Cartilaginous and mucosal effects of absorbable versus nonabsorbable sutures in a rabbit nasal septoplasty model

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Abstract

Objective: To compare various types of absorbable and nonabsorbable sutures commonly used in the septoplasty procedure in terms of their effects on nasal mucosa and septal cartilage.

Methods: Ten New Zealand white male rabbits aged approximately 4 months and weighing from 2.5 to 3 kg (mean 2.74 kg) were included in the experiments and randomly divided into five groups each with 5 rats: 5-0 coated polypropylene (Prolene), 5-0 poliglecaprone 25 (Monocryl), 5-0 coated irradiated polyglactin 910 (Vicryl Rapide), polyglycolic acid (Vicryl), and polydioxanone (PDS). Five rabbits in each group were sacrificed at 15 days and 5 rabbits at 30 days after septoplasty, and nasal septal cartilage and surrounding mucosal tissue of the damaged side and contralateral normal side were removed for histopathological and scanning electron microscope (SEM) evaluations.

Results: Both histopathological and SEM evaluations of the specimens at 15 and 30 days after suturing indicated that the minimum mucosal and cartilaginous damage was induced by Vicryl Rapide suture followed by Monocryl, Vicryl, PDS and Prolene sutures. At 15 days after suturing, the thickness of mucosa was highest in Vicryl Rapide group and lowest in Prolene group (867.7 µm vs. 467.2 µm), but after 30 days it was highest in Prolene group and lowest in PDS group (590.9 µm vs. 373.7 µm). However, the cartilage thickness was highest in Prolene group and lowest in Monocryl group in both 15 days (503.9 µm vs. 357.0 µm) and 30 days (503.9 µm vs. 357.0 µm) assessments.

Conclusions: For suturing during septoplasty, Prolene, Monocryl, Vicryl Rapide, Vicryl, and PDS sutures have similar cartilaginous and mucosal effects in general, however Vicryl Rapide had best outcome on histopathological and SEM evaluations. Further clinical studies are needed to conclude on the clinical and histological effects of various suture types used in nasal septoplasty procedure.

Introduction

Septoplasty is one of the most common procedures applied in the practice of otorhinolaryngology [1,2]. It is an effective procedure performed to correct septal deviation causing nasal airway obstruction [3,4]. In order to minimize the postoperative complications such as bleeding, intranasal adhesions, cartilage perforation, and to maintain septal stability, postoperative packing or septal splints have been traditionally used, both of which are associated with significant morbidity [2,5]. To overcome the disadvantages of packing and splints, many surgeons recently use suturing technique, which closes mucosal tears and supports the septal cartilage, thus decrease the need for packing and septal splints [6-8]. Current data supports the use suturing technique as the first-line intervention during septoplasty [1].

Multiple different suturing techniques have been defined and performed by using various types of suture absorbable or nonabsorbable-in septoplasty surgery [3,9-13]. There is a wide range of suture materials mainly absorbable and nonabsorbable for surgical purposes [14]. Vicryl, Monocryl and PDS are examples of synthetic absorbable sutures, which are broken down in the tissue. In contrary, nonabsorbable sutures are not metabolized in the body, thus needs to be removed after a few weeks. Prolene is a monofilament nonabsorbable suture used in septoplasty. Although absorbable and nonabsorbable sutures have comparable cosmetic outcomes [15], there is no evidence on advantages and disadvantages of individual suture types used for septoplasty at histological level.

Therefore, in this study we aimed to compare various types of sutures commonly used in the septoplasty procedure in terms of their effect on nasal mucosa and septal cartilage. The results of this study would guide surgeons to choose the most appropriate suture for nasal septoplasty.

Materials and methods

Animals and experimental study design

The animal experiments and procedures were performed in accordance with national guidelines for the use and care of laboratory animals and were approved by the Bagcilar Education and Research Hospital Ethics Committee for Animal Research (2014/137). Ten New...
Zealand white male rabbits aged approximately 4 months and weighing from 2.5 to 3 kg (mean 2.74 kg) were included in the experiments and randomly divided into five septoplasty groups (each with a different suture).

After proper anesthesia, open nasal septoplasty incision was performed, and then sutured by using either of 5 sutures: 5-0 coated polypropylene (Prolene, Ethicon Inc., Somerville, NJ, USA), 5-0 poliglecaprone 25 (Monocryl, Ethicon Inc, Somerville, NJ, USA), 5-0 coated irradiated polyglactin 910 (Vicryl Rapide, Ethicon Inc, Somerville, NJ, USA), 5-0 polyglycolic acid (Vicryl, Ethicon Inc, Somerville, NJ, USA) polydioxanone (PDS), each for 8 rats randomly.

The 3 rabbits in each group were scarified at 15 days and 5 rabbits at 30 days after suturing, and nasal septal cartilage and surrounding mucosal tissue of the damaged side and contralateral normal side were removed for histopathological and scanning electron microscope (SEM) evaluations.

**Histological examination**

The specimens were fixed immediately in 10% buffered formaldehyde solution for 72 hours and then processed for routine light microscopic examination in tissue processing machine (Leica TP 1020, Wetzlar, Germany). Briefly they were dehydrated through a graded ethanol series (70%, 80%, 90%, 96%, and 100%), cleared in xylene for transparency, and embedded in paraffin blocks, which were sectioned at 5 µm thickness and stained with hematoxylin and eosin after deparaffinization. The samples were examined under a light microscope (Leica DM6000B, Wetzlar, Germany) and photographed by a digital camera (Leica DCA40, Wetzlar, Germany).

Each specimen was evaluated for mucosal inflammation and the loss of pseudostratified columnar epithelium. The severity of the inflammation was scored from 0 to 3 by the number of inflammatory cells in a ×400 magnification area (no inflammatory cells, 0; less than 10 inflammatory cells, mild, 1; 10-30 inflammatory cells, moderate, 2; and over 30 inflammatory cells, severe, 3).

The thickness of mucosa, perichondrium, cartilage, and the inner layer of perichondrium were measured from 5 different areas throughout mucosa with image analysis software and averaged (Leica Application Suite software, Leica).

**SEM analysis**

The fresh specimens were immediately fixed in 2.5% glutaraldehyde for 24 hours, washed in phosphate buffer (pH 7.4), post-fixed in 1% osmium tetroxide in phosphate buffer (pH 7.4), and dehydrated in increasing concentrations of alcohol. After dehydration, the specimens underwent drying to a critical point and were mounted on metal stubs with double-sided adhesive tape. Then, the samples were sputtered with 150-A° thick layer of gold in a sputter apparatus (Bio-Rad Laboratories, Inc., Hercules, California, USA). The images were taken by a SEM electron microscope (JEOL SEM ASID-10, Tokyo, Japan) within a magnification range of 500-3000.

**Results**

Both histopathological and SEM evaluations of specimens at 15 and 30 days after suturing indicated that the minimum mucosal and cartilaginous damage was induced by Vicryl Rapide suture followed by Monocryl, Vicryl, PDS and Prolene sutures.

On histological examination, nasal septal tissue was composed of hyaline cartilage in the middle and connective tissue on both sides, which contains lamina propria including glands, blood vessels and nerve fibers and pseudostratified columnar epithelium with goblet cells. In all study groups, suture material and its residuals were observed in the connective tissue beneath the epithelium on which debris was present.

**Findings at 15 days after suturing**

The specimens from all suture types showed continuous epithelium on the suture material obtained 15 days after suturing. Prolene suture (Figure 1) was close to surface. Empty space left by the suture material was surrounded by a thin capsule, which composed of fibroblasts and thick eosinophilic collagen fibrils in parallel to perichondrium. The collagen fibrils were looser in the contralateral side.

All the sutures induced significant mucosal edema and inflammation. The thicknesses of both mucosa and perichondrium were increased at sutured side compared to contralateral intact side in all suture groups (Table 1). The thickness of the layer of perichondrium where chondrogenic cells were located increased in Vicryl (Figure 2), Monocryl (Figure 3), PDS (Figure 4) and Prolene (Figure 1) sutures, as it did not show remarkable change in Vicryl Rapide suture (Figures 5-7) (Table 1).

On the sutured side, round maturing chondrocytes beneath flat chondroblasts were observed under the perichondrium, which indicate interstitial growth of cartilage. However, in the contralateral side, there was less chondroblasts and chondrocytes.

The mean cartilage thickness was highest in Prolene group and lowest in Monocryl group (503.9 µm vs. 357.0 µm) (Table 1).

**Findings at 30 days after suturing**

There was a slight mucosal edema and inflammation at 30 days after suturing in all suture types. The thicknesses of both mucosa and perichondrium were increased at sutured side compared to contralateral intact side (Table 2). Suture debris inside the mucosa in the form of
Table 1. Histopathological findings at 15 days after suturing. Data represent the mean of measurements from 5 rabbits in each suture group

<table>
<thead>
<tr>
<th></th>
<th>Vicryl</th>
<th>Vicryl Rapide</th>
<th>Monocryl</th>
<th>PDS</th>
<th>Prolene</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness of mucosa (µm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sutured side</td>
<td>609.6</td>
<td>867.7</td>
<td>581.0</td>
<td>361</td>
<td>467.2</td>
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<tr>
<td>Contralateral side</td>
<td>381.6</td>
<td>670.3</td>
<td>221.0</td>
<td>218</td>
<td>338.7</td>
</tr>
<tr>
<td>Thickness of perichondrium (µm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sutured side</td>
<td>60.2</td>
<td>133.8</td>
<td>54.6</td>
<td>55</td>
<td>82.2</td>
</tr>
<tr>
<td>Contralateral side</td>
<td>52.2</td>
<td>51.6</td>
<td>27.3</td>
<td>25</td>
<td>50.4</td>
</tr>
<tr>
<td>Thickness of inner cellular perichondrium (µm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sutured side</td>
<td>15.3</td>
<td>12.4</td>
<td>12.3</td>
<td>15</td>
<td>14.7</td>
</tr>
<tr>
<td>Contralateral side</td>
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<td>12.1</td>
<td>9.4</td>
<td>14</td>
<td>13.1</td>
</tr>
<tr>
<td>Thickness of cartilage (µm)</td>
<td>424.6</td>
<td>378.1</td>
<td>357.0</td>
<td>488</td>
<td>503.9</td>
</tr>
<tr>
<td>Severity of inflammation</td>
<td>2.0</td>
<td>2.5</td>
<td>2.7</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td>New cartilage formation</td>
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<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Edema</td>
<td>2.0</td>
<td>0.5</td>
<td>2.0</td>
<td>1.0</td>
<td>2.3</td>
</tr>
</tbody>
</table>

We observed thick collagen fibrils and active fibroblasts inside the lamina propria just under suture material, which were better organized than 15 days. The fibroblasts inside the perichondrium, chondrogenic cells, and flat chondroblasts were increased in the suture side supporting the appositional and interstitial growth. Furthermore, active chondrocytes grouped in two or three cells under perichondrium. These chondrocytes had cytoplasmic basophilic areas, which are indicative of protein synthesis, and transparent areas just above the cytoblast, which are indicative of large Golgi complex actively producing matrix. The contralateral side showed fewer maturing chondrocytes. Perichondrium had more cells compared to 15 days. The specimens from Prolene group contained more differentiation of chondrocytes in the suture side than PDS group. In all groups, contralateral side had increased differentiation of chondrocytes and chondroblasts. In 2 out of 4 samples from Vicryl Rapide group there was formation of new cartilage in the connective tissue above the existing cartilage.

Discussion

In this experimental study, we compared the mucosal and cartilagenous effects of various absorbable and nonabsorbable sutures used in septoplasty surgery, and found that among Prolene, Monocryl, Vicryl Rapide, Vicryl, and PDS sutures, Vicryl Rapide has best mucosal and cartilagenous effects on both histopathology and SEM.

Septoplasty is a very effective surgical procedure to correct nasal septal deformity causing airway obstruction [16]. Although it has been known for thousands of years and widely performed [9], a clinical consensus statement has only recently been published by American Academy of Otolaryngology addressing definition, diagnosis, medical management, surgical, perioperative, and postoperative procedures in nasal septoplasty [17]. According to this statement, nasal septoplasty was defined as a surgical procedure aimed to correct a deviated nasal septum for the purpose of improving nasal function and/or form. Additionally, it was stated that sutures can obviate the need for nasal packing after septoplasty [17]. Supporting this recent statement, previous comparative studies proved the superiority of suturing technique over nasal packing in septoplasty procedure. In a retrospective analysis of 697 septoplasty cases, Cukurova et al. [18] compared trans-septal suturing with the anterior packing technique and found that postoperative pain was significantly less in patients undergoing trans-septal suturing. Similarly Ghimre et al. [19] indicated the superiority of trans-septal suturing over nasal packing in terms of postoperative pain, complications and hospital stay. In a meta-analysis of 869 patients from eight randomized controlled trial, postoperative pain and headache were found to be significantly lower in trans-septal suturing group than...
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Figure 4. Histopathological findings of vicryl suture at 15th and 30th days

Figure 5. Histopathological findings of monocryl suture at 15th and 30th days
Figure 6. Histopathological findings of PDS suture at 15th and 30th days

Figure 7. Histopathological findings of rapid vicryl suture at 15th and 30th days
conventional nasal packing, thus suturing techniques were suggested as the first-line intervention in septoplasty for prevention of bleeding, enhancement of apposition of mucosal flaps and stabilization of septal cartilage [1].

Although suturing is commonly accepted as the first-line intervention to prevent postoperative complications of nasal septoplasty, there is no report in the literature on the type of suture material used for septoplasty. In this respect, this is the first study evaluating the effects of various absorbable and nonabsorbable sutures on mucosa and cartilage of nasal septal tissue. We used a rabbit septoplasty model by performing open nasal septoplasty incision, which is a commonly used model in literature to simulate septoplasty procedure in human [20-22]. We used four absorbable (Vicryl, Vicryly Rapide, Monocryl and PDS) sutures and one nonabsorbable (Prolene) suture, all are widely utilized in clinical practice of septoplasty procedure. Previous studies comparing absorbable and nonabsorbable sutures mainly focused on the cosmetic results, surgical site infection and other operative morbidity of suture materials caused by suture materials [23,24]. This is the first study evaluating the mucosal and cartilaginous effects of various sutures used in septoplasty procedure by histopathology and SEM.

Our findings indicated that all the suture types induced significant mucosal edema and inflammation, increase in mucosal and perichondrial thicknesses, and interstitial growth of cartilage. In general, there was no remarkable difference between suture types in terms of their effect on nasal mucosa and septal cartilage. However, both histopathological and SEM evaluations indicated that the best mucosal and cartilaginous response was obtained by Vicryl Rapide suture followed by Monocryl, Vicryl, PDS and Prolene sutures.

In conclusion, for suturing during septoplasty, Prolene, Monocryl, Vicryl Rapide, Vicryl and PDS sutures have similar cartilaginous and mucosal effects in general, however Vicryl Rapide had best outcome on histopathological and SEM evaluations. Based on findings of this experimental model, further clinical studies are needed to conclude on the clinical and histological effects of various suture types used in nasal septal procedure and to guide the surgeons in the process of selecting the best suture material.

References
4. de Ru JA (2015) Septoplasty is a proven and effective procedure: an expert's view of a burning issue. B-ENV 11: 257-262. [Crossref]