Rhinoplasty is one of the most commonly requested and performed plastic surgery procedures and it is often regarded as the most difficult. The width of the nasal tip, which is determined by the position and width of the lower lateral cartilage, is frequently the cause of patient complaints during rhinoplasty consultation. Furthermore, otoplasty is the most commonly performed procedure of the external ear framework; prominent ears affect approximately 5% of the population and represent the most common congenital deformity of the external ear. The frequencies with which these two techniques are performed makes the reduction of complications associated with reshaping and transformation of the existing cartilages an important issue.

Numerous methods have been described to narrow the nasal tip and control the curvature of the nasal and auricular cartilage. Suture techniques to reshape cartilage have been described since the early 20th century. Mustardé and Tardy et al reported various suture techniques to modify the shape of prominent ear cartilage. The first suture in tip rhinoplasty was described by Joseph in 1931 and is considered the beginning of modern rhinoplasty. Many tip suturing techniques have evolved since then.

All of these suturing techniques for both otoplasty and rhinoplasty may serve different purposes. However, they have one thing in common—they rely on the suture to achieve and maintain the intended shape. Most surgeons have used nonabsorbable suture materials, such as nylon or polypropylene, to ensure that the cartilage change will be enduring. The use of permanent sutures to secure the cartilages raises issues with respect to palpability, extrusion, foreign body reaction, and infection. While the use of absorbable suture materials is one of the most commonly used means to reshape the nasal cartilage; however, no data exist regarding the optimal suture material and its long-term effect.

Objective: The aim of the present study was to determine whether any absorbable materials will provide the same long-lasting effect on cartilage reshaping as permanent materials.

Methods: Thirty-six New Zealand white rabbits were divided into three groups of 12. A 3 mm × 4 mm cartilaginous fold was created on a 5 mm × 10 mm in situ strip of cartilage on the posteromedial surface of each ear with different suture materials to simulate transdomal sutures. Nylon was used as a control suture material on the right ear of every rabbit, while plain catgut, monocryl, or polydioxanone (PDS) was used on the left ear, depending on the study group. At the end of 3 months, the folds were harvested and their dimensions and histology were compared.

Results: The cartilaginous folds were graded on a scale of 1 to 4 based on the final fold height measurement. The mean grades were 3.51 for nylon, 3.50 for PDS, 2.08 for monocryl, and 1.83 for plain catgut. Nylon provided a significantly better fold grade compared to monocryl and plain catgut (P < .05 for both groups), whereas there was no difference between the fold created with nylon and PDS (P > .05). Among the pathologic factors examined, only the amount of adipose tissue between the fold correlates with a higher fold grade (P < .05).

Conclusions: Cartilaginous folds created using PDS are comparable to those created using nylon and are significantly better than monocryl and plain catgut materials. On this animal model, it appears that permanent suture material is not required to maintain a long lasting cartilaginous fold as long as the suture material holds the fold in shape for a certain period of time. (Aesthetic Surg J 2009;29:93–97.)
Material may decrease these risks, no experimental evidence is available concerning the effect of such materials on the durability of the newly achieved cartilage shape. The objective of the present study was to determine whether any absorbable materials could provide the amaranthine effect on cartilage reshaping as non-absorbable materials. We also analyzed these induced cartilaginous folds histologically to assess the possible cause of the cartilage reshaping. This is the first study, to our knowledge, that investigates the effect of different types of suture materials used for cartilage reshaping.

MATERIALS AND METHODS

Young adult New Zealand white rabbits (weight 2.5 to 3 kg) were used to prevent the rapid healing and remodeling response seen in immature animals. US Public Health Service guidelines for humane care and use of laboratory animals were followed. Thirty-six rabbits were divided into three groups of 12 and the different absorbable suture materials were used to create the cartilaginous fold on each group. The control suture material, 5-0 nylon, was used on the right ear of every rabbit. Plain catgut (5-0), 5-0 monocryl, and 5-0 polydioxanone (PDS) were used on the left ear, to serve as the experimental ear.

A 5 mm × 10 mm in situ strip of cartilage was isolated on the posteromedial surface of the rabbit ear, 5 cm from the tip and 1 cm from the edge (Figures 1 and 2). A 3 mm × 4 mm cartilaginous fold was then created using the suture, similar to the transdomal suture (Figure 3). The type of absorbable suture used on the left (experimental) ear was assigned by a random table generated from Microsoft Excel. The skin incision was closed with 5-0 chromic catgut. The incision was then covered with Laser-Seal (Innovation Alley, Cleveland, OH), which worked as a soft splint to prevent the animal’s easy access to the wound; this remained on the ear for 2 weeks. A collar was placed on every rabbit for 2 weeks to prevent unfolding caused by scratching. All rabbits were kept for 3 months. This period matches 3 years of human life.

At the end of 3 months, all rabbits were euthanized and the dimensions of the cartilaginous folds were measured and classified on a scale from 1 to 4. All of the cartilaginous folds also were examined histologically. The pathologic features examined included the amount of fibroadipose tissue, inflammation, foreign body granuloma (FBG), presence of osteocytes and chondrocytes, suture material, and inclusion cyst. The first three pathologic parameters were graded on a scale from 1 to 3 by a board-certified pathologist who was not aware of the type of suture that was used or the cartilaginous fold measurement results, while the latter 3 parameters were classified as present or absent. All data were statistically analyzed using JMP software (SAS institute, Cary, NC).

RESULTS

The cartilaginous folds were graded on a scale of 1 to 4 based on a measurement of the final fold height (grade 1 = 0.0 to 1.0 mm; grade 2 = 1.01 to 2.0 mm; grade 3 = 2.01 to 3.0 mm; and grade 4 = 3.01 to 4.0 mm). The mean fold grade was 3.51 for nylon, 3.50 for PDS, 2.08 for monocryl, and 1.83 for plain catgut. The mean fold grade in the PDS group was not statistically different from that of the nylon group (P = .83), whereas the fold grade in both the plain catgut (P < .001) and monocryl (P < .001) groups were statistically significantly lower than that of the nylon group (Table 1).

Linear regression analysis revealed a correlation between the fold height grade and the amount of fibroadipose tissue (P < .05). This indicates that the greater amount of fibroadipose tissue found from the pathologic sections, the higher the cartilaginous fold.
grade. The other parameters (FBG, inflammation, the presence of osteocytes and chondrocytes, suture, or inclusion cysts) were not significantly correlated to the fold height grade \( (P > .05; \) Table 2).

Histologic examination of a cartilaginous fold using absorbable suture material revealed the presence of a fibrous stroma in the center of the fold with no FBG (Figure 4). A fold using nonabsorbable suture material also revealed the presence of a fibrous stroma; however, it was associated with a prominent foreign-body granulomatous reaction around the nonabsorbable suture material (Figure 5).

**DISCUSSION**

There are a number of conditions that require cartilaginous reshaping. Prominent ears and nasal tip deformity are two of the most common. More than 200 procedures have been described in the literature for treating patients with these abnormalities.\(^4,5,6\) Among them, suturing techniques are the most reliable and most commonly used methods. Despite the popularity of suturing techniques, there is no consensus among surgeons regarding the optimal suture material. The ultimate goal of these techniques is to produce an optimal shape with minimal complications or recurrences. As a result, most authors advocate the usage of nonabsorbable suture materials to ensure long-term durability and avoidance of recurrences.\(^3,11,13,15\)

The use of nonabsorbable suture material is associated with an increased incidence of foreign body granuloma, suture extrusion, wound breakdown, and sinus tract formation.\(^5,9,12,15,20\) To avoid these complications, several authors have used absorbable suture material to reshape
the cartilage because they believe that the final, newly-shaped cartilage will be held in shape and position by the scar tissue.\textsuperscript{11,16,21,22} These authors believe that absorbable suture material is strong enough and long-lasting enough to retain the cartilage shape and position until scar tissue is formed, which may take up to 6 months.\textsuperscript{18} This hypothesis is further supported by the fact that removal of extruded suture material after otoplasty is not associated with recurrence in the majority of instances, especially after 6 months postoperatively.\textsuperscript{4} PDS is the most commonly selected absorbable material to serve this purpose. However, to the best of our knowledge, there has been no investigation and no compelling scientific evidence to confirm the validity of this hypothesis.

We used rabbits as the animal model for cartilage reshaping because rabbit ear cartilage has the same physical properties as human ear cartilage and because the rabbit model has been used in most studies investigating ear and nasal cartilage reshaping.\textsuperscript{2,24-26} In our study, we compared cartilaginous folds created by three different absorbable suture materials with different in vivo integrity (plain catgut, monocryl, and PDS) to those created by nylon. The results confirmed that in this animal model, only PDS, which has the longest in vivo integrity among the absorbable suture materials tested, provided a cartilaginous fold of comparable quality to that of nylon at 3 months. We also further explored the mechanism of this long-lasting cartilaginous reshaping by incorporating histopathologic analysis. The presence of suture material is not correlated with the final cartilaginous fold quality.

Our finding points to the fact that other factors, such as cartilaginous remodeling or scar tissue formation, are responsible for the long-term success of these suturing techniques. Although we found chondrocytes and osteocytes between the two limbs and around the fold, which provides evidence of cartilaginous remodeling in some specimens, this presence was also not correlated with the fold quality at 3 months. As a result, it is less likely to be a key factor accounting for this long-term cartilage transformation. On the contrary, the amount of fibroadipose tissue around and within the cartilaginous fold is the only independent histologic finding associated with a better fold quality in both the absorbable and nonabsorbable suture groups. This finding emphasizes the importance of scar tissue as the main factor responsible for holding the cartilaginous fold in its new shape and supports the hypothesis of many previous authors who have relied on longer-lasting absorbable suture materials for cartilage reshaping.

The results of this study confirm that the presence of suture material is not crucial to the permanency of cartilage reshaping. PDS provides the same long-lasting cartilaginous reshaping as nylon and avoids the long-term risks associated with the presence of a foreign body. We have suggested PDS as the preferred suture for cartilage reshaping procedures. This study has changed the practice of the senior author (BG), who has switched from using clear nylon for nasal tip sutures to PDS to avoid long-term complications. Over 2 years, the postoperative results from using PDS have been as enduring and predictable as the results obtained from nylon.

**CONCLUSIONS**

PDS provides long-lasting cartilaginous fold quality that is comparable to that of nylon. Nonabsorbable suture material is not necessary for long-term success with suture cartilage reshaping technique. Scar tissue is the key factor that holds the cartilage in its newly-formed shape.

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Dr. Guyuron has an ownership interest in Laser-Seal. The other authors have no disclosures with respect to manufacturers of products mentioned in this article.

**REFERENCES**


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