The use of barbed sutures has been well documented in facial aesthetic surgery1-4 but has been limited to lifting and shaping tissue. With body contouring surgeries on the rise, especially combined procedures and more extensive procedures for massive weight loss, the focus appears to have shifted to the use of these sutures in wound closure. Because the use of barbed sutures eliminates the need for knot tying, an obvious presumed benefit would be decreased operative times due to faster closures.5 This could translate into patient benefits, such as decreased anesthesia and reduced operating room costs,6 and surgeon benefits including ease of closure and potentially increased revenue by allowing more cases to be performed in a given day. Knotless closures may also decrease the potential for knot-related complications such as extrusion, pain, or visibility.7 Since the barbs precisely grasp tissue at numerous points (evenly spreading tension across a wound), the closures provide secure tissue approximations while using less suture material than conventional closures. These tight closures may also lead to improved scar cosmesis. Barbed sutures are currently being used in all areas of the body, with specific published articles highlighting improved outcomes in abdominal and arm contouring. I incorporated Quill (Angiotech Pharmaceuticals, Inc, Vancouver, British Columbia, Canada) sutures into my own practice in 2007 and have since utilized them with a low incidence of complications in more than 300 body contouring procedures. I have also pleasantly experienced savings in operative time, ease of tissue manipulation, and a positive impact on my postoperative drain management. To realize the benefits of barbed suture use, however, one must be willing to commit not only to the additional time spent overcoming the learning curve but also to the additional cost per suture when incorporating knotless closures into specific procedures.
Today, barbed sutures are available in both unidirectional (V-Loc; Covidien, Mansfield, Massachusetts) and bidirectional (Quill) patterns, as well as both nonabsorbable and absorbable monofilament materials. The V-Loc is a unidirectional suture with evenly spaced, circumferentially distributed barbs, with a needle on one end and a welded loop on the other. The suture is available in different sizes but in absorbable (V-Loc 90 and V-Loc 180) formulations only. The V-Loc 90 suture undergoes complete absorption by 90 to 110 days, while the V-Loc 180 suture undergoes minimal absorption by 60 days and is substantially complete by 180 days.

The Quill is a bidirectional suture with a needle on each end that incorporates evenly spaced bars in a helical array on either side of a nonbarbed central segment (Figure 1). The suture is available in several different lengths and sizes, in either absorbable (polyglycolide-polycaprolactone copolymer [Monoderm] or polydioxanone [PDO]) or nonabsorbable (polypropylene [PPN] or nylon) formulations. Monoderm absorption is complete by 90 to 120 days, while PDO sutures undergo minimal absorption by 60 days and is substantially complete by 180 days. The formation of barbs with both of these devices reduces the tensile strength relative to nonbarbed suture material of the same size; thus, a +1 upsizing should be employed to properly select the correct equivalent (Table 1).

### SUTURING TECHNIQUE

As with any operative technique, it is important to select the appropriate suture for each tissue being treated to maximize the desired outcome and to minimize complications. This becomes even more important with the use of Quill, since there is a much larger selection of suture sizes and formulations. For high-tension areas that are deep to the superficial fascia, such as abdominal wall plication, a large nonabsorbable suture (PPN) or longer-lasting absorbable suture (PDO) would be appropriate. For high-tension areas that are deep to the skin, such as superficial fascia repair, a large longer-lasting absorbable suture (PDO) would also be appropriate. This selection of barbed sutures would provide the strongest and most secure closures, thus limiting a potential wound dehiscence. At the same time, if any of these sutures were used in the dermis or even near the skin (including thin overall tissues with very little subcutaneous substance, such as the upper arm), there would be an increased risk for a potential wound complication (extrusion segment), leading to poor scar cosmesis. Use of a shorter-lasting absorbable suture (Monoderm) is appropriate for dermal repair. The availability of Monoderm (early 2009) and its substitution for PDO during subcuticular skin closures addressed my early experience of an increased incidence of extrusion with Quill sutures. In my practice, I prefer to use a #2 PDO for superficial fascia repair in the trunk or thighs, since its overall strength provides a reliable closure under significant tension. I have found that this large-gauge suture does not create an issue with wound healing, even in thin patients, since there are no knots required. I tend to select a smaller (0 or 2-0) PDO suture for superficial fascia repair in the arms to avoid an increased inflammatory response, which may lead to the extrusion I have witnessed with

### SUTURE SPECIFICATIONS

<table>
<thead>
<tr>
<th>USP Suture Size</th>
<th>Suture Tensile Strength, kgf</th>
<th>Quill Device Equivalent Size</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>5.08</td>
<td>2</td>
</tr>
<tr>
<td>0</td>
<td>3.90</td>
<td>1</td>
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<tr>
<td>2-0</td>
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<tr>
<td>3-0</td>
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<td>4-0</td>
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<tr>
<td>5-0</td>
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For details, refer to product-specific instructions for use.
larger-gauge options. For this same reason, I only use Monoderm sutures in the skin for dermal repair. If a suture segment does become exposed in the postoperative period (which, in my experience, after proper material selection, does not appear to exceed the incidence of exposure with traditional sutures), I successfully manage the issue by simply removing the segment (as I would do with an extruding knot from a traditional suture) and treat the superficial wound with topical ointment as needed.

Just as important as selecting the appropriate suture, proper suturing technique can have a significant impact on wound healing and overall cosmetic result. This is equally true with barbed sutures, and there is a learning curve associated with avoiding poor outcomes. (Since my experience is limited to Quill, I will address techniques with bidirectional devices only.) I tend to divide a wound into segments that can be closed with a single Quill device. I start the suture at the center of the segment and pass one end through the tissue until the nonbarbed central segment has been reached. A quick way to estimate this midpoint is to align both needles and pull on the strands in opposite directions (Figure 2A). I pass at least 2 loose loops per side prior to initial barb fixation (Figure 2B). I then pull the strands in opposite directions and lock...
the barbs into the tissues as they are being approximated (Figure 2C). (In a high-tension closure, it helps to pull the strands parallel to the wound to avoid accidentally rupturing the suture.) The strands are then run to the ends of the wound, with each loop being cinched down individually. A backstitch (J-loop) should be employed to secure the end of the suture within the wound margin when completing a deep-layer closure (Figure 2D), while a bite 1 to 2 cm away from the end of the wound should be employed to secure the end of the suture when completing a subcuticular closure (Figure 3B). Another technique that can also be utilized is a multilayered closure with the same device, which is my preferred method for many of my body contouring cases. Instead of securing the ends after superficial fascia repair, I run both ends back toward each other in the subcutaneous layer, which helps align the skin for closure.

I have discovered a few important suturing caveats during my experience with the device. First, to minimize the amount of embedded material when placing barbed sutures, it is important to avoid taking too many short bites during closure. Since there is an even distribution of tension, longer bites still provide a reliable and secure closure, but without the potentially negative sequel of increased suture burden (extrusion, etc). Second, it is equally important not to strangulate tissue by overzealously cinching down each suture loop. This excessive tension not only creates unsightly bunching of the tissue due to the self-locking barbs, but the anchored areas prevent relaxation of the intervening segments, which may result in pressure-induced ischemia and potentially lead to fat necrosis during a deep-layer closure. The best way to remove an overly tight bidirectional barbed suture is to cut its center and disengage the barbs by pulling the lateral ends of the suture halves. Both of these early mistakes are easy to make, since the concept of not having to tie a knot initially feels foreign and we all want to make sure our closures will hold together in the postoperative period.

**ABDOMINAL CONTOURING**

There have been several recent publications regarding the use of barbed sutures in abdominal contouring, including the utilization of the sutures in tissue manipulation and in wound closure, such as the positive experience described by Weiler et al.9 Their retrospective review of 173 consecutive lipoabdominoplasty cases performed by a single surgeon involved the use of absorbable (short or long) barbed suture repairs of the superficial fascia and dermis. In their opinion, the device significantly facilitated the ability to eliminate a lateral dog-ear by progressively medi- alizing the superficial flap with incrementally longer needle bites. Utilizing this technique, they observed a reduction and, in some cases, elimination of tissue pleating that was often the result with standard sutures. The article did not specifically mention the type of absorbable material used for the dual-layer closures or the size of the suture used along Scarpa’s fascia, but 3-0 was chosen for single dermal layer closures. Wound complications included 12 patients (6.9%) with partial dehiscence/skin necrosis, 13 patients (7.5%) requiring some sort of intervention (antibiotics, etc), and only 1 patient (0.5%) who experienced suture extrusion.

Another favorable article by Paul and Budd10 evaluated the closing times for 3 basic aesthetic procedures (abdominoplasty, brachioplasty, and mastopexy) with a bidirectional barbed suture technique compared with a traditional suture technique. The senior author served as his own control regarding abdominoplasty closures, all of which were performed on nonpreserved fresh cadavers. He discovered a significant reduction in closing time with Quill by approximately 50%, since the standard closure of 3 separate layers (superficial fascia/deep tissue, deep dermis, and superficial dermis) with traditional sutures required only 2 running bidirectional sutures (the superficial and deep dermis were approximated together). He was able to accomplish this because the barbed segments allow equal distribution of tension along the suture and can easily and securely close more than 1 layer. This reduction in closing time could potentially translate into a 50% decrease in the cost for anesthesia and operating room facilities during the closure.

Two other publications by Warner and Gutowski10 and Rosen11 (which reaffirmed the original work of Pollock and Pollock12,13 regarding drain-free abdominoplasties with use of progressive tension sutures) again demonstrated the advantage of reducing operative time by utilizing Quill bidirectional barbed sutures versus conventional interrupted sutures. The first article10 evaluated 58 patients who underwent an abdominoplasty procedure, including 9 circumferential resections. Zero (0) PDO was utilized not only to plicate the abdominal flap down to the abdominal wall (1 vertical running Quill per side; Figure 4) but also to approximate the Scarpa’s fascia and dermis. The authors reported a significant reduction in time (40%-55%) to complete the progressive tension closure with no (0%) reported wound complications (including skin necrosis, infections, or revision procedures). The second article11 documented the same beneficial conclusion of surgical time savings (shorter by 15 minutes on average), which translated into overall procedural cost savings due to the running of bidirectional barbed sutures. Rosen evaluated 24 total patients, with the latter 12 (similar baseline characteristics to the standard sutures group) undergoing the entire procedure with Quill only (including abdominal wall plication, vertical running progressive tension suturing technique, and skin closures). PDO was utilized for fascial plications, and PDO and/or Monoderm was placed for dermal approximation. Rosen also reported no significant wound complications but acknowledged that, although minor complications were not reported in the series, they were comparable to those in similar case studies.

In contrast, a recent article by Shermak et al14 concluded that barbed sutures present a problem with wound healing and do not appear to provide operative time savings. They performed a retrospective review of 496 body...
contouring patients who underwent 910 operations over an approximately 10-year period. Zero (0) PDO bidirectional barbed sutures were utilized for closure of Scarpa’s fascia in 114 cases (abdomen, n = 98; chest, n = 1; thigh, n = 8; and arm, n = 7) with wound complications (open areas requiring dressings, packing, or vacuum-assisted closure care) occurring in 17 (abdomen, n = 14; arm, n = 2; and thigh, n = 1). A multilevel analysis using a generalized estimating equation method revealed that age and body mass index (BMI) at the time of contouring were significant in impaired wound healing, and barbed sutures were not associated with the wound complication rate. Yet, in subset analysis, barbed sutures were associated with a significantly higher wound complication rate in the arm only. Since the operative settings involved 2 surgical teams addressing multiple body regions, it was not possible to record time differences between Quill and interrupted closures, but the authors believed that any time savings were insignificant.

I have been utilizing Quill bidirectional barbed sutures in my traditional (single-incision) abdominoplasty closures for more than 3 years (42 patients). I have experienced the same benefits (faster closures and easier-to-manipulate tissues while working out “dog ears”) discussed in earlier publications, also without apparent increase in wound or anesthesia complications compared with conventional sutures. The reduction in my operative times (slightly greater than 30 minutes on average) was immediate, since I completely eliminated the majority of my interrupted sutures (although I occasionally place a few as needed to complete abdominal wall plication and assist in lining up deep tissue and skin). One of the most notable advantages I discovered was the

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**Figure 4.** Progressive tension closure utilizing PDO Quill suture to plicate the abdominal flap down to the abdominal wall in a vertical direction. From Warner and Gutowski. Reprinted with permission of SAGE Publications.

**Figure 5.** (A) During a limited abdominoplasty several loops of each #2 PDO Quill suture strand are passed into the deep tissue (superficial fascia) starting at the center of the wound. (B) Barbs locked into the tissue by pulling on suture strands in opposite directions.
elimination of hand fatigue, which usually occurred due to the many knots required for a 2-layer plication of the abdominal wall with a large-gauge monofilament. Today, I still use 2 rows of suture, but with a single #2 PDO or PPN Quill above and below the umbilicus. I use the multilayered suturing technique and run the 2 ends back toward one another in a vertical manner. A video of this technique (Video 1) is available at www.aestheticsurgeryjournal.com. You may also scan the code on the first page of this article with any smartphone to be taken directly to the video on www.YouTube.com.

To address fascial laxity around the umbilicus and decrease the necessity for additional sutures, I usually end my last stitch with each suture partially around the umbilicus. I tend to place a permanent PPN for larger abdominal girths, since there is no loss of tensile strength over time. I prefer a #2 PDO for Scarpa’s fascia approximation (Figure 5) and, again, utilize a multilayered suturing technique by running the ends back in the subcutaneous tissues (helping to align the skin for closure). I approximate the dermis with 2-0 Monoderm, then apply skin glue over the epidermal suture line. The conversion from 2-0 PDO to 2-0 Monoderm for my dermal subcuticular closures significantly reduced the incidence of Quill extrusion in the postoperative period (50%, or 3 of 6 cases with PDO, vs 5.5%, or 2 of 36 cases with Monoderm). Any exposed suture requiring removal was considered an extruded stitch, and those occurring with Monoderm closures were all less than 1 cm in length and required no local treatment.

TRUNK CONTOURING

Only one currently published article mentions any reference to barbed sutures in trunk contouring. Warner and Gutowski described their circumferential abdominoplasties, but this appears to be limited to the application of
abdominal progressive tension sutures and associated tissue closure as outlined above.

My experience with barbed sutures in trunk contouring over the past 3 years includes the use of Quill bidirectional barbed sutures in lower bodylifts (10 cases; Figures 6 and 7), fleur-de-lis abdominoplasties (64 cases), and corset trunkplasties (77 cases). Currently, Quill is the predominant suture utilized in all cases. It is extensively used for abdominal wall plication, repair of superficial fascia, and skin closure. The “workhorse” suture for approximation of all deep tissues under tension is #2 PDO. I discovered that a proper suturing technique under high tension must be utilized for success (Figures 8-10). I begin by having my assistant push the skin edges together to decrease overall wound tension. I then throw 3 to 4 loops per strand in opposite directions, then evenly pull on the end of the strands to lock the barbs into the tissues. Note that it is important to grasp the suture directly adjacent to the needle instead of pulling on the needle itself, to avoid accidental pop-off. It is equally important to only pull the suture strands parallel to the wound (vs at an angle) to reduce the risk of accidental suture rupture. The same technique (placement of and cinching down suture) is continued for each end until the closure is completed. A video of this technique (Video 2) is available at www.aestheticsurgeryjournal.com. You may also scan the code on the first page of this article with any smartphone to be taken directly to the video on www.YouTube.com.

With this approach, I have been able to obtain reliable and secure deep closures while exclusively utilizing this device. Because of the learning curve associated with the use of barbed sutures, however, I highly recommend that new users continue to place a few interrupted sutures while approximating high-tension areas until the specific suturing technique has become very routine.

In my opinion, an added benefit of closing my vertical wounds with Quill appears to be improved scar cosmesis (thinner scars; Figures 11 and 12), which may be due to several factors. First, because there is no need for knots, I am able to use a larger-gauge suture (#2 as opposed to 2-0 or 0), even in thin patients. I believe this larger suture helps maintain a tension-free skin closure over a longer...
period during scar maturation. Second, the barbed suture also has a positive impact on my closing technique, as I am able to completely approximate the deep tissues under direct visualization (no temporary skin stapling needed), which aids in securing good “bites” of superficial fascia with every throw.

**ARM CONTOURING**

A few articles have mentioned the use of barbed sutures in arm contouring. As described previously in the Abdominal Contouring section, Paul and Budd showed a significant reduction in closing time of approximately 50% with Quill (as opposed to conventional sutures), which could also translate into a 50% decrease in the cost for anesthesia and operating room facilities. No complications were reported since all the closures were performed on nonpreserved fresh cadavers.

A publication by Hurwitz and Jerrod regarding their L-brachioplasty technique described the beneficial use of Quill for all closures. The authors utilized either a 0 or #1 PDO to approximate superficial fascia and a 3-0 Monoderm to approximate dermis of the upper arm and axilla. The only wound complication reported that could be associated with suture placement was limited incision dehiscence (less than 1 cm) in 5 of 30 arms from the evaluation group. The authors concluded that the barbed suture closure reduced operative time and was more secure with fewer minor wound separations.

Again, in contrast (and as described previously), Shermak et al concluded that barbed sutures presented a problem with wound healing, especially in the arms, and they believed the sutures did not offer a benefit of any operative time savings. Not only did this evaluation utilize 0 PDO Quill exclusively, but only 7 brachioplasties were included, with the procedures likely performed by multiple surgeons (including residents) with different levels of...
barbed suture experience. In my opinion, surgeons who have only recently begun using the device are still becoming comfortable with proper barbed suturing technique and may place too many short throws and/or overcinch each suture loop, leading to a higher incidence of wound complications. These early mistakes can lead to increased suture burden, resulting in extrusion of material and strangulated tissue, leading to fat necrosis.

I have used Quill as the primary closing device in my last 38 brachioplasties (19 patients). My barbed suturing technique for these procedures has changed over the years not only due to the “learning curve” issues discussed previously but also because of the availability of a newer Quill formulation. I migrated to a smaller-gauge PDO suture for the thin superficial fascia system/subcutaneous tissue of the upper arm and eliminated the use of PDO along the dermis. I currently perform a similar L-brachioplasty technique to the one described by Hurwitz and Jerrod16 and Hurwitz and Neavin17 but prefer a #2 PDO for deep closure of axillary tissues and a 0 or 2-0 PDO for deep closure of the thin upper arm tissues (Figures 13 and 14). I utilize a multilayered suturing technique (continuation of the same deep suture just below the dermis) in both areas prior to approximating the skin. I prefer a 3-0 Monoderm for dermal approximation (it became available in early 2009). I have also discovered that my current technique of closing these wounds with Quill has shortened my overall operative times, has provided a more secure closure of the thin tissues along the upper arm, and is associated with a low incidence of wound complications.

**THIGH CONTOURING**

There are currently no published articles regarding the use of barbed sutures in thigh contouring. I began incorporating Quill into my thigh procedures in 2007. I have utilized it as my primary closure device in 31 patients (62 thighs)
Figure 10. (A) This 48-year-old woman presented with a body mass index of 31.17 after a 90-pound weight loss following laparoscopic gastric bypass. (B) One week after first-stage contouring with combined corset trunkplasty and medial thighplasties without the use of drains. All closures were completed with #2 PDO Quill and 2-0 Monoderm.

Figure 11. (A) This 52-year-old woman presented with a body mass index of 20.08 after a 140-pound weight loss following laparoscopic gastric bypass. (B) Three months and (C) 2 years after first-stage corset trunkplasty (5.5-pound skin resection), and 14 months after combined periareolar mastopexies with submuscular implant breast augmentations. The vertical abdominal closure was completed with #2 PDO Quill and 2-0 Monoderm, which seems to have improved the long-term appearance of the scar.
Figure 12. (A) This 39-year-old woman presented with a body mass index of 27.37 after a 120-pound weight loss following laparoscopic gastric bypass. (B) Five weeks and (C) 14 months after first-stage contouring corset trunkplasty (9-pound skin resection). The vertical abdominal closure was completed with #2 PDO Quill and 2-0 Monoderm, which seems to have improved the long-term appearance of the scar.

Figure 13. During a major brachioplasty the deep tissue/superficial fascia and subcutaneous layers of the axilla (A, B) and the upper arm (C, D) are approximated utilizing a multilayered suturing technique with #2 PDO Quill and 2-0 PDO Quill, respectively.
Figure 14. (A) This 56-year-old woman presented with a body mass index of 27.85. (B) One year after combined major brachioplasties and reduction mammaplasties. The major brachioplasties were completed with #2 PDO Quill, 2-0 PDO Quill, and 3-0 Monoderm.

Figure 15. (A) Medial thighlift defect along the groin. (B) Several loops of each #2 PDO Quill suture strand are passed into the deep tissue (superficial fascia) starting at the center of the wound. (C) Barbs locked into the tissue by pulling on suture strands in opposite directions.
to date, which includes 3 medial thighlifts (groin incision only; Figure 15) and 28 medial thighplasties (groin and vertical incisions; Figures 16 through 18). Again, the key suture for my deep closures is #2 PDO, which is used with both a high-tension technique and in a multilayered manner (superficial fascia and subcutaneous tissue approximation). I approximate the dermis along the groin and vertical wounds with 2-0 Monoderm. All epidermal suture lines are then sealed with skin glue.

In my experience, due to their even distribution of tension across the suture line, bidirectional barbed sutures appear to better handle poor-quality tissues (as opposed to conventional sutures), such as the ill-defined superficial fascia along the inner thigh. Because Quill devices provide a tight and secure closure, eliminating dead space and movement of tissues, I have recently (as of June 2010) been able to successfully discontinue using drains in all of my inner thigh contouring procedures when coupled with
Figure 18. (A) This 38-year-old woman presented with a body mass index of 21.15 after a 150-pound weight loss following laparoscopic gastric bypass. (B) Six weeks after combined extended abdominoplasty and medial thighplasties. The procedures were completed with #2 PDO Quill and 2-0 Monoderm.

Figure 19. (A) This 59-year-old woman presented with a body mass index of 20.43 after a 110-pound weight loss following laparoscopic gastric bypass. (B) One week after second-stage contouring with combined modified corset trunkplasty and medial thighplasties without the use of drains. The procedures were completed with #2 PDO Quill and 2-0 Monoderm.
the use of Harmonic technology (Ethicon-Endo Surgery, Somerville, New Jersey). I have documented 6 consecutive cases without development of a wound dehiscence or postoperative seroma (Figure 19).

CONCLUSIONS

Barbed sutures appear to have a growing foothold in body surgery. There are a handful of published articles that describe their use and benefits, from arm to abdominal contouring. I have been utilizing bidirectional barbed sutures (Quill) for more than 3 years as the primary closure device during arm, trunk, and thigh procedures. I have experienced the same benefits described by several previous authors, which include decreased operative times (and associated reduction in anesthesia and facility fees), ease of tissue manipulation, ease of wound closure, reduction in hand fatigue, reduced need for drain management, and possible improvement in scar cosmesis. Even with all these apparent benefits, one must be cognizant of the added cost per suture (ranging from 4 to 10 times more expensive as compared with traditional sutures) when selecting an appropriate procedure for use. Therefore, I tend to limit my Quill use to larger closures only (a standard abdominoplasty as opposed to a minibrachioplasty). As with any new surgical device, a learning curve is present and must be overcome to realize the full benefits of incorporating barbed sutures into one’s body contouring practice. The conversion from the use of conventional sutures to knotless closures requires not only a change in mental approach but also key changes in suturing technique to maximize outcomes and minimize wound complications. I am confident that with a few good pointers, new users may be able to avoid some of the early pitfalls during this exciting transition.

Disclosures

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