Suture With Resorbable Cones: Histology and Physico-Mechanical Features

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Abstract

Background: Silhouette Sutures (Kolster Methods, Inc., Corona, CA) exhibit different biological characteristics at various time points after their placement.

Objectives: The goals of this study were to understand the biological reactions of Silhouette Sutures in human tissues at different time intervals and to determine the index of resistance of the sutures in subcutaneous tissue.

Methods: Histologic examination was performed on section soft tissue containing the sutures at 1 month, 3 months, 6 months, and 1 year after suture placement. The study comprised 8 patients, each of whom received 4 sutures in the lower abdomen under local anesthesia. The sutures were placed exactly 1 month, 3 months, 6 months, and 1 year before planned post-bariatric abdominal surgery. Dynamometric evaluation was performed on a never-used suture and on sutures removed from 1 year after placement. The scar process around the threads was also examined.

Results: A progressive increase in scar tissue around the sutures was observed. One year after placement, there was a reduction of 16.7% in yield and tensile strength and a reduction of 14.29% in elongation at break, relative to the never-used suture. By 1 year, the cones in polylactic and glycolic acids had been replaced by scar tissue.

Conclusions: Fibrous tissue around the sutures increased progressively over time, and was most prominent at the level of the nodes. Cones were completely resorbed within 6 months. A reduction in the index of resistance of the suspension sutures occurred over 1 year.

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In recent years, surgical rejuvenation of the face has focused heavily on minimally invasive procedures. The goal of such surgery is to obtain the best possible results with minimal invasiveness, resulting in greater patient satisfaction, faster recovery, less stress, and reduced scarring. The growing demand to improve facial aesthetics without highly invasive techniques has led to the success of a new generation of so-called “short scar” facelifts (Figure 1). The utilization of suspension sutures during facial surgery typically results in minimal trauma and meets patients’ expectations.

Prior to this study, knowledge of the histologic changes that occur in subcutaneous tissue after placement of these sutures was lacking. We believe it is important to understand the evolution of the scarring process around the threads and to determine whether the threads undergo mechanical alterations.

Suspension sutures were derived from sutures utilized to repair tendons, as described by Jennings et al in 1952 and subsequently by McKenzie in 1967. In 1992, Gregory Ruff developed absorbable sutures characterized by barbed hooks in a spiral pattern along the surgical suture body. In 2001 and 2002, Sulamanidze et al. utilized the first bidirectional barbed polypropylene sutures (“Aptos threads”) for suspension of facial soft tissues. In a 2005 publication,

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the same authors presented a case study with a follow-up period of 2.5 years.9 Also in 2005, the polypropylene unidirectional barbed “Ise endo progressive” suture was described.10 Sutures of this type were applied to suspend the middle third of the face, and were anchored to the deep temporal fascia.11 In 2004, unidirectional barbed sutures made of polypropylene (Contour Threads; Surgical Specialties Corp, Vancouver, BC, Canada) were approved by the US Food and Drug Administration (FDA), and in 2006, a case report of their use was published.3

In 2006, the Silhouette Suture (Kolster Methods, Inc., Corona, CA) was approved by the FDA for use in facial surgery.12,13 Today, Silhouette Sutures remain the only suspension sutures approved by the FDA. CE marking also was received in 2006. Commercial use of these sutures began in early 2007. Small changes were made to the original Silhouette Sutures to improve structural characteristics. In addition to the 3-0 polypropylene sutures for the face, 2-0 sutures with 9 cones were produced for lifting the buttocks. The current surgical indications for these sutures are symmetrization of the middle third of the face in patients with facial nerve paralysis, and lifting the midface, brow, and neck in aesthetic surgery patients.13

The purpose of the present study is to understand the biological reactions of Silhouette Sutures in human tissues at different time intervals after their placement and to determine the sutures’ index of resistance (tensile strength, yield strength, elongation at break) after insertion into subcutaneous tissue.14,15

**The Silhouette Suture**

This suture is composed of an 8-inch (20-cm) straight needle attached to a 14.7-inch (37.3-cm) 2-0 and 3-0 polypropylene suture (Figures 2 and 3). In the distal part of the suture are 8 (2-0) or 9 (3-0) knots that span 8 cm at approximately 10-mm intervals. Each knot is intercalated...
with an absorbable cone to compose a series of 8 or 9 engaging elements. The cones are hollow, with an outer diameter of 1.27 mm at the base at 0.46 mm at the top, and a length of 2.53 mm. The cones are made with a polymer composed of L-lactic acid and glycolide.

METHODS

The study included 8 women aged 33 to 57 years (average, 46 years) who were awaiting post-bariatric abdominal surgery. Excluded from the study were smokers and patients who refused to provide informed consent, had abdominal scars from previous trauma or surgery, or had diabetes mellitus.

The 8 study participants provided written informed consent for placement of 4 Silhouette Sutures in the abdominal adipose tissue. The study was approved by, and conducted in collaboration with, the Institute of Pathological Anatomy, University of Udine (Udine, Italy), and the Research Centre Polimeri Laboratory (Mantova, Italy). The study was conducted in accordance with the principles of the Declaration of Helsinki.

The proximal end of the suture was attached to a 26-mm, semicircular needle. Four 3-0 polypropylene sutures (14.7 inches long each) were placed in the subcutaneous tissue of the each patient’s abdomen (~2.17 inches from the navel) during local anesthesia (lidocaine 2%). To maintain the sutures under tension, each thread was fixed with 4-0 Vicryl sutures to simulate what takes place in vivo (Figure 4). This placement technique prevented bunching of the abdominal tissue.

The sutures were removed at precisely 1, 3, 6, or 12 months later, during each patient’s abdominoplasty. (Two patients underwent suture removal at each time point.) All operations were performed in the Medicenter in Ronchi dei Legionari.

One month after suture placement, the first 2 patients underwent abdominoplasty. During the surgery, all 4 polypropylene sutures, surrounded only by scar tissue and cleaned from adipose tissue with scissors, were removed and were sent to the Department of Histology of the University of Udine for histologic examination. The same surgery and histologic testing was performed in the next 2 patients 3 months after suture placement, and in another 2 patients at 6 months. For the final 2 patients (1-year interval), 2 threads for each patient surrounded only by scar tissue and cleaned from adipose tissue were sent to the Department of Histology of the University of Udine for histologic examination, and the other 2 sutures of these patients were sent to the Polimeri Laboratory for physical analysis. For comparison purposes, we also sent four 3-0 never-used polypropylene sutures to the Polimeri Laboratory, which were subjected to the same dynamometric evaluation (tensile strength, yield strength, elongation at break) (Figure 4). Tensile strength refers to the maximum weight that a suture can shift without breaking. All results were given in count-related yarn tenacity (cN/tex) and were expressed according to UNI 1932 (Italian Organization for Standardization) (Table 1).

Table 1. Research Laboratory Testing of Sutures’ Yield Strength, Tensile Strength, Elongation at Break, and Young’s Modulus: Virgin Suture vs 1 Year After Placement

<table>
<thead>
<tr>
<th>Analysis Type</th>
<th>Virgin Suture Characteristics (mean)</th>
<th>Suture Characteristics 1 year After Placement (mean)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yield strength (cN/Tex)</td>
<td>1.08</td>
<td>0.9</td>
</tr>
<tr>
<td>Tensile strength (cN/Tex)</td>
<td>44.7</td>
<td>22.4</td>
</tr>
<tr>
<td>Elongation at break (%)</td>
<td>35</td>
<td>30</td>
</tr>
<tr>
<td>1% Secant modulus (cN/Tex)</td>
<td>324</td>
<td>140</td>
</tr>
<tr>
<td>Young’s modulus (cN/Tex)</td>
<td>280</td>
<td>140</td>
</tr>
</tbody>
</table>

cN/Tex, count-related yarn tenacity.  
*Secant modulus denotes the ratio of stress to strain at any point on a curve in a stress-strain diagram.
The histologic analysis was performed on several sections of tissue containing the sutures, whether or not cones were present. The thread of fibrous material was cut into 4 segments. We preserved the tissue in 10% neutral buffered formalin (4% formaldehyde in phosphate-buffered saline) because it prevents tissue degradation and maintains the structure of cells. The site analyzed was far from that of the Vicryl suture. Subsequently, the specimen was placed in a solvent of the paraffin and fitted on a solid support. The prepared specimen was then stained with hematoxylin-eosin and placed on coverslip with natural resin. All specimens were analyzed under an optical microscope with white light; magnifications ranged from × 10 to × 25.

**RESULTS**

All analyzed threads were from 14.7-inch, 3-0 polypropylene sutures that contained 9 knots. The length of the suture assessed during physical testing for each side of the jaw was 2 inches. (The remaining 10.7 inches represented the length between the jaws.)

At 1 year, there was a 16.7% reduction in yield and tensile strength as well as a 14.29% reduction of the elongation at break, relative to the never-used suture (Table 1). Moreover, there was a 50% reduction in Young’s modulus, which is a measure of the stiffness of an elastic material and is utilized to characterize different materials. Also
noted was a reduction of 56.8% in the Secant modulus (Table 1), which expresses the ratio of stress to strain at any point on curve in a stress-strain diagram. The histologic images (Figures 5-9) showed that scar tissue around the suspension suture increased progressively from 1 month to 1 year, with reductions in the number of inflammatory cells (mast cells, lymphocytes) and an increase in collagenous tissue.

At 1 month a chronic inflammatory response was observed, with histiocytes, lymphocytes, and multinucleate giant cells near the cones and knots (Figure 5). Moreover, at this time, the suture was effectively surrounded by a very small amount of scar tissue. The inflammatory tissue prevailed until month 3, when only minimal collagen and connective tissue was present (Figure 6). By month 6, there was a drastic reduction in the number of inflammatory cells and an increase in the deposition of connective tissue (Figure 7). The degradation of cone material started after 6 months and lasted until approximately 12 months (Figures 8 and 9). Fibrous tissue surrounded the suspension sutures, and was most apparent at the level of the knots.

During physical testing at the 1-year mark, breakage near the knots was observed in all cases (behind or in front of the knot).

**DISCUSSION**

In recent years, the popularity of suspension sutures has increased due to the growing demand for minimally invasive facial rejuvenation. With these sutures, satisfactory results can be attained from a simple technique performed during local anesthesia. Elevation of soft tissues with these sutures can help counteract the effects of aging and aid in reconstructive surgery for facial paralysis. The simplicity and minimally invasive nature of this suturing technique have led to its widespread use, despite lack of comprehension of the biological reaction between the host tissue and the sutures.

The purpose of our study was 2-fold: (1) to ascertain the index of resistance (tensile strength, yield strength, elongation at break) of Silhouette Sutures 12 months after their placement; and (2) to determine whether scar tissue develops around the threads, cones, and knots. Histologic examination showed a progressive increase in scar tissue around the suspension sutures, with reductions in the quantity of inflammatory cells and an increase in collagenous tissue. By 12 months, there was complete reabsorption of the cones of lactic acid and glycolic acid.

Our study also showed that the hyaline fibrous tissue (which is composed of collagen and elastin fibers) underwent gradual remodeling until 12 months after suture placement sutures (end of study).

Findings of the physical study confirmed weakening of the thread structure by 1 year, which led to a reduction in traction resistance. Relative to the unused sutures, there was a 16.7% reduction in yield and tensile strength (Table 1).

In future research, it would be interesting to examine the histologic and physical changes that occur beyond the 1-year mark.

The anatomy of adipose fascial tissue in the abdomen differs substantially from that in cervico-facial areas. Although these differences may limit the interpretation of...
our results, this experimental model would be difficult to replicate in patients who are candidates for facelifts. Furthermore, the patients in our study had undergone rapid weight loss, and thus the subcutaneous tissue that was sutured had been altered structurally. However, the basic scarring process is similar for all parts of the body. These factors must be considered when attempting to draw accurate conclusions from the results.

CONCLUSIONS

A progressive increase in scar tissue occurs after placement of Silhouette Sutures. When inserted in subcutaneous tissue, these sutures elevate the hypodermis and create a solid fibrous tissue, which appears to be most prominent at the level of the nodes. Cones were completely resorbed by 6 months. A reduction in the index of resistance occurred over 1 year. We believe that the increased scar tissue results in more stable and durable support.

Disclosures

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