

# Effects of Different Suture Materials on Cartilage Reshaping

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**Objective:** To examine the effects of different suture materials and suturation techniques on cartilage reshaping in a rabbit model.

**Methods:** Twenty-two rabbits were used. Posterior skin flaps were elevated, and 4 cartilage struts were prepared on each auricula. Each strut was bent at its midpoint, and the skin under the bent area was elevated only in 1 side. The strut was sutured either with catgut, polyglactin 910, polydioxanone, or polypropylene sutures. Anteriorly, the suture was passed subcutaneously on 1 side, while transcutaneously on the other. Animals were killed at the first and fourth months. The shape of the struts was macroscopically evaluated. Inflammation and foreign body reaction around the suture were examined under light microscopy.

**Results:** Maintenance of shape with all suture materials was significantly lower in the transcutaneously sutured group than in the subcutaneously sutured group. Because of high rates of suture loss in the transcutaneously sutured group, further evaluations on cartilage tissue were made only in subcutaneously sutured group. Success rate in maintenance of shape was similarly high in the polydioxanone, polyglactin 910, and polypropylene suture groups; however, it was significantly lower in the catgut suture group.

**Conclusion:** Long-lasting absorbable suture materials are as effective as nonabsorbable ones, and the subcutaneous technique is more effective than the transcutaneous technique.

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**C**ARTILAGE RESHAPING IS widely used in rhinoplasty and otoplasty procedures. The excision, scoring, suturing, and grafting of the cartilage may be used in reshaping. The suturing is an effective method in controlling the shape and curvature of the cartilage.<sup>1</sup> Sutures may be applied in otoplasty, septoplasty, correction of the bulbous and broad nose, collapsed internal or external nasal valves, warped grafts, and struts.<sup>1,2</sup> Also, sutures reestablish tip strength, which might be lost with incisions, and provide better long-term tip shape.<sup>3</sup> The fibrocartilaginous proliferation and new cartilage formation further strengthen the stabilization of the cartilage.<sup>2</sup> The reshaped cartilage is naturally prone to return to its initial position due to intrinsic forces.<sup>4,5</sup> Two to twelve weeks are needed for the formation of scar tissue and achievement of the permanent shape.<sup>2,6</sup> The type of the suture material used in reshaping is important, since the reshaped cartilage may return to its original position if the suture material is lost earlier than the time needed to maintain the shape. Placement of the suture under the vestibular skin or mu-

cosa is also important to prevent infection and extrusion.<sup>3,7-9</sup>

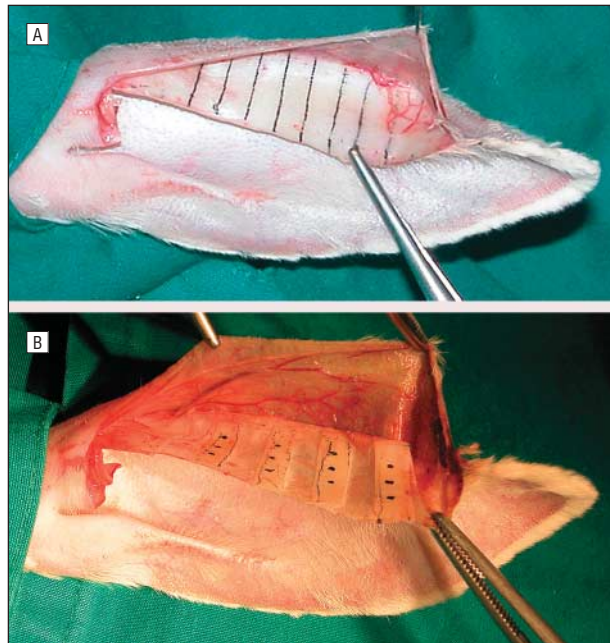
Various suture materials such as catgut, polyglactin 910, polydioxanone, nylon, and polypropylene are used for the cartilage reshaping.<sup>1,7,10-13</sup> However, the nature, absorption time, and tissue reactivity of these suture materials differ, and this must be taken into account when choosing the suturing material. Although there are many studies in the literature about the effect of different suture materials on soft tissue,<sup>14-18</sup> the effect of suture materials on cartilage tissue and which suture material is the best for the cartilage reshaping has not yet been identified.

Our aims in this study were to examine the effects of different suture materials and suturation techniques on cartilage reshaping and to compare tissue reactions caused by these suture materials on cartilage tissue in the rabbit model.

## METHODS

The ethics committee of Baskent University, Ankara, Turkey, approved the study, and all procedures were in compliance with the *Guide*

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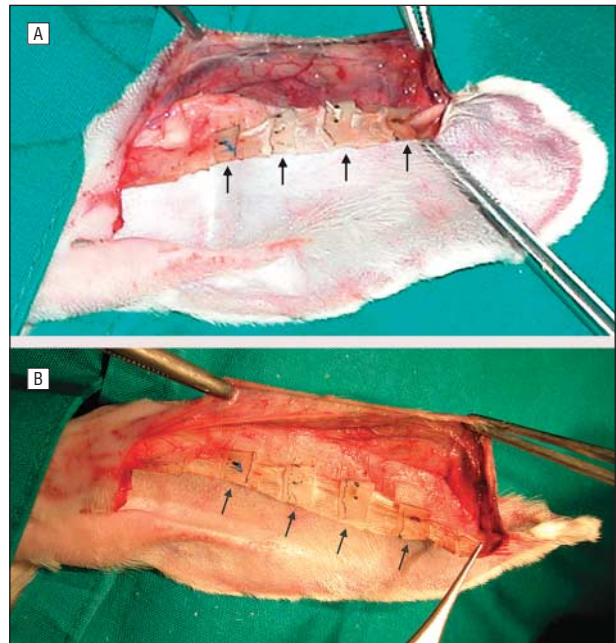


**Figure 1.** Preparation of the 4 cartilage struts. A, The incision lines were marked. B, The cartilage pieces between the struts were resected, and the locations of the sutures around the midpoints were marked.

for the Care and Use of Laboratory Animals.<sup>19</sup> In the present study, 22 white Vienna rabbits were acquired for the experiment. The animals were aged 8 months to 1 year and weighed 2 to 3 kg. No rabbits died before the end of the study.

Each rabbit was administered general anesthesia with an intramuscular injection of 50-mg/kg ketamine hydrochloride and 5-mg/kg xylazine. The auriculae were cleaned with polyvinylpyrrolidone iodine solution, 10%, and draped in a sterile environment. Following infiltration anesthesia with 1-mL lidocaine, an incision was made at the dorsal surface of the auricula. The posterior skin flap was elevated until a piece of cartilage (5.0 × 2.5 cm) was exposed. On each auricular cartilage, 4 bridge-like cartilage struts (each 0.5 × 2.0 cm) were obtained by excising the cartilage pieces between the struts (**Figure 1**). The middle portion of each cartilage strut was then bent over itself on the longitudinal midpoint. The anterior skin flap under the bent area was elevated on the left auricula, while it was not elevated on the right auricula. Four different suture materials with the same type of needle (16-mm cutting needle) and thickness (4-0) were used: catgut (Katgut; Dogsan AS, Trabzon, Turkey), polyglactin 910 (Vicryl; Ethicon Inc, Johnson and Johnson Co, Somerville, New Jersey), polydioxanone (PDS; Ethicon Inc), and polypropylene (Prolene; Ethicon Inc). A mattress suture with one of these sutures was passed through the posterior aspect of cartilage, approximately 2 mm ahead of the middle of the bending point (**Figure 1**). Consequently a slim, Ω-shaped cartilage was obtained. Anteriorly, the suture was passed through the 2 folds of the bent cartilage (subcutaneously) on the left auricula and through the 2 folds of bent cartilage and the anterior auricular skin between the cartilage folds (transcutaneously) on the right auricula (**Figure 2**). The posterior skin flap was relaid to the original position and fixated with transcutaneous 5-0 catgut suture to prevent hematoma. The antibiotic prophylaxis was made with penicillin G procaine (300 000 IU) + penicillin G potassium (100 000 IU). Intramuscularly, 40 000 IU/d were administered for 1 week.

Half of the animals were killed during the first month to demonstrate early changes on the cartilage tissue, and the remaining animals were killed in the fourth month to evaluate the long-



**Figure 2.** Arrows show the cartilage struts that were sutured transcutaneously on the right ear (A) and subcutaneously on the left ear (B) with polypropylene, polydioxanone, polyglactin 910, and catgut sutures (from left to right).

term effects. Posterior skin flaps on the auricula was elevated, and a macroscopic examination of the cartilage was performed (**Figure 3**). During the visual examination, the presence of struts, persistence of the suture materials, and the shape of the cartilage struts were inspected. When the suture was present and tied, it was accepted as persistence of suture material. If the suture was absent or had become untied, it was accepted as suture loss. If the cartilage struts flattened partially or totally, the maintenance of shape was accepted as failed. If the Ω shape of the cartilage struts persisted, the maintenance of shape was accepted as achieved. Later, pathological examinations of the cartilage specimens were made.

Specimens were fixed in 10% formalin solution. Transverse sections of sample tissues were taken at the folded areas around the suture level. After a routine follow-up examination, specimens were mounted in paraffin blocks. Sections (4-μm-thick) were taken from the cut surface of the tissues with a rotary microtome. Hematoxylin-eosin stains were used for each section. Each specimen was examined microscopically for the presence of inflammation and foreign body reaction around the suture materials (**Figure 4** and **Figure 5**).

SPSS statistical software (version 10.0; SPSS Inc, Chicago, Illinois) was used for all calculations. The  $\chi^2$  and Fisher exact tests were used to compare findings.  $P < .05$  was considered statistically significant.

## RESULTS

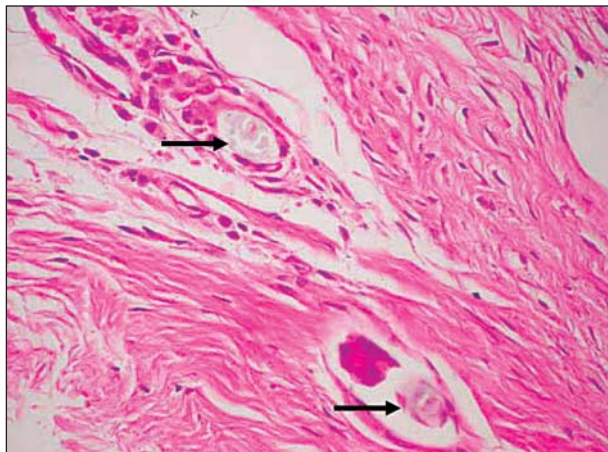
During the macroscopic examination, 42 of the cartilage (catgut was used in 13, polyglactin 910 in 13, polydioxanone in 9, and polypropylene in 7) struts were found to be completely absent. No sign of infection was observed around the localization of these lost struts. These absent struts were excluded from the study, and future research was performed on the remaining 134 struts.

The comparison of suture loss and maintenance of the shape between and within the transcutaneously and sub-



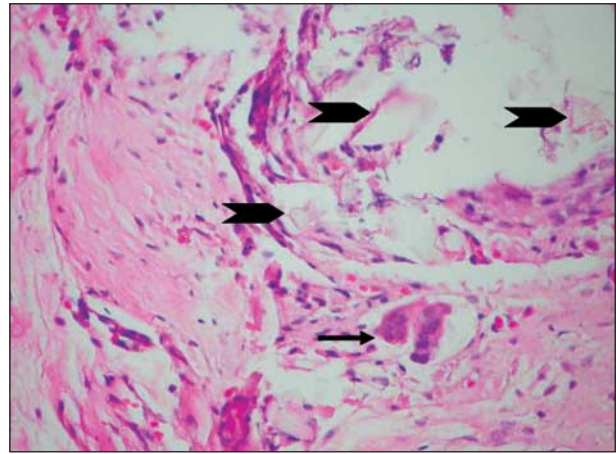


**Figure 3.** Specimens of the left and the right ears at the postoperative fourth month. The upper specimen is from the right ear (transcutaneously sutured struts), and the lower one is from the left ear (subcutaneously sutured struts). The order of suture types from left to right was as follows: polypropylene, polydioxanone, polyglactin 910, and catgut. All struts in the transcutaneously sutured group were completely flattened. In the subcutaneously sutured group, the struts that were sutured with polypropylene and polydioxanone persisted in the given shape and the struts sutured with polyglactin 910 and catgut were partially flattened.



**Figure 4.** The multinucleated foreign body giant cells surround the polypropylene suture (arrows) (hematoxylin-eosin, original magnification  $\times 400$ ).

cutaneously sutured groups is given in **Table 1**. The *P* values in the columns are the statistical results of the comparison between the transcutaneously and subcutaneously sutured groups of the same suture material. The *P* values in the last row of Table 1 are the statistical results of the comparison of different suture materials within the corresponding transcutaneously and subcutaneously sutured group. The rate of suture loss for all types of suture materials was higher in the transcutaneously sutured group compared with the subcutaneously sutured group (Table 1). The difference, however, was found to be statistically significant only for the polydioxanone and polypropylene sutures (*P* = .03 and .002, respectively). Maintenance of the shape with all types of su-



**Figure 5.** The polydioxanone suture material in the cartilage tissue (arrowheads) and the multinucleated foreign body giant cells (arrow) (hematoxylin-eosin, original magnification  $\times 400$ ).

ture material was significantly lower in the transcutaneously sutured group than in the subcutaneously sutured group (Table 1). Maintenance of the shape was significantly lower with catgut suture than it was with polyglactin 910, polydioxanone, and polypropylene sutures in the subcutaneously sutured group. Because of high rates of suture loss in the transcutaneously sutured group, further evaluations on the cartilage tissue were made only in the subcutaneously sutured group.

Comparison of the macroscopic and microscopic findings of the different suture materials between and within first- and fourth-month groups are presented in **Table 2** and **Table 3**. The *P* values in the columns in Table 2 and Table 3 are the statistical results of the comparison of the same suture material between the first- and fourth-month groups. The *P* values in the last row in Table 2 and Table 3 are the statistical results of the comparison of different suture materials within the corresponding first- and fourth-month group. The presence of catgut suture was found to be significantly lower compared with polyglactin 910, polydioxanone, and polypropylene sutures at the first month (*P* = .04) (Table 2). At the fourth month, the only visualized suture materials were polydioxanone (1 of 7 struts [14%]) and polypropylene (7 of 9 struts [78%]). The other suture materials could not be seen macroscopically, and this difference was statistically significant (*P* = .001). Presentation of suture material at the fourth month was significantly reduced only for the polydioxanone suture (*P* = .02).

At both the first and fourth months, the rate of success in maintenance of the shape was similarly high in the polydioxanone, polyglactin 910, and polypropylene suture groups, while it was significantly low in the catgut suture group (*P* = .04 and .009, respectively) (Table 2). There was no significant difference in maintenance of the shape with any of the suture materials between the first and fourth months.

When inflammation and foreign body reaction to different suture materials within the first- and fourth-months groups were compared, only the foreign body reaction to polydioxanone suture was found to be significantly higher than the other suture materials at the

**Table 1. Comparison of Macroscopic Findings of Different Suture Materials Within and Between the Transcutaneously and Subcutaneously Sutured Groups<sup>a</sup>**

Suture Type	Existence of Suture			Maintenance of Shape		
	Transcutaneous	Subcutaneous	P Value	Transcutaneous	Subcutaneous	P Value
Catgut	1/16 (6)	2/15 (13)	.60	1/16 (6)	<b>6/15 (40)</b>	<b>.04</b>
Polyglactin 910	1/15 (7)	4/16 (25)	.33	2/15 (13)	14/16 (88)	<b>.001</b>
Polydioxanone	2/18 (11)	8/17 (47)	<b>.03</b>	5/18 (28)	16/17 (94)	<b>.001</b>
Polypropylene	4/18 (22)	<b>15/19 (79)</b>	<b>.002</b>	7/18 (39)	17/19 (90)	<b>.004</b>
P value	.44	<b>.001</b>		.10	<b>.001</b>	

<sup>a</sup>Values in bold are statistically significant ( $P < .05$ ).

Data are given as number of struts with positive findings/total number of struts (percentage), unless otherwise specified.

**Table 2. Comparison of the Macroscopic Findings of the Different Suture Materials Within and Between the First- and Fourth-Month Groups<sup>a</sup>**

Suture Type	Existence of Suture			Maintenance of Shape		
	Month 1	Month 4	P Value	Month 1	Month 4	P Value
Catgut	<b>2/8 (25)</b>	0/7	.47	<b>3/8 (38)</b>	<b>3/7 (43)</b>	>.99
Polyglactin 910	4/9 (44)	0/7	.09	8/9 (89)	6/7 (86)	>.99
Polydioxanone	8/10 (80)	1/7 (14)	<b>.02</b>	9/10 (90)	7/7 (100)	>.99
Polypropylene	8/10 (80)	<b>7/9 (78)</b>	>.99	8/10 (80)	9/9 (100)	.47
P value	<b>.04</b>	<b>.001</b>		<b>.04</b>	<b>.009</b>	

<sup>a</sup>Values in bold are statistically significant ( $P < .05$ ).

Data are given as number of struts with positive findings/total number of struts (percentage), unless otherwise specified.

**Table 3. Comparison of the Pathologic Findings of the Different Suture Materials Within and Between the First- and Fourth-Month Groups<sup>a</sup>**

Suture Type	Inflammation			Foreign Body Reaction		
	Month 1	Month 4	P Value	Month 1	Month 4	P Value
Catgut	8/8 (100)	3/7 (43)	<b>.03</b>	5/8 (63)	0/7	<b>.03</b>
Polyglactin 910	7/9 (78)	1/7 (14)	<b>.04</b>	4/9 (44)	0/7	.09
Polydioxanone	8/10 (80)	3/7 (43)	.16	2/10 (20)	<b>4/7 (57)</b>	.16
Polypropylene	6/10 (60)	2/9 (22)	.17	6/10 (60)	2/9 (22)	.17
P value	.24	.54		.22	.02	

<sup>a</sup>Values in bold are statistically significant ( $P < .05$ ).

Data are given as number of struts with positive findings/total number of struts (percentage), unless otherwise specified.

fourth month ( $P = .02$ ) (Table 3). When tissue reaction to the suture materials between the first and fourth months were compared, the incidence of inflammation and foreign body reaction around the catgut suture and the inflammation around the polyglactin 910 suture were reduced significantly at the fourth month ( $P = .03$ ,  $.03$ , and  $.04$ , respectively) (Table 3).

#### COMMENT

In our study, we found higher rates of suture loss for all types of suture materials in the transcutaneously sutured group than in the subcutaneously sutured group, and this difference was statistically significant in the polydioxanone and polypropylene suture groups. Subcutaneous passage of suture protects the surrounding

skin, which is an important barrier for external infective agents. Because this barrier is not intact in transcutaneous suturation, the transcutaneously sutured group carries higher infection and extrusion risks that may lead to early loss of suture materials. Accordingly, shape maintenance with all suture materials in the transcutaneously sutured group was significantly lower than in the subcutaneously sutured group. In addition, the direct contact between facing cartilage surfaces in the subcutaneous suturation technique promotes fibrotic tissue formation and stabilizes the reshaped cartilage. In contrast, the presence of skin or mucosa between 2 cartilage surfaces in the transcutaneous suturation may impede the fibrocartilaginous proliferation and consequent stabilization of the reshaped cartilage. Because of these unexpectedly high rates of suture

loss in the transcutaneously sutured group, further evaluations on cartilage tissue were made only in the subcutaneously sutured group.

If suture material used in reshaping the cartilage is lost earlier than the time needed for maintenance of its new shape, the cartilage may return to its original position. The absorption process of catgut and polyglactin 910 sutures are completed between 30 and 80 days and 60 and 90 days, respectively.<sup>14-16,20</sup> Polydioxanone has prolonged absorption time when compared with polyglactin 910, and complete absorption does not occur until 180 days.<sup>16,17</sup> Polypropylene has no apparent degradation or absorption. In our study, there was no significant difference in terms of maintenance of the shape among subcutaneous polyglactin 910, polydioxanone, or polypropylene suture groups at the first and fourth months. However, at the first and fourth months, maintenance of the shape of the cartilage with catgut suture was found to be significantly worse compared with the other suture materials. Although most polydioxanone and all polyglactin 910 sutures were not seen macroscopically at the fourth month, the success in maintaining the shape with these 2 long-lasting absorbable suture materials was similar with nonabsorbable polypropylene suture at both terms. These findings led us to believe that the absorption period of the polyglactin 910 and polydioxanone sutures was long enough to stabilize the reshaped cartilage. Our results support those of DeMars and colleagues<sup>6</sup> showing that permanence of cartilage reshaping does not depend on durability of suture material after the formation of scar tissue. Because 2 to 12 weeks are enough for the formation of scar tissue that will maintain the shape in place,<sup>2,6</sup> we do not expect additional changes in the reshaped cartilage after 4 months.

The inflammatory reactions due to the passage of needle and suture through the soft tissue are observed in all suture materials during the first 7 days.<sup>15</sup> The reaction to the suture material is directly related to the nature, type, and rate of degradation of the material. The tissue reaction to catgut suture is high, to polydioxanone is slight, to polyglactin 910 is between minimal and slight, and to polypropylene is minimal.<sup>14,16-18</sup> In our study, the incidence of inflammation was high for each suture material at the first month and reduced at the fourth month. This decrease was statistically significant in catgut and polyglactin 910 sutures. Although polypropylene is accepted as an inert material,<sup>14,16</sup> we observed inflammation at cartilage around the polypropylene sutures in 60% and 22% of the animals at the first and fourth months, respectively. The high incidence of inflammation observed for all types of suture materials at the first month can be explained by the traumatic effect of the suturation process. While there was no foreign body reaction to catgut and polyglactin 910 sutures, we observed increased foreign body reaction to polydioxanone suture at the fourth month. Since we did not observe polydioxanone suture in the majority of cartilage specimens during the macroscopic examination at the fourth month, the high foreign body reaction may imply that the absorption process of the polydioxanone suture is continuing.

According to observation in human subjects, it is stated that the type and size of the suture material is the least important in cartilage reshaping.<sup>3</sup> However, the nonabsorbable sutures have a potential for late complications such as infection, foreign body reaction, and extrusion.<sup>1,3,9</sup> However, Tebbets<sup>10</sup> reported no suture complication in his patient series with polypropylene or nylon suture during 1 to 7 years of follow-up, nonabsorbable sutures were reported to result in more long-term problems compared with absorbable sutures, especially in cases with poor soft tissue coverage above the suture.<sup>1,3,9</sup>

There are some limitations of our study. The reshaped rabbit ear cartilage struts might be exposed to more external trauma owing to their positions compared with human cartilage. Consequently, lower rates of suture loss could be expected in humans. In addition, findings from animal studies are only partially transferable to humans because of the differences in metabolism between the species. Although our study is based on an animal model, its results provide valuable information regarding the comparison of different suture materials and techniques. Our results suggest that long-lasting, absorbable suture materials (polyglactin 910 and polydioxanone sutures) are as effective as nonabsorbable (polypropylene) suture in maintaining the shape of the cartilage. Regarding the suturation technique, subcutaneous suturation better preserves the reshaped cartilage compared with transcutaneous suturation. We advise the use of long-lasting absorbable suture materials and subcutaneous technique instead of nonabsorbable materials and transcutaneous technique.

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