION

It is ascertained that the large NSP is a significant risk factor for surgical failure. With respect to the use of mucosal flap application, although unilateral flap coverage has its theoretical advantages, bilateral coverage would be more desirable, if feasible. Interpositional grafts seem to reduce reperforation rates, although there is still a controversy over their necessity.

Acknowledgements

None.

Conflicts of interest

The authors report no conflicts of interest.

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