The Results of Polypropylene Mesh Usage for Nasal Septal Perforation Repair: An Experimental Study

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Abstract

Objective: The aim of this study was to evaluate the effectiveness and biocompatibility of the polypropylene mesh in an animal model of nasal septal perforations on rabbits.

Materials and Methods: After creating a 1X1 centimeter full thickness defect on 12 rabbits, the perforation was reconstructed with two different methods. For Group 1, we used mucosal flaps and polypropylene mesh as an interpositional graft. For Group 2, we only used mucosal flaps. After four weeks we removed the nasal septa of the rabbits and we analyzed the samples for acute rejection, infection, inflammatory response, fibrosis and granuloma formation histologically.

Results: The samples of the Group 2 showed that all septal perforations remained the same. On the other hand, the septal structure remained intact on all samples of the Group 1. None of the samples of the Group 1 showed acute rejection or infection. Five samples of the Group 1 (62.5%) showed +1, one sample (12.5%) showed +2, and two samples (25%) showed +3 inflammatory response respectively. Three samples of Group 1 (37.5 %) did not show any fibrosis, four samples (50%) showed mild fibrosis and only one sample (12.5%) showed moderate fibrosis. In fact, total of seven samples (87.5%) showed mild fibrosis at most in the Group 1. We did not see any severe fibrosis at all. In the Group 1, we observed that six samples (%75) showed no granuloma formation as a foreign body reaction and two samples (25%) showed few giant cells. Also, severe vascular and epithelial proliferation was seen along the borders of propylene mesh.
Conclusion: Propylene mesh showed good biocompatibility with the septal mucosa, and it can be used for the repair of septal perforation as an interpositional graft safely.

Keywords: Septal perforation, interpositional graft, polypropylene, polypropylene mesh, septal perforation surgery

Introduction

The septal perforations which affect 0.9 % of the population is a relatively frequent clinical condition (1). Most septal perforations are iatrogenic, traumatic or drug-induced; however, inflammatory processes, malignity, and infectious diseases are among the rare etiologies.

Various techniques are described for the repair of perforations, and the most frequent method is the advancement of the mucosal flaps. If the area between the mucosal walls is left empty, the septum will lack the required resistance, and support. In fact, the septum will bend to the right, and left with each inspirium, and expirium, leading to nasal fullness. For this reason, cartilage or other materials are used as interpositional grafts between the mucosal walls. Several different success rates have been reported about these grafts in the literature, but reperforations are frequent in the long term follow-up. Nevertheless, the usage of cartilage and several biologic materials as interpositional grafts for avoiding the reperforation yields better results in the literature.

Polypropylene mesh is used successfully for the repair of inguinal hernia for a very long time. The native host tissue passes through the pores of this material, making it sturdy, biocompatible, and stable.

In our study, we have used the polypropylene mesh that has never been used before for the repair of the septal perforations. After perforating the septum of the rabbits, polypropylene mesh has been placed between the two mucosal flaps. Our aim was to determine the effectiveness of the polypropylene mesh in the repair of septal perforations.

Materials and Methods

This study was done with the 20110121 numbered consent of the ethical committee of Istanbul Bağcılar Training and Research Hospital Experimental Surgical Research and Skill Improvement Training Center. Twelve healthy adult New Zealand rabbits of the same age with weights ranging from 2510 to 3560 kilograms were included in our study.

The rabbits were assigned either to the study or the control groups. Eight rabbits were placed in the study group (Group 1). Interpositional graft (Polypropylene mesh) was used for the repair of the septal perforation, and it was covered with double sided mucoperichondrial flaps. Four rabbits were included in the control group (Group 2), and the septal perforation was reconstructed only with double sided mucoperichondrial flaps. No interpositional grafts were used in the Group 2.
Ketamine (35 mg/kg), and xylazine hydrochloride (5 mg/kg) were administered intramuscularly. Then, columellar incision was carried on the midline (Figure 1). The nasal skin was elevated on the midline, and the nasal dorsum was exposed (Figure 2). The nasal bone extends towards the nasal tip in the rabbits. For this reason, the nasal bones were separated with medial osteotomies in order to reach the nasal septum (Figure 3).

A full thickness septal perforation with the dimensions of 7X8 millimeters was created with the excision of the septal mucosa, and the cartilage. The mucoperichondrium of the septum was reached between the nasal bones which were separated after the osteotomy. These flaps were elevated on both sides of the septum towards the nasal base inferiorly. Thus, the mucoperichondrial flaps were based posteriorly. In the Group 1, a two layered polypropylene mesh with the dimensions of 1X1 centimeters was placed between the mucoperichondrium as interpositional grafts (Figure 4). The flaps were advanced bilaterally, and they were fixated with 4-0 absorbable sutures. No bioprosthetic material was placed inside the flaps of the rabbits of the Group 2. The raw surfaces of the flaps were coapted, and sutured to each other primarily in order to close the septal perforations.

The skin was repaired with 4.0 polypropylene sutures, and antibiotic ointment was applied on this site. The same ointment was applied once a day for four weeks. The rabbits were followed up for four weeks, and ketamine, and xylazine were administered as anesthetics. The columella was protected, and the septum was totally taken out. The septal specimen were fixated in 10 % formaldehyde solution, and they were sent to the pathology department for further examination. At the end of the study, all of the rabbits were sent back to the laboratory because the defects in the septa did not affect their lives.

Initially, the specimen that were excised from the nasal septa were examined macroscopically. The mucosal continuity over the graft, and the integrity between the graft, and the septum were assessed. Then, they were fixated with buffered 10 % formaldehyde solution for two days at the Bağcılar Training and Research Hospital Pathology Department. After the tissue follow-up process, the specimen were buried in paraffin blocks, and they were sectioned in 5 μm thickness. After the haematoxyline and eosin (H&E) staining, the microscope slides were examined under the light microscope (Olympus BX51), and the histopathologic changes were determined.

A biocompatible mesh material must be in a mechanic unity with the native tissue, and it must give an appropriate inflammatory reaction. Foreign body granuloma formation, inflammatory response, and fibrosis were assessed during the histopathological analysis, and the histological scales which were approved by the literature were utilized. The absence of fibrosis was designated as 0; mild fibrosis, medium fibrosis, and severe fibrosis were designated as 1, 2, and 3 respectively. The absence of inflammation was designated as 0; the presence of rare giant cells, lymphocytes, and plasmocytes were designated as 1. Giant cells, plasmocytes, and neutrophil presence were designated as 2. The widespread presence of inflammatory cells, and of microabscesses were designated as 3. On the other hand, the presence, and absence of foreign body granulomas were assessed (Table 1).

Results

The septa of eight rabbits in the Group 1 were exposed with the same incision. Macroscopically, the integrity between the native septum, and the polypropylene mesh was
acceptable. In fact, no perforation was seen. The septa of four of the rabbits in the Group 2 were examined macroscopically, and all of them were perforated.

The mesh materials of eight of the rabbits in the Group 1 were examined, and inflammatory response (host reaction) was seen in all of the specimen (100 %) (Figure 5).

The inflammatory response was + 1 in 5 of the specimen (62.5 %), and it was + 2 in one of them (12.5 %). The response (microabscess formation with dominant neutrophil clusters) was + 3 in 2 of the rabbits (25 %) (Table 2), (Figure 6).

In the Group 1, mild fibrosis around the mesh was detected in 4 rabbits (50 %). Medium fibrosis was detected in 1 rabbit (12.5 %), and no fibrosis was detected in 3 rabbits (37.5 %). In fact, total of seven samples (87, 5%) showed mild fibrosis at most in the Group 1. Severe fibrosis was seen in none of the rabbits (Table 3).

The foreign body reaction was limited to a few giant cells, and granuloma formation was seen in only 2 rabbits (25 %). No granuloma was seen in 6 rabbits (75 %) (Figure 7), (Table 4).

Dense vascular proliferation was present at the periphery of the mesh tissue, and reepithelisation was seen at these areas (Figure 8, 9, 10). As a result, the mesh material showed excellent biocompatibility with the septal mucosa.

**Discussion**

Septal perforation which can be either symptomatic or asymptomatic is seen in 0.9 % of the population (1). The septal perforations can be caused by iatrogenic conditions, trauma, digital trauma, or several medications. Inflammation, malignity, and infectious diseases are among the other causes of this pathology. The symptoms are correlated with the location, and size of the defect. The laminar air flow in the external nose is deranged in the presence of septal perforation; in fact, crusting, nasal bleeding, whistling, and fullness are among the most prominent symptoms (2).

Conservative, and surgical methods can be utilized in the reconstruction of the septal perforations. The most popular, and easy treatment is the temporary closure of the defect with a septal button. This silicon button can be applied in the office setting with either topical or local anesthesia. However, there are some complications related to this button. Nasal bleeding, crusting between the wings of the button, nasal pain, and increase in the dimensions of the defect due to the chronic irritation of the button are some of the complications (2). Døsen et al. worked on 47 patients with septal buttons, and they reported that 34 patients (67 %) did not have any benefits from this treatment. Two thirds of the patients could not tolerate the button, and they refused to use it after two months. The crusting, and nasal fullness are the most prominent complaints caused by the button. The remaining 13 patients were followed up for four years, and their complaints were evaluated with the visual analogue scoring system. Two patients were free of complaints. When the snoring was ignored, a total amelioration of 59 % in the visual analogue score was detected in the aspects of crusting, fullness, bleeding, pain, infection, button dislocation, and nasal discharge. Crusting, bleeding, and nasal fullness showed an improvement of 70 %. Although all of the 13 patients of the follow up were satisfied with the septal button, 8 of them stated that they would prefer surgery
In another study prepared by Osma et al., it was found that the septal button decreased the epistaxis; however, it did not inhibit the nasal whistling, and crusting (4). In the literature, it is reported that the conservative methods such as septal button, and nasal lavage enable a relief in some of the symptoms of the patients. However, these methods are found to be insufficient in the cases with large perforations. On the other hand, small perforations with epistaxis, and crusting can enlarge with the deterioration in the mucosal circulation. With the decrease in the nasal support, functional and aesthetic problems such as the saddle nose deformity can be seen. Due to their temporary effects, insufficiency in the treatment of the complaints, and the aforementioned complications, surgery has replaced the conservative techniques such as the septal button.

The aims of the surgical therapy are protecting the normal nasal physiology, enabling the mucociliary flow by maintaining the mucosal unity, avoiding the respiratory turbulence, and reconstructing the nasal septum that supports the nose. A tension free closure of the defect is obligatory for the optimal success of surgery. However, there is not a consensus about the surgical technique. Some authors suggest the transposition of nasal mucosal flaps, and other authors believe that the interpositional grafts placed between the nasal mucosal flaps increase the success of the repair. Actually, the dimensions of the perforation, its anteroposterior, and superolateral diameters, the amount of the remnant cartilage, the presence of the mucosal scar tissue, and the experience, and the skills of the surgeon affect the success of the treatment options (5).

Teymoortash et al. treated 13 patients with symptomatic septal perforation. They preferred unilateral inferior meatal mucosa for the reconstruction. The nasal floor mucosa was elevated from the edge of the perforation to the inferior part of the lower concha, and it was freed from the anterior to be transposed to the perforation site. The patients were followed up for an average of 3.5 months, and total closure, and full symptomatic relief were seen in all of them (6). Ileri et al treated 12 patients with septal perforations ranging from 5 to 30 mm in diameter, and they preferred the mucosa flaps for reconstruction. The mucoperichondrial flaps were elevated bilaterally, and after the elevation of the superior flap, the upper lateral cartilage was dissected without harming the perichondrium, and the elevation continued towards the inner surface of the cartilage. The mucoperichondrium over the septal cartilage was freed with releasing incisions from the nasal base, and the anterior part. It was freed from the lateral part at the ending point of the upper lateral cartilage. This flap was transposed, and the perforation was reconstructed. The patients were followed up for 6 to 9 months. The perforation was closed completely in 11 patients (92 %). The dimensions of the defect decreased in one patient, but it was not closed completely (7).

The septal perforation which can be repaired with mucosal flaps can also be reconstructed with interpositional grafts, placed between the mucosal flaps. Park et al. repaired the septal perforations with bilateral mucosal advancement flaps in 14 patients, and they were followed up for 6 months. In fact, successful closure was maintained in 12 patients (87.5 %). Interpositional grafts were used in 7 patients whose mucosal flaps were very thin, and whose closure was not tension free. The perforation of 2 patients were not closed, and interpositional grafts were not used in these patients. The perforations were repaired successfully in all the patients treated with interpositional grafts. The perforations were closed initially in these 2 patients without the interposition grafts, but the septa were reperforated in the long term follow-up. As a result, it was thought that the interpositional graft acts as a template in the regeneration of the poorly vascularized flaps (8). Taşkin et al used bilateral auricular cartilage as interpositional grafts, and they reconstructed the septal
perforations with bilateral mucosal advancement flaps. This technique was applied in 17 patients, and the perforation was closed in 16 of them (9).

In a review made by Kim et al., it was found that the success rate was 90.9% in the studies which used interpositional grafts between the flaps. On the other hand, it was 86.5% in the studies without the interpositional grafts, and this difference was not statistically significant. The factors that affect the success of the septal perforation reconstruction surgery were assessed in this review, and it was stressed that the utilization of interpositional grafts increased the surgical success. There was not a consensus on the type of the grafts in the studies of the review. None of the graft materials were found to be more effective; however, the remnant septal cartilage, and the allograft were advised because of minimal donor site morbidity (10). Goh et al. reviewed 49 studies about the surgical treatment of septal perforation reconstruction. These studies were classified in two major groups according to the preferred technique. The first group consisted of the studies with local mucosal transposition flaps, and the second group consisted of the studies with interpositional grafts sandwiched between local mucosal transposition flaps. A success rate ranging from 30 to 70% was found in the first group, and a success rate ranging from 67 to 100% was found in the second group (11). The authors hypothesized that this difference was caused by the insufficiency of the mucosal flaps and the vascular compromise due to the tension at the repair site in the cases without interpositional grafts. In fact, distal flap necrosis, and reperforation would be seen in such cases. On the other hand, the dimensions of the flap would decrease after the rotation of the flap, and it could be a cause for the failure. The authors believed that the application of grafts would alleviate these disadvantages, and the graft would act as a template during the mucosal healing (11). Moon et al. evaluated the factors that affect the success of the repair of septal perforation in 35 cases. Allografts (Alloderm, Gore-Tex, Lyodura), conchal or septal cartilage, temporal muscle fascia, or perpendicular plates were used as interpositional grafts. Bilateral mucosal transposition flaps were used in 28 patients, and 7 cases were treated with unilateral mucosal flaps. It was stressed that the usage of bilateral mucosal flaps was the most efficient way of decreasing the reperforation rates. Reperforation was seen in 11 of the 28 patients treated with bilateral mucosal flaps, and it was seen in 6 of 7 patients treated with unilateral flaps (p<0.05). The interpositional grafts were compared, and they were classified as allografts and autologous grafts. Perforation was seen in 8 of the 17 patients treated with allografts, and it was seen in 9 of the 18 patients treated with autologous grafts (p>0.05). Also, these two groups were compared in the aspect of relief in the complaints, regardless of the closure of the defect. The complaints were not relieved in 6 patients of the allograft group, and they were not relieved in 3 patients of the autologous group (p>0.05). As a result, various autologous, and alloplastic graft materials were used, and it was found that the result was not related to the type of the material. It was suggested that any graft material should be placed between the mucoperichondrial flaps (12).

The cartilage is the most popular interpositional graft material, and several materials such as bone, fascia, allograft, gore-tex, titanium, polyethylene, dacron, and bioactive glass are preferred too. The cartilage is the most favorite material because of its easy harvest, permanence, cost effectiveness, tissue compatibility, and the manipulability of its dimensions. However, the cartilage of some patients may be insufficient, and shapeless. For this reason, alternative materials are chosen. The role of the interpositional grafts in the success of the septal perforation repair is proven; however, the ultimate material, and the advantages of different materials over each other are not clear. According to Ansari et al, the ideal graft material must be free of donor site morbidity, and it must be accessed easily. It
must be cheap, versatile, easily fixated to the surgical field, and stable in shape and volume. The material must be similar to the missing tissue in the aspects of rigidity, and elasticity. Microscopically, it must be biointegrated easily to the host, and it must not aggravate any inflammation at the recipient site. The material has to be inert, and pure. The graft surface has to attach to the surrounding soft tissue without extreme mezenchimal infiltration, and capsule formation. The material must not cause carcinogenic processes, and it must not carry microorganisms such as human immunodeficiency virus or hepatitis virus. It has to be defensive against infections, and its degradation products must not be toxic (13).

Bioactive glass was preferred as a graft in the repair of septal perforation in a study conducted by Stoor et al. This biosynthetic material is composed of SiO$_2$ (53 \%), Na$_2$O (23 \%), CaO (20 \%), and P$_2$O$_5$ (4 \%). Bioactive glass was used in 23 of the 39 patients with septal perforations, and the remaining 16 patients were treated with sliced cartilage, or bone placed between the mucosal flaps. In 17 patients treated with bioactive glass, the perforation was closed, and none of the patients faced infection, or graft rejection. Fourteen of the 16 patients treated without the bioactive glass had full closure of the defect, and the remaining two patients were treated with a second operative stage of interpositional bioactive glass placement. It was stated that the bioactive glass avoided the adhesion, and growth of the upper respiratory tract pathogens such as Streptococcus pneumonia, and Haemophilus influenza (14). Kridel et al. worked on 12 patients, and they selected the acellular human dermis allograft for interposition between the bilateral mucosal advancement flaps. The perforation was closed in 11 of the repaired septa, and the perforation of the remaining patient became 5 millimeters in diameter from 3 centimeters. In fact, this patient was free of symptoms after the operation. Although alloderm yielded satisfactory perforation repair rates, it had risks such as infection transport, and inflammation triggering (15).

In our study, we preferred the polypropylene mesh which is frequently used, biocompatible, cheap, and manipulable in the aspect of dimensions. The septal tissue match was found to be satisfactory in our study. We showed that the mucosa could proliferate on this graft, and it could cover the edges of the defect as good as the cartilage. On the other hand, rejection was seen in none of the animals. The difficulty, and deficiency in the defect closure in rabbits without the interpositional grafts, and the 100 \% success in the polypropylene mesh group supported the efficiency of the graft. In our study, the fibrosis, and the foreign body granuloma were caused by the chronic inflammation that was stimulated by the graft material. However, we think that the immune system gives such a response in order to protect the graft material from infection, and rejection. We showed that the polypropylene mesh stimulated the immune system very mildly, causing limited fibrosis, and foreign body formation. Overall, rejection, and infection were not seen in any of the rabbits. The polypropylene mesh interposed between the septal mucosa integrated with the septal tissue very well, avoiding rejection. Also, this material enabled reepithelisation during the wound healing, and revascularisation between its pores. Thus, the biocompatibility of this material with the septal mucosa was very high.

In our study, we did not see any infection signs at the transplantation site caused by the polypropylene mesh. However, we were not able to find any signs, or symptoms about the carcinogenic properties of the material, due to the short follow-up period.

In the literature, alloderm is the most popular graft material in the repair of septal perforation. It is an organic substance, and theoretically, it has risks of carrying a slow virus disease, or a prion. Also, it can be resorbed in the long term, and it can lack the appropriate
support for the nose. The high cost is another disadvantage of allograft. On the other hand, the polypropylene mesh is an easily accessible, safe, and cost-effective material which has been utilized in gynecologic, and urologic surgeries for years.

The polypropylene mesh has been used as an interpositional graft in the repair of septal perforations for the first time. The low probability of fibrosis, and foreign body granuloma formation, the low risk of rejection, the ability of mucosal growth over its surface, and the ability of nasal support as a hard, and sturdy material can make the polypropylene mesh the first choice graft in the repair of nasal septal perforations.

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The Figure and Table Legend:

**Figure 1**: Horizontal nasal incision

**Figure 2**: The elevation of the nasal skin

**Figure 3**: The nasal septum after the medial osteotomy

**Figure 4**: Polypropylene mesh

**Figure 5**: Minimal inflammation around the mesh, and the area of fibrosis (H&E; X 200)

**Figure 6**: The microabscess formation around the mesh (Neutrophilic infiltration)(H&E; X 100)

**Figure 7**: The granuloma formation with a few giant cells (H&E; X200)

**Figure 8**: Prominent vascular proliferation under the epithelium (H&E; X200)

**Figure 9**: Reepithelisation under the mesh area (H&E; X40)
**Figure 10:** The septal mucosa that is covered with epithelium bilaterally, and with reepithelised mesh in the middle (H&E; X40)

**Table 1:** The pathological scoring

**Table 2:** The inflammatory response

**Table 3:** Fibrosis

**Table 4:** Foreign body granuloma