Quill Barbed Sutures in Body Contouring Surgery: A 6-Year Comparison With Running Absorbable Braided Sutures

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Abstract

Background: Body contouring operations are concluded with suture closure of long incisions under tension. While an expeditious and secure repair without complications is the objective, wound closure typically consumes a substantial percentage of the operative time and too often leads to delayed wound healing and other problems.

Objectives: The authors evaluate suture-line wound healing for body contouring operations with barbed suture wound closure compared with absorbable running suture closure.

Methods: In this retrospective study, wound-healing complications for a 228 consecutive-patient cohort with barbed sutures over a period of 4 years were compared with those for a prior 132 consecutive-patient cohort with absorbable running sutures over a period of 2 years. Complications were classified according to severity: grade 1 (mild), grade 2 (moderate), and grade 3 (severe). The preferred suture techniques for the closure of either thick or thin subcutaneous tissue under tension are described. The authors’ clinical impressions are also presented.

Results: Patients whose wounds were closed with absorbable running sutures had a significantly greater incidence of complications at all severity grades of severity than did those with barbed suture closures, with the exception of grade 3 (severe) complications in thighplasty. Logistical regression was <1, and the confidence interval was also <1, in support of these results.

Conclusions: Proper barbed suture selection and 2-layer technique led to a statistically significant lower rate of wound-healing complications as compared with prior experience with traditional running braided absorbable sutures. Other benefits were more rapid speed of closure, adequate security of the wound closure, and increased surgeon satisfaction.

Level of Evidence: 3

Keywords

barbed sutures, wound closure, body contouring surgery, lower bodylift, upper bodylift, thighplasty, brachioplasty

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the senior author (D.J.H.) replaced interrupted permanent braided sutures with running absorbable braided sutures tied at each end of the wound. Despite a satisfactory experience in 139 patients, there remained the concern that premature breakage or exposure would result in unraveling with major wound dehiscence. In December 2006, encouraging early experience with recently Food and Drug Administration (FDA)–approved self-retaining absorbable sutures6–8 prompted the senior author to adopt Quill barbed sutures (Angiotech Pharmaceuticals, Vancouver, British Columbia, Canada) as the exclusive material for closure of all body contouring operations. In addition to decreased operative time, other anticipated benefits included no unraveling of running stitches despite breakage, no tying of knots, no knot exposure, less suture packs, an even distribution of tension, and, with months of suture line immobilization, better scars. An unanticipated and satisfying benefit was the capacity to precisely align and shape long wound closures in the process.

**METHODS**

In this retrospective, single-surgeon, 6-year clinical review, we compared 2 groups of body contouring patients with 2-layer suture closure: 1 group in whom wounds were closed with absorbable barbed sutures (Quill) in the deep layer and 1 group in whom wounds were closed with braided running sutures (Polysorb; Covidien, Mansfield, Massachusetts). In addition to standardized suture closure, several other wound-healing–related initiatives were incorporated into patient care. Among these were preoperative nutritional analysis and treatment, perioperative patient warming, improved team surgery efficiency, and advanced management of postoperative swelling, all of which had become routine for the senior author by 2005.5

Relevant information was acquired from the operative reports, clinical notes, and digital photographic archives of 360 consecutive patients who underwent complex body contouring surgery from December 2005 through December 2010. Isolated cases of breast augmentation, breast reduction, mastopexy, and liposuction were excluded. Operations were performed at Magee-Womens Hospital of the University of Pittsburgh Medical Center (UPMC) throughout the study and, during 2010, also in the senior author’s American Association for Accreditation of Ambulatory Surgery Facilities (AAAASF)–accredited private practice facility. The total operative time comparison was limited to the time in and out of the hospital operating room, as documented by Magee-Womens Hospital of UPMC. In and out operative times were provided as a financial hospital document and were not influenced by the number of assistants in surgery. The total operative time comparison was limited to the time in and out of the hospital operating room, as documented by Magee-Womens Hospital of UPMC.

Patients were divided between Quill and running Polysorb closures with variables consisting of presurgical body mass index (BMI) and weight loss, procedures per operative session, and magnitude of wound-healing complications. Suture selection was a function of time. Since our prior study5 found that age, sex, comorbidity, and the number of assistants in surgery did not influence the rate of wound-healing complications, we did not compile that information for this report. As healing complications were documented by complications per suture line, single suture-line operations such as abdominoplasty were counted as 1 suture line at risk for suture breakdown. T-shaped abdominoplasty and bilateral procedures such as brachioplasty, mastopexy, and upper and lower body lifts were evaluated as having 2 suture lines at risk. Bilateral vertical thighplasties were evaluated as having 4 suture lines at risk for complications.

The magnitude of each complication was designated as grade 1 (mild), grade 2 (moderate), or grade 3 (severe). Grade 1 complications were temporary suture-line erythema or exposed sutures needing removal. A grade 2 designation applied to complications involving limited areas of no more than 12 weeks of delayed wound healing due to seroma, hematoma, skin necrosis, or exposed suture that responded to suture closure outside the operating room or topical care (Figures 1 and 2). A grade 3 complication included wound care over 3 months, wounds with exposed sutures needing removal. A grade 2 designation applied to complications involving limited areas of no more than 12 weeks of delayed wound healing due to seroma, hematoma, skin necrosis, or exposed suture that responded to suture closure outside the operating room or topical care (Figures 1 and 2). A grade 3 complication included wound care over 3 months, wounds that negatively affected quality of life, use of VAC (KCI, San Antonio, Texas) negative-pressure wound therapy, or return to the operating room for repair (Figure 3). Attributing the entire gamut of wound-healing complications to suture material is an oversimplification of etiology; individual patient characteristics, tissue handling, healing complications, we did not compile that information for this report. As healing complications were documented by complications per suture line, single suture-line operations such as abdominoplasty were counted as 1 suture line at risk for suture breakdown. T-shaped abdominoplasty and bilateral procedures such as brachioplasty, mastopexy, and upper and lower body lifts were evaluated as having 2 suture lines at risk. Bilateral vertical thighplasties were evaluated as having 4 suture lines at risk for complications.
and suture technique (rather than suture material) often may play a significant role. Nevertheless, if the same surgeon has controlled for these variables, then the suture product may well be the determinant of different rates of complications.

Categorical variables were compared using $\chi^2$ analysis or Fisher exact test, as appropriate. Continuous variables were compared using the 2-tailed t test. Two group comparisons for ordered categorical variables were performed using the Wilcoxon-Mann-Whitney test. Statistical analysis also included multiple logistic regressions to assess complications with the Quill suture. Complications were divided into our 3 categories (mild, moderate, and severe) and compared according to whether the patient experiencing the complication had received Quill or running Polysorb sutures. Variables assessed in the model were the type of surgical procedure (abdominoplasty, fleur-de-lis abdominoplasty, lower bodylift, vertical thighplasty, brachioplasty, upper bodylift) and ancillary procedures that can influence wound complications (mastopexy, use of autologous fat flaps, ultrasound-assisted liposuction). Significance for all statistical tests was set at $P > .05$. All $P$ values were 2-tailed. All analyses were performed using statistical computer software (STATA 9.0; STATA Corporation, College Station, Texas).

**RESULTS**

**Complications**

In this retrospective series, we analyzed 950 procedures in 360 patients with 1590 suture lines at risk for wound-related complications (Table 1). Among the 132 patients whose wounds were closed with a deep running layer of Polysorb and intradermal running BIOSYN (Covidien), 86 had lost more than 40 pounds preoperatively and were therefore considered massive weight loss (MWL) patients. Among the other 228 patients, 134 had lost more than 40 pounds. Patients in that group were closed with a deep running layer of polydioxanone (PDO) Quill followed by BIOSYN until September 2008; after that time and through 2010, when the study period concluded, BIOSYN was replaced with intradermal Monoderm (Angiotech Pharmaceuticals) (Table 2). There were significantly fewer overall wound complications in the Quill group compared with the running Polysorb group ($P < .05$). This difference
Figure 3. (A) This 59-year-old woman presented with a body mass index of 31.3 after losing 200 pounds from gastric bypass surgery. She previously had undergone a panniculectomy, medial thighplasty, and brachioplasty. Her preoperative markings for an inverted-T abdominoplasty, lower bodylift (LBL), and vertical thighplasties are shown. Eight days after surgery, the patient fell on her bathroom floor, splitting open the right hip wound, and was transported to an emergency room for bandaging. Two days later, her 14 × 4 × 2-cm, grade 3 wound was closed under local anesthesia with a single layer of interrupted permanent monofilament suture in the office operating room. The posterior 20-cm portion of the running Quill closure did not dehisce. Healing was uneventful, and the sutures were removed 2 weeks later. (B) Markings are shown, 5 months later, for upper bodylift (UBL), mastopexy with spiral flap augmentation, and revision of both the right and left LBL. While her right hip secondary closure healed well, she did have greater subcutaneous depression on that side, requiring a broader excision there than on the left side (not shown). The LBL revisions and UBL excisions were closed with #2 polydioxanone (PDO) Quill and intracuticular 2-0 Monoderm. The reverse abdominoplasty subcutaneous fascial system was advanced and secured along the sixth rib (along the inframammary fold, IMF) with interrupted 0 Surgilon (Covidien, Mansfield, Massachusetts). The inferior portions of the breast flaps were closed along the IMF with horizontal running #1 PDO Quill and 3-0 intracuticular Monoderm (Angiotech Pharmaceuticals, Vancouver, British Columbia, Canada). The periareolar and vertical incisions were closed with a single running intracuticular 3-0 PDO Quill suture (Angiotech). All closures were covered with dermal glue. (C) Six days following revision LBL and new UBL surgery, all suture lines are clean, dry, and intact with minimal skin discoloration from ecchymosis. (D) All closures healed uneventfully with anticipated improvement in torso and breast contours and fine faded scars, as seen 7 months later in a photo taken by the patient at home.

persisted in our subgroup analysis between MWL patients and those who lost less than 40 pounds preoperatively. Total mild, moderate, and severe wound complications between our subgroups of MWL versus non-MWL patients were significantly different \((P < .05;\) Table 2). Evaluation of the differences in complications between the 2 suture groups by multivariable logistical regression, controlling for ancillary surgical procedures (ultrasound-assisted liposuction, utilization of autologous gluteal flaps, breast implants, spiral breast flaps, and presurgical patient BMI), confirmed that the Quill suture was associated with significantly fewer complications (Table 3).

Grouping results by common operations and body regions and comparing complications of Polysorb to Quill, there were statistically fewer complications for Quill for all regions and in all categories except severe thigh complications. For brachioplasty, there were a total of 117 procedures, with 44 completed using Polysorb and 73 using Quill. A total of 151 mastopexy procedures were performed, 62 with Polysorb and 89 with Quill. For 111 upper
bodylift procedures, 47 were completed with Polysorb and 64 with Quill. There were 259 abdominoplasty cases, 106 performed with Polysorb and 153 with Quill. For transverse abdominoplasty, 46 cases were performed, 17 with Polysorb and 29 with Quill. A total of 127 patients underwent a lower bodylift, with 64 receiving Polysorb and 63 receiving Quill. A total of 27 horizontal thighlifts were performed, 19 with Polysorb and 8 with Quill. Finally, 112 vertical thighlifts were performed, 45 with Polysorb and 67 with Quill. Grouping the body into 3 regions (arms, trunk [upper bodylift, abdominoplasty, transverse abdominoplasty, and lower bodylift]) and thighs [transverse and horizontal lifts]), complications were significantly lower in cases with the Quill suture compared with running Polysorb in all wound classifications except severe complications in the thigh group (Table 4).
Operating Time

The hospital-provided lists of total time in and out of the operating room showed considerably more procedures per patient session with the Polysorb group, making the analysis unreliable. Dividing the total time by the number of suture lines for Quill, the mean (SD) time was 72.45 (74.35) minutes; Polysorb time was 68.58 (70.82) minutes. Based on this analysis, there was no significant difference between the times ($P = .63$).

Scar Quality

A random review of postoperative photos revealed a wide range of scar quality, independent of the type of suture closure. While it was not in the purview of this study to assess scar quality, our clinical impression was that Quill scars matured faster than scars associated with prior sutures. We did not judge that mature scars associated with Quill sutures were of higher quality. Over a period of years, primary healing usually led to fine line scars. Thinning along the closure accompanied by partial recurrence of the saddlebag deformity occasionally occurred along the lateral portion of lower bodylifts in both Quill and Polysorb groups.

DISCUSSION

Discouraged by excessively lengthy and complication-laden standard suture closures during complex body contouring surgery, we considered the emerging Quill suture in 2006. Despite a few supportive experimental and limited clinical reports, the senior author did not adopt large-gauge barbed PDO suture closure in body contouring surgery until convinced by conversations with inventor Dr Gregory Ruff, who stated that the suture tissue retainers would maintain uniform high tension in deep subcutaneous closure without knot tying (G. Ruff, personal communication, November 2006). As the intradermal use of long-lasting 3-0 PDO at times led to exposure, it was soon replaced with BIOSYN and then, in September 2008, with...
the newly available, rapidly absorbing barbed Monoderm. Since wound-healing complications from intradermal Monoderm were expected to be only minor, we did not feel that the midseries change would significantly affect wound-healing results.

Wound closure is integral to surgery. Since much of what plastic surgeons do involves excising skin, we are indoctrinated during our training with an accepted method of subcutaneous tissue closure, which, through our early clinical experience, usually remains sacrosanct. Nevertheless, plastic surgeons are familiar with unresolved controversies such as the optimal number of suture layers, permanent versus absorbable sutures, running versus interrupted, absorbable versus nonabsorbable staples, and so on.

Despite debate on those controversies, the importance of including the multilayered subcutaneous fascial system (SFS) as the tension-relieving layer of closure in body contouring surgery is generally accepted. Citing an adverse clinical case using absorbable sutures, Lockwood advocated that large-gauge interrupted permanent braided sutures and full-thickness bites of the SFS were necessary for optimal healing. An initially consistent adopter of this technique, the senior author of this article nevertheless abandoned it after 10 years because it became apparent during the course of revision surgery that permanent interrupted subcutaneous sutures provide no long-lasting closure retention and, on occasion, permanent sutures cause difficulties in treating delayed suture abscesses months to many years postoperatively. Thinner patients complain of palpable knots or persistent tissue dimpling, especially in the lower abdomen and buttock-thigh junction, which may require secondary suture removal. A curious lack of attention in the literature to this continuing “liability” of permanent subcutaneous sutures most likely attests to the scarcity of serious complications but still does not negate the depth of impact on patients and surgeons when such problems occur.

With the development of the total bodylift, the longer operative time needed for the MWL patients demanded more efficiency—hence compulsive night-before-surgery skin markings, detailed preoperative planning and postsurgery debriefing, improved training and management of team members, conversion to a running absorbable suture closure, and so on. However, with a running suture comes concern for uneven tension, several large knots, and, most important, major dehiscence should it unravel. Our extensive experience with Quill has relieved us of those concerns.

As a fundamental understanding of the technology and optimal technique is essential to obtaining consistent outcomes, relevant product information and our preferred usage are described.

### Suture Characteristics

The Quill device consists of bidirectional, helically positioned tissue retainers (barbs) cut on a variably thick and long suture on either side of a central short, smooth segment. Variably sized and shaped needles are swedged at both ends. Quill sutting begins at the center of the wound and proceeds outward in both directions, to allow each side of the wound closure to counterbalance the tension of the other side. Not only are knots unnecessary but, unlike nonbarbed thread, the retention cuts uniformly distribute restraining tension across the length of the suture. Since there are no knots, the initial retention capacity of the suture relates to the material properties, core diameter, barbed cut angle, position, frequency, and depth, as well as the manner of placement. Quill sutures are available with either nonabsorbable or absorbable cores.

Body contouring closures do not require the prolonged suture retention of nylon or polypropylene, which may be palpable and become a nidus for abscesses. The absorbable suture choices are PDO and Monoderm (polyglycolide-poly-e-caprolactone copolymer; PGA-PCL). Two important characteristics describe the in vivo performance of absorbable sutures: tensile strength retention and absorption rate (loss of mass). For the most part, the purple-dyed PDO, which in laboratory studies retains 92% of its original strength at 42 days, is used to close (under tension) the subcutaneous layer. We only use PDO in the dermis for moderately tense closure of periareolar and circumvertical portions of mastopexies. Large, outer-ring horizontal bites are alternated with much shorter areolar bites with 3-0 PDO. As Monoderm retains 67% to 74% of its original retention strength at 7 days and only 34% to 45% after 2 weeks, it is recommended for low-tension dermal closure. Absorption of Monoderm is essentially complete at 90 days. Monoderm is contraindicated where extended approximation of tissue under stress is required.

### Technique

Optimal superficial wound closure begins with a minimally traumatic and perpendicular incision from dermis to muscular fascia. Preinjecting with epinephrine allows for point vessel electrocautery after the scalpel incision. Wound margins are undermined as little as possible, handled gently, and not allowed to dry before closing under moderate to high tension.

After a 3-case learning experience, in January 2007, the senior author developed a systematic and consistent technique exclusively using Quill closures. This technique was taught to all rotating University of Pittsburgh plastic surgery residents, who participated to a great extent in the closures reported in this article. With this technique, the subcutaneous tissues were approximated with an encompassing running large-gauge PDO, which began with bites directly opposite on either side of the center of the wound and gap-advanced to the next 2 directly opposite bites on either side of the first pass, continuing both ways until a J-shaped return was made into the closed wound near its end. From the onset, a purist approach was taken in that the multilayered SFS of long and deep wounds were closed under tension, exclusively with barbed PDO sutures. A knotted, interrupted suture was used when the Quill ran short or under extreme closure tension. Since back roll and lower...
bodylift excisions create the deepest and longest wounds and are closed under considerable tension, the heaviest gauge, longest thread, and largest needle were used (#2 PDO, 36 × 36 cm on a 48-mm taper-point curved needle). The first PDO-encircling SFS suture pass started subdermally in the middle of the closure, encircled the full-thickness subcutaneous layer to exit deep near the muscular fascia, and then continued directly across the wound, entering deep; this suture pass included the entire subcutaneous layer and exited in the subdermal layer. A video (Video 1) demonstrating this technique is available at www.aestheticsurgeryjournal.com. You may also use any smartphone to scan the code on the first page of this article to be taken directly to the video on www.YouTube.com.

After similar passes on either side of the middle non-barbed segment, the 2 ends were pulled equally along the axis of the wound to approximate the central wound margins. The suturing was then similarly continued from either end, most efficiently with 2 operators. The needles came closest to the dermis as they cours ed furthest from the wound margin. After every 2 complete passes, the operator pulled the suture to approximate and then sync the wound edges. The mindful approximation of the tissues allowed the surgeon precise control. In other words, the suture was slowly pulled so that the wound edges were broadly touching, with subtle dimpling in the skin furthest from the closure and slight eversion of the approximated dermis. Not only was the closure neither too tight nor too loose, but the barbs retained the tissue approximation without the need of a helping hand to maintain suture closure tension. As the closure proceeded in either direction from the center, a continuous adherence of thread to tissues, similar to Velcro (3M, St Paul, Minnesota) fasteners, was created.

Depending on the depth of the wound margins or proximity to the end of the closure, the suture throws were changed from vertical to horizontal. Uneven thickness wound edges were evenly approximated with varied-depth horizontal stitching. In abdominoplasty closure, the subdermis of the thicker epigastric flap was aligned to the Scarpa’s fascia of the thinner groin incisions. For simplicity, the superior advancement of the reverse abdomino-plasty flap to the muscular fascia of the inframammary fold was changed. Instead of dozens of interrupted 0 braided permanent sutures, this was changed to rapidly placed #2 PDO Quill.

At the termination of the wound, it was possible to rapidly match wound edges of uneven length, flatten bulging, and eliminate dog ears through thoughtful precision-suturing. Toward the last 6 cm, suturing was switched from vertical to horizontal. Near termination, suturing went from the short side across, as superficially as possible at the end of the long side, and then returned back to the already closed portion of the short side. The closure was completed and secured with a J-shaped return through the just-closed incision. If the needle was prematurely avulsed, the thread was cut short or suturing continued with a free-eyed needle. Care was taken to avoid tying barbed suture, due to damage to the barbs and the large mass of foreign body.

When there were uneven wound edge lengths, which are so common in body contouring surgery, gathering of tissues on the longer side was accomplished by spacing larger gaps between bites on the longer side along the entire closure. Preliminary crosshatch alignment was helpful to pace the closure. As this gathering maneuver left bulging along the longer side, the J-return of the suture was run horizontally along the subdermis on the bulging side to deeper subcutaneous on the shorter side. The stitching depressed the more gathered tissues to the level of the shorter side, thereby leveling edges for the intradermal Monoderm closure.

For the thinner medial arms and thighs, the initial vertical throw was followed by deep horizontal passes along the entire length of the closure (Figure 4). The suture passed in an undulating path, nearest to the dermis away from the wound margins, to recruit both horizontal and vertical subcutaneous fascia.13 A video (Video 2) showing this closure technique, edited from a more complete demonstration of the L-brachioplasty operation on the Aesthetic Surgery Journal website, is available at www.aestheticsurgeryjournal.com. You may also use any smartphone to scan the code on the first page of this article to be taken directly to the video on www.YouTube.com. Deep and safe placement of the #1 or 0 barbed PDO suture left a 2- to 3-mm dermal gap, which was closed under minimal tension with a single 3-0 Monoderm 36 × 36-cm suture.

Recognizing both efficiency and economy, Angiotech manufactures extremely long sutures for body contouring surgery. It is better to use a 36 × 36-cm length at $28.60 than 24 × 24-cm lengths at $26.16 each for a total of $52.32. In the smaller gauges, needles are easily avulsed if the pull is not in line with the swedge. Since reversing an errantly placed Quill suture damages the barbs and requires discard of the entire thread, each bite needs to be deliber-ately and accurately placed. Costly waste can also be avoided by not placing a suture on the sterile field until it is certain that it will be used. Quill suture contact with sponges or paper drapes should also be avoided, as the fibers engage the barbs, which may be flipped upon separation.

For skin approximation, an absorbable monofilament with a knot tied on either side completed the closure until the introduction of Monoderm in September 2008. Subsequently, a knotless 2-0 or 3-0 Monoderm criss-crossed the dermis with advancement taking place within the dermis. Topical dermal glue completed the 2-layer suture closure. If the Quill suture is too short to complete the designated closure, the surgeon should finish with interrupted absorbable sutures. Alternatively, after the 2-0 Monoderm closes the overlying dermis, it can be continued deeper to close the low-tension subcutaneous tissues at the ends of the wound and J-return to approximate the dermis until just passing the completed central dermal closure.

As stated earlier, extra care and deliberation must be taken with each pass of a barbed suture, as a poorly placed bite or clumsy needle avulsion usually necessitates removal of the entire suture. The craftsmanship of placing each undulating, encompassing large bite through uneven tissue lengths and depths, followed by precise sync approximation of the wound edges, is both engaging and satisfying for the surgeon. The usual mundane, time-consuming,
Figure 4. This 58-year-old woman (5 ft 6 in) weighed 145 pounds upon presentation, after an 80-pound weight loss accomplished through lifestyle changes. Two-layer Quill (Angiotech Pharmaceuticals, Vancouver, British Columbia, Canada) brachioplasty closure is shown intraoperatively. (A) Passage of the second deep horizontal proximal bite of 0 polydioxanone (PDO). The initial horizontal bites of the subcutaneous tissue in the middle of the closure have been taken. (B) The tissues have been approximated by pulling on the ends of the PDO suture. Dimpling of the dermis away from the wound edge is evident. (C) A series of horizontal bites approximate the arm subcutaneous layer with vertical throws closing the thicker chest adipose. The first layer of PDO closure is completed. The large PDO suture is deeply placed and not exposed. (D) Intradermal closure with 3-0 Monoderm (Angiotech Pharmaceuticals) is finished. A few scattered, smooth 5-0 monofilament permanent sutures correct any minor misalignment. (E) Eight-day postoperative appearance at the time of the first dressing change shows little inflammation along an intact closure. (F) The 14-month result shows a well-reduced and contoured upper arm with a faded, thin scar.
and tedious exercise of wound closure is exchanged for the capacity to more rapidly and precisely shape, mold, and retain wound-edge approximation. From the experience of the senior author, thoughtful surgical technique is critical to the success of the application of this knotless suture technology. We have learned from our own errors as well as the avoidable problems reported to us from residents in our training program, other attending surgeons, and morbidity conferences. The same care that plastic surgeons take in the closure of soft tissues, orthopedic surgeons apply to the closure of joints and tendons, which have been found to be secure even with the deliberate interruption of the running suture.\(^\text{14}\)

The large, tapered needles easily pass beyond the wound edges to provide a nonischemic, retention-suture type closure. The relative stiffness of the PDO thread allows it to hold the proper shape and barb configuration under tension in the SFS. We use PDO for the deep dermis only when approximating the periareolar tissues under tension. We like the handling and retention properties of 2-0 and 3-0 Monoderm for low-tension subcutaneous and intradermal closures. By exiting all spent sutures through the wound, we have eliminated palpable ends and removal of exposed dermal suture. We have been relieved to confirm that even multiple short removals along an exposed Quill suture do not result in lengthy dehiscence (Figure 3). There is confirmation of the retaining power of Quill, despite multiple interruptions, in the arthroscopy literature.\(^\text{14}\)

### Complications

Wound-healing complications such as seroma, hematoma, dehiscence, cellulitis, and abscesses after body contouring surgery are fairly common.\(^\text{1,5}\) The etiology is multifactorial. Contributing factors are obesity, malnutrition, length of surgery, advanced age, chronic diseases, diabetes, smoking, and hypertension. While suture selection and technique have not surfaced as determinants of delayed healing, early dehiscence without infection suggests suture failure. Moreover, delayed wound healing due to tissue necrosis or hematoma invariably exposes the suture (Figure 1). Since this was a retrospective chart review, we included every mention of a suture-line problem, no matter how trivial.

At the extremes of indications, there are many clinical differences in body contouring surgery between non-weight loss (cosmetic) and MWL patients. Those differences fade when the weight loss is less massive. As we examined our total list of patients, we found that a 40-pound weight loss precisely separated strictly cosmetic from MWL presentations. Over the 6 years of this study, there was a slight but steady increase in the percentage of cosmetic patients; in the first 2 years with Polysorb, 35% of patients were deemed cosmetic, whereas in the last 3 years with Quill, 41% were cosmetic. That correlated well with the anticipated greater magnitude of surgery in the earlier cohort, averaging 5.1 suture lines at risk per operative session compared with the later group at 3.9 suture lines at risk per operation session. While that slight degree of difference seems to favor Quill, in our opinion, it is not enough to explain the overwhelming difference in the rates of complications.

While there are many factors that influence wound healing beyond the choice and technique of wound closure, we chose these 2 suture-type cohorts because the patients were otherwise prepared and treated in the same manner. The senior surgeon was well into his 34-year career and, over the prior 5 years, had fully developed his approach and techniques for body contouring surgery. While grade 3 complications relate more to surgical plan, execution, patient condition, and so on, a difference between the rate of complications of similar cohorts can be attributed to suture material and its usage. Nutritional evaluation and support was advanced and was the same for each cohort. We relied on the routine use of ProCare MD surgical formula (NutrEssential, Rolling Hills Estate, California) and perioperative patient warming protocols. Since rapid reduction of swelling speeds wound healing, our staff has been aggressively treating postoperative swelling, edema, and induration with Marina (Lawrenceville, Georgia) elastic garments, manual lymphatic massage, Endermologie (LPG, Montreal, Canada), Hivamat 200 electrophysiological lymphatic stimulation (Physiomed, Van Buren, Arkansas), Medex low-level laser and pulsed light treatments (Lighthouse Medical Equipment, Trappe, Maryland), and Sequential Circulators (Bio Compression System, Moonachie, New Jersey), as needed.

Our data clearly show that, regardless of the magnitude of the complication, running Polysorb closures had a significantly greater incidence of complications than did the Quill closures. We feel that, to be clinically relevant, wound-healing complications should not be lumped together but classified according to severity, as we did in this study. Our logistical regression was \(<1\), and the confidence interval was also \(<1\), which means that the Quill suture was protective for complications when compared with running Polysorb.

If there was no tissue necrosis or excessive sudden tension, Quill closures uniformly held. Quill did not unravel when exposed or broken as demonstrated in the clinical cases presented in Figures 2 to 4. While localized wound-healing breakdown remains common and annoying, it does not present overwhelming concern to the prepared and accepting patient.

With Monoderm intradermal closure, our incidence of exposed suture dropped dramatically. Since sutures often surface many months after closure, that was a very significant improvement, particularly for our numerous out-of-town patients. Most commonly, grade 2 wound complications were due to localized areas of skin and/or fat necrosis and were healed secondarily by a variety of topical agents and without systemic antibiotics. In most instances, the role of suture closure was unclear. Grade 3 complications were attributable to early large dehiscence due in part to suture failure, large areas of tissue necrosis requiring prolonged care and/or secondary surgery, or (rarely) a superficial surgical site infection requiring systemic antibiotics. To a great extent, the low reactivity, ease of removal, or absorption of
the Quill PDO suture aided the expeditious resolution of these difficult clinical problems. We had no instances of very late suture abscess that can, on rare occasion, occur with the use of permanent sutures.

Our data do show significantly reduced complications of 2-layer Quill closure in all regions except for grade 3 (severe) complications in thighplasty. With regard to vertical thighplasty, it would be naive to attribute severe complications simply to the suture selection, as there are many other detriments to pristine wound healing in that operation. Furthermore, the SFS of thighs and arms necessitates closure of flimsy tissues further stressed by the preinfusion and trauma of excision-site liposuction. It is best to gently gather this swollen, flimsy subcutaneous tissue by large horizontal bites of continuously self-retaining running suture. In the arms, most of our wound-healing problems were related to breakdown due to skin-edge necrosis of the suspended flap in the axilla or along the T-juncture of the vertical thighplasty, which had nothing to do with the Quill closure.

Time of surgery is influenced by the number and difficulty of operations in a session, number and quality of assistants, anesthesia issues, BMI, and method of closure. While a running, simple, braided suture closure is much faster than an interrupted closure, we are concerned about uneven tension causing short gaps and breakage leading to major dehiscence. With the limited time information available—and factoring in the increased complexity for the first cohort—we were unable to detect a significant increase in closure speed using either of the 2 running sutures. Since this was not an institutional review board (IRB)–approved study, we did not have access to individual hospital chart anesthesia records—only the incomplete in and out operating room records of the hospital. There were too many variables to truly compare the effect of suture closures. A running Polysorb closure is very fast, despite tying knots at either end. In our hands, however, the slightly more deliberate placement of the Quill device is comparable. A prospective comparative study to record the times for suture closure has been designed by Angiotech and some volunteer surgeons, but experienced users of Quill have been reluctant to alternate with other materials and technique. Until a proper study contradicts our assessment, we are convinced that our preferred method of Quill usage is comparable or considerably faster than interrupted suture closure. It is perhaps more secure and also, in our opinion, more satisfying and engaging.

The greater cost of Quill suture packs must be contrasted with the need to open many more nonbarbed sutures and the secondary costs of less efficient and insecure closures. This efficiency saves money and increases productivity. Regardless of the charge method, less time for a procedure means lower operating room and anesthesia time costs, a savings for patients that greatly exceeds the slightly increased suture expense. Faster closures shorten the operating room time per case and may allow the scheduling of more cases, thereby increasing the number of procedures completed within a day’s operating room list and potentially increasing earnings for the primary surgeon. Most important, avoiding excessively long inpatient operative times should reduce complications and their associated costs. Since the Pennsylvania Department of Health limits ambulatory surgical center (ASC) operative time to less than 4 hours, faster Quill closures increase patient eligibility for complex outpatient cases in our clinic. Time overruns lead to significant fines and, if repeated, may lead to closure of an ASC.

While there are a few supportive studies in the plastic surgery literature, a recent report from Shermak et al on the use of #1 PDO to close the SFS in body contouring patients found no time savings and declared an increased but statistically nonsignificant incidence of complications. This retrospective review included 910 operations in 496 patients, of whom 103 had their 113 operations closed with #1 PDO for 1.1 operations per patient. The remaining 393 patients underwent 797 operations for 2.0 operations per patient and were closed with interrupted 2-0 braided suture. The criteria for selecting the 113 procedures for barbed sutures were independent of patient characteristics, although those patients had only 1.1 procedures as opposed to 2.0 procedures per operation for the nonbarbed closure. The article by Shermak et al singles out brachioplasty as presenting a greater risk than other contouring operations. The authors reported 2 wound-healing problems in 14 arms for a reasonable 14% complication rate per operated arm. This is similar to our recently published experience. The failure of Shermak et al to find shorter operating times using barbed sutures probably is due more to the overwhelming time savings of 2 teams performing coincidental operations than to efficiency of closure. Also, the authors may not have taken advantage of 2 operators suturing from each end of the Quill suture.

Our reanalysis of the published data from Shermak et al is more favorable toward barbed suture complications. Realizing that we may have been confused by their patient, case, and procedure designations, we retabulated the data. We simply assumed that the number of complications occurring in non-Quill patients was the difference

<table>
<thead>
<tr>
<th>Complication</th>
<th>Quill (n = 103), No. (%)</th>
<th>Standard (n = 393), No. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wound healing</td>
<td>17 (16.50)</td>
<td>88 (22.39)</td>
</tr>
<tr>
<td>Hematoma</td>
<td>3 (2.91)</td>
<td>6 (1.53)</td>
</tr>
<tr>
<td>Infection</td>
<td>1 (0.97)</td>
<td>11 (2.80)</td>
</tr>
<tr>
<td>Seroma</td>
<td>1 (0.97)</td>
<td>66 (16.79)</td>
</tr>
<tr>
<td>Acute bleeding requiring reoperation</td>
<td>0</td>
<td>4 (1.02)</td>
</tr>
<tr>
<td>Scar contracture</td>
<td>0</td>
<td>2 (0.51)</td>
</tr>
<tr>
<td>Suture abscess requiring surgery</td>
<td>0</td>
<td>1 (0.25)</td>
</tr>
</tbody>
</table>
between the tabulated complications for the patients having Quill closures less the total number of wound-healing complications described in the results section. By this method, we found that the use of barbed sutures produced an overwhelming reduction in complications (Table 5). Standard closure resulted in many more wound problems, infections, and seromas than did Quill PDO closures. We disagree with the explanation by Shermak et al that the purported increase in inflammation was because the barbed suture is an “exaggerated example of a braided suture, with regard to increased surface area, inciting increased risk of bacterial adherence to all the ‘nooks and crannies.’” The staggered barbs barely increase suture surface area and provide no microscopic foothold for bacteria.

We found that larger gauge (#2, #1, and 0) sutures have deeper barbs that more firmly retain tissue closures under tension. The thicker the tissues and greater the opposing tension, the thicker the PDO should be. This is clear from simply pulling the suture through the tissues and observing tissue recoil or noting the bending back of the barbs when under too much stress. Hence, our selection through clinical experience is the heaviest grade needed to self-retain against wound disruption tension. We believe that more experimental and clinical research should be done to determine the optimal barb length and intervals for each tissue type.

We believe that the low 23.6% suture-line complication rate for Quill is due to 2 factors. First, the absence of suture tying eliminates the foreign body challenge of thick knots and the possibility of strangulating tissues through a too-tight closure. Second, the numerous tiny tissue retainers lock in the wound approximation, eliminating micro motion with unwavering tissue closure tension. Quill closure appears to have no healing advantage in the malnourished or obese patient. It will, of course, become exposed with excessive postoperative suture-line stress or swelling, or necrosis. As mentioned in the product information, we employ supplemental interrupted sutures in adverse situations. We suspect that barbed sutures are more likely than knot-secured sutures to release under sudden high tension, such as the early postoperative fall as presented in Figure 3. We caution our patients not to suddenly overstress their skin closures by falls or extreme limb or trunk positions against skin closures.

The overall high rate of 71.2% of suture-line wound-healing complications for Polysorb begs an explanation. It was the first of 2 sequential series; however, the senior surgeon had previously spent 6 years focusing on body contouring surgery, and the advanced care of patients as described above was the same in both series. Furthermore, the difference between the rate of severe complications when multiple clinical factors clearly played a role was less clinically significant, with 7% for running Polysorb and 3% for Quill. Our theory for the large difference in overall wound-healing complications is that Polysorb closure appears to often fail to maintain proper uniform approximation of the tissues, thereby being prone to excessive tightening or gaps that lead to fat necrosis, microseromas, and bacterial contamination with localized infection facilitated by the braided interstices. The multiple throws to our knots form large foreign bodies with known adverse complications.

**CONCLUSIONS**

This retrospective examination of clinical data statistically confirms, in more than 900 body contouring surgery suture lines over the past 6 years, our clinical impression that proper Quill suture selection and a 2-layer technique lead to a statistically significant lower rate of wound-healing complications as compared with prior experience with traditional running braided absorbable sutures. In addition to carrying a reduced rate of complications, it is clinically evident that Quill closure is most advantageous in brachioplasty and vertical medial thighplasty. Quill also appears to lead to better consistency of scar quality across the wide range of body contouring operations. Furthermore, barbed sutures and a 2-layer technique, in our hands, allow more rapid closure, improved security of closure, and increased surgeon satisfaction with the process and wound-healing results.

**Disclosures**

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**REFERENCES**


