

Perioperative Closure-related Complication Rates and Cost Analysis of Barbed Suture for Closure in TKA

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Abstract

Background The use of barbed suture for surgical closure has been associated with lower operative times, equivalent wound complication rate, and comparable cosmesis scores in the plastic surgery literature. Similar studies would help determine whether this technology is associated with low complication rates and reduced operating times for orthopaedic closures.

Questions/purposes We compared a running barbed suture with an interrupted standard suture technique for layered closure in primary TKA to determine if the barbed suture would be associated with (1) shorter estimated closure times; (2) lower cost; and (3) similar closure-related perioperative complication rates.

Methods We retrospectively compared two-layered closure techniques in primary TKA with either barbed or knotted sutures. The barbed group consisted of 104 primary TKAs closed with running barbed suture. The standard group consisted of 87 primary TKAs closed with interrupted suture. Cost analysis was based on cost of suture and

operating room time. Clinical records were assessed for closure-related complications within the 6-week perioperative period.

Results Average estimated closure time was 2.3 minutes shorter with the use of barbed suture. The total closure cost was similar between the groups. The closure-related perioperative complication rates were similar between the groups.

Conclusions Barbed suture is associated with a slightly shorter estimated closure time, although this small difference is of questionable clinical importance. With similar overall cost and no difference in perioperative complications in primary TKA, this closure methodology has led to more widespread use at our institution.

Level of Evidence Level III, therapeutic study. See Guidelines for Authors for a complete description of levels of evidence.

Introduction

Reducing perioperative wound complications and improving the cosmetic appearance are important reasons to improve multilayered closure in total joint arthroplasty. With decreasing reimbursement and rapidly increasing surgical demand, closure time is one target to reduce operative time and cost while increasing operative productivity [1, 2, 5]. Although knotted interrupted sutures have traditionally been used for TKA capsular closures, they can be time-consuming and may present several potential disadvantages compared with barbed sutures [3]. These include increased focal stitch bulk and stitch abscesses, local tissue ischemia, and increased needle handling.

A running knotless suture technique using barbed suture technology has been described to facilitate closure and

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repair of soft tissues in the plastic surgery literature [3, 8]. For finger flexor tendon repairs, knotless barbed sutures provide comparable strength to standard knotted sutures [4, 6]. The plastic surgery literature has reported improved closure efficiency and equivalent wound complication rates for dermal closure [3] and separately plication of abdominoplasty flaps to the underlying abdominal wall [8]. Whether these advantages apply to multilayered closure in total joint arthroplasty is unclear.

We compared a barbed suture with an interrupted suture technique in layered closure in primary TKA to determine if the barbed suture would be associated with (1) shorter estimated closure times; (2) lower cost; and (3) similar closure-related perioperative complication rates.

Patients and Methods

We retrospectively compared two different layered closure techniques in primary TKA. The barbed closure group consisted of all 104 primary TKAs performed in 98 patients by the senior author (CLP) between January 1, 2010, and July 15, 2010, because this time period reflected our first 6-month experience using barbed suture in TKA. This group consisted of 32 men (33%) and 66 women (67%). The standard group consisted of 87 primary TKAs performed in 85 patients closed with interrupted suture between January 1, 2009, and July 15, 2009, because this time period was similar to that chosen for the barbed suture group. This group consisted of 30 men (35%) and 55 women (65%). We excluded no patients undergoing primary TKA operated on during these time periods. No patients were lost to followup. No patients were recalled specifically for this study; all data were obtained from medical records. We had approval of our Institutional Review Board.

There were no differences between the two groups in terms of gender, age, height, weight, or body mass index (BMI) (Table 1). There were also no differences between the two groups in terms of the following risk factors for poor wound healing: diabetes mellitus, rheumatoid arthritis, smoking, or renal insufficiency (Table 1).

The medial parapatellar approach was universally used in this study. The barbed suture closures entailed the use of running knotless #2 Quill™ SRS PDO (Angiotech, Vancouver, BC, Canada) suture for arthrotomy closure, running knotless 0 Quill™ SRS PDO (Angiotech) for subdermal closure, and staples for skin closure. This technique used a bidirectional barbed suture with a needle on each end; the barbs change direction at midpoint allowing one directional passing and creating oppositional traction when engaged. The suture was passed through both sides of the incision at its midpoint and the lengths

Table 1. Patient demographics by group

Factor	Barbed (n = 98)	Standard (n = 85)	p Value
Age	61 (11)	63 (11)	0.186
Gender*	32 M (33%) 66 F (67%)	30 M (35%) 55 F (65%)	0.707
Height (in)	66 (4)	66 (4)	0.780
Weight (lb)	200 (48)	205 (52)	0.537
Body mass index (kg/ m ²)	32 (7)	33 (7)	0.415
Diabetes mellitus*	15 (15%)	11 (13%)	0.648
Rheumatoid arthritis*	7 (7%)	2 (2%)	0.179
Smoking*	5 (5%)	9 (11%)	0.164
Renal insufficiency*	2 (2%)	1 (1%)	> 0.99

Data presented as means with standard deviations in parentheses; * these are binary variables and are thus presented as absolute numbers with percentages in parentheses; M = male; F = female.

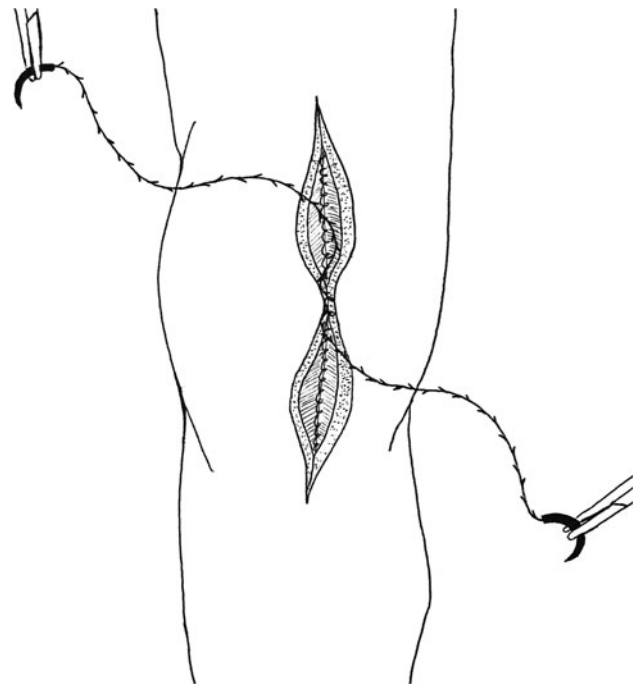


Fig. 1 Subdermal closure showing suture being cinched after several throws to approximate the incision and engage the barbs in each direction. In this figure, the underlying arthrotomy has already been closed using a similar technique.

equalized. This allowed both ends to be simultaneously run in a baseball-stitch fashion in opposing directions and after several throws, the suture was cinched to approximate the incision and engage the barbs in each direction (Fig. 1). At the end of the incision, the direction was reversed for several throws to further anchor the ends by engaging additional barbs. The suture ends were then cut without tying knots. This same procedure was used for both

arthrotomy closure and subdermal closure. The standard suture closures entailed the use of interrupted figure-of-eight #1 Ethibond™ (Ethicon, Somerville, NJ, USA) sutures for arthrotomy closure, interrupted buried simple 2-0 Monocryl™ (Ethicon) sutures for subdermal closure, and staples for skin closure. Because this study was performed at an academic institution, the surgical closure team was not constant and potentially consisted of a variety of individuals such as a physician assistant, third- or fifth-year orthopaedic surgery resident, adult reconstruction fellow, or the senior author (CLP). Both groups received staples for final skin closure followed by nonadhesive gauze, cast padding, a cooling jacket, bulky dressings, and a knee immobilizer.

The standard TKA perioperative regimen at our institution included the following: femoral nerve block catheter for 2 days; knee immobilizer for ambulation as tolerated during the first 2 days; and physical therapy for gait, mobilization, and strengthening starting the evening of surgery and continuing for 6 weeks after surgery or as needed. Two weeks postoperatively, patients were evaluated for clinical progress, pain control, and early wound complication. The 6-week postoperative check included assessment of incision, ROM as well as weightbearing AP, sunrise, and lateral knee radiographs.

Clinical results were graded according to the Knee Society knee score, which was obtained before the index surgery and postoperatively at 6 weeks. Patient records were assessed for perioperative complications within the first 6 postoperative weeks. We assumed this is the time-frame in which the closure technique would be related to complications. Because this is a retrospective study, we determined closure-related complications based on review of clinic notes and operative reports. Pertinent closure-related complications encountered included: hematoma treated conservatively, hematoma treated with irrigation and débridement (I&D), cellulitis treated with antibiotics, superficial infection treated with I&D, arthrofibrosis treated with manipulation under anesthesia, and traumatic wound dehiscence. Complications such as deep vein thrombosis, pulmonary embolism, myocardial infarction, and pneumonia were not included in this study.

Along with obtaining demographic information and medical comorbidities, patient records were reviewed for operative data points, including operative start time, operative end time, and tourniquet time. A tourniquet was used in all cases and was inflated at the time of incision and deflated just before beginning the closure. Estimated closure time was defined as tourniquet time subtracted from the total operative time (surgery start to end time).

We performed a cost analysis that was based on the material costs and the cost of operating room time for each closure technique. Material costs were acquired from our

institution's purchasing department and were based on bulk purchasing prices. Cost of operating room time was based on our institution's fee of \$28.00 (US dollars) per minute for the use of the operating room after the initial 30 minutes. Multiplying estimated closure time by the \$28.00 per minute for the operating room and adding this value to the material costs of each closure technique estimated the total cost of wound closure.

Data were analyzed by an independent statistician using commercially available software (STATA Version 11, College Station, TX, USA). In our sample, eight patients had both knees operated on. Ordinary statistics assume all observations are independent. To check if lack of independence was introduced by having 16 TKAs in eight patients, we fit a multivariable mixed effects linear regression with knees nested inside these patients. The intraclass correlation coefficient in that model was 0. This confirmed that using ordinary statistics was sufficient, and so ordinary statistics were used throughout. Student's *t* test was used for comparing the continuous variables: estimated closure time, total closure cost, knee society scores, age, height, weight, and BMI. The chi-squared test was used to compare all binary variables if the expected frequencies were all greater than five. Fisher's exact test was used to compare those binary variables in which the expected frequencies were not adequate for the chi-squared test. To compare the two groups on total number of complications, an incidence rate approach was used. This approach was applicable because each patient could potentially have more than one complication. An ordinary chi-squared test could not be used, because that test only applies if each patient can have at most one complication. Letting the total complications for a given group be the numerator and the number of patients in the group be the person-time denominator, the rate was (total complications)/(number of patients). The rates for the two groups were then compared using the binomial probability mid-*p* exact test for person-time data. Of the demographic data evaluated, potential confounders were identified as age, rheumatoid arthritis, and smoking because the *p* values were nonsignificant but < 0.25 . A multivariable linear regression controlling for these potential confounders was performed for estimated closure time and total closure cost. A post hoc power analysis for a two-sample comparison of means and proportions was performed, respectively, for both total closure cost and total number of complications because the differences were not significant for either of these variables.

Results

Mean estimated closure time was less ($p = 0.009$) with the use of the barbed suture technique with a mean estimated

Table 2. Closure time and cost analysis

Factor	Barbed (n = 104)	Standard (n = 87)	Adjusted mean difference*	p Value*
Closure time (minutes)	19.6 (18.5–20.7)	22.0 (20.7–23.3)	2.3 (0.6–4.0)	0.009
Total closure cost (\$)	595 (564–626)	627 (590–663)	28 (20–76)	0.259

Data presented as means with 95% confidence intervals in parentheses; * adjusted for age, rheumatoid arthritis, and smoking in a multivariable linear regression model; p value for the adjusted mean difference from the linear regression model.

Table 3. Knee Society knee scores

Knee Society score components	Barbed (n = 104)	Standard (n = 87)	p Value
Preoperative clinical	49 (45.94–52.86)	55 (52–58)	0.398
Preoperative functional	65 (60–70)	52 (48–56)	0.176
Preoperative total	114 (107–121)	107 (102–112)	0.552
Postoperative clinical	88 (86–90)	87 (83–91)	0.779
Postoperative functional	77 (72–81)	82 (78–86)	0.562
Postoperative total	165 (160–170)	169 (162–176)	0.771
Total score improvement	51 (46–56)	58 (53–63)	0.479

Data presented as means with 95% confidence interval in parentheses.

closure time of 19.6 minutes in the barbed group and 22.0 minutes in the standard group and an adjusted mean estimated closure time difference of 2.3 minutes (Table 2).

The material costs of the interrupted closure were \$6 (two #1 Ethibond™ sutures and two 2-0 Monocryl™ sutures) and the barbed closure \$43 (one #2 Quill™ SRS PDO suture and one 0 Quill™ SRS PDO suture). Therefore, the barbed closure cost \$37 more in materials for each knee closure. There was no difference in total closure cost (Table 2). The observed power for total closure cost was 25% in our post hoc analysis.

Postoperative Knee Society knee scores at 6 weeks were compared with those obtained preoperatively in both groups. There was no difference between groups in terms of pre- or postoperative clinical and functional knee scores. Most notably, there was no difference ($p = 0.479$) in the postoperative total score improvement between the two groups (Table 3).

The rate and type of perioperative complications were similar between the groups (Table 4). One patient in each group had a traumatic wound dehiscence from a ground-level fall; both patients had I&D and revision closure. The observed power for the total number of complications was 21% in our post hoc analysis.

Discussion

Although interrupted knotted sutures have traditionally been used for TKA closures, they present several potential

Table 4. Perioperative complications

Complication	Barbed (n = 104)	Standard (n = 87)	p Value
Total perioperative complications	7 (7%)	11 (13%)	0.197
Hematoma treated conservatively	1 (1%)	1 (1%)	> 0.99
Hematoma treated with I&D	0 (0%)	2 (2%)	0.206
Cellulitis treated with oral antibiotics	1 (1%)	4 (5%)	0.179
Superficial infection treated with I&D	1 (1%)	0 (0%)	> 0.99
Arthrofibrosis treated with MUA	3 (3%)	3 (3%)	> 0.99
Traumatic wound dehiscence requiring I&D and closure	1 (1%)	1 (1%)	> 0.99

I&D = irrigation and débridement; MUA = manipulation under anesthesia.

disadvantages, including increased focal stitch bulk and stitch abscesses, local tissue ischemia, and increased needle handling [3]. Barbed sutures are self-anchoring, requiring no knots for wound closure, which may increase the speed of closure, enabling increased operative day efficiency. We compared a running barbed suture with an interrupted suture technique in layered closure in primary TKA to determine if the barbed suture would be associated with (1) shorter estimated closure times; (2) lower cost; and (3) similar closure-related perioperative complication rates.

There were several limitations to our study. First, closure time was calculated from commonly recorded operative times rather than directly measured. This estimation potentially introduces measurement error in our closure times. Second, we did not have another study group in which standard suture was placed in a running fashion for closure. This would have helped to evaluate whether the running technique alone accounted for all of the time savings seen. However, despite the fact that some surgeons use running standard suture for TKA closure, this technique is not a standard practice and is not used at our institution for the fear that suture breakage could lead to catastrophic dehiscence. In a recent biomechanical analysis of this concern with running barbed suture, Vakil et al. compared running barbed suture with interrupted knotted suture for closure of parapatellar arthrotomies in cadaveric knees and found that both methods maintained closure with

cyclical loading [7]. With sequential cutting of sutures from the midpoint out and repeat cycling, the barbed suture survived more cuts before gapping of 2 mm occurred compared with the interrupted technique. Third, adaptation to shorter closure times may have underestimated operative efficiency gains with the barbed suture. Anecdotally, we have noticed that the size of our closure team changed over time with use of the barbed suture; typically our closures were performed by two members of the operative team, whereas with the barbed suture technique, closure is now more commonly performed by one individual as a result of perceived increased efficiency. Our records do not indicate whether one or two individuals performed closures. Although we found a minimal reduction in estimated closure time, we believe, based on this anecdotal experience, use of barbed suture would yield further reduction in closure time if tested head to head with a standardized number of individuals closing.

We found the use of barbed suture was associated with shorter estimated closure times when compared with the interrupted suture technique in primary TKA but we question the clinical importance of a 2.3-minute mean difference. Warner and Gutkowski evaluated the use of a running barbed suture technique in abdominoplasty surgery to plicate the flap to the underlying abdominal fascia through a progressive tension closure [8]. They found this technique was associated with reduced closure times compared with previously published data. Murtha et al. performed a prospective, randomized, controlled trial comparing running knotless barbed suture with running knotted standard suture in dermal closure of Pfannenstiel incisions after elective cesarean delivery [3]. The authors observed no difference was found in mean closure times. Both groups in this study used a running technique, which may explain the lack of difference in the closure times.

Our cost analysis, although rudimentary by some measures, demonstrated the overall cost for closure was equivalent for the two techniques when both suture cost and cost of operating room time were combined. We are unaware of any other available literature evaluating the cost-effectiveness of barbed suture for surgical wound closures. Further prospective studies would be helpful to better evaluate the cost-effectiveness of this relatively expensive new technology.

Perhaps most importantly, we found no difference in either the rate or type of complications between the two suture techniques. However, we did note a tendency toward a lower rate of cellulitis treated with a course of oral antibiotics in the barbed group (1% versus 5%, $p = 0.179$). It is difficult to ascertain whether these patients truly had a superficial infection, because the decision to give

antibiotics to these patients was based on subjective clinical judgment. The decreased amount of cellulitis seen may have been the result of the decreased suture bulk with the knotless barbed suture potentially decreasing the local inflammatory response. Warner and Gutkowski in their evaluation of the barbed suture technique in abdominoplasty found this technique was not associated with any increase in complications compared with previously published techniques [8]. Murtha et al. in their randomized controlled trial evaluating the use of barbed suture in dermal closure of Pfannenstiel incisions found no difference in patient-derived cosmesis scores, adverse events, or pain scores between the groups [3].

In conclusion, we found the use of barbed suture was associated with shorter but clinically unimportant estimated mean closure times, equivalent overall closure cost, and similar rates and types of perioperative closure-related complications in primary TKA. Positive experience and improved efficiency with this closure methodology has led to more widespread use at our institution. Further studies are needed to prospectively evaluate closure efficiency, cost-effectiveness, and rates of perioperative closure-related complications associated with barbed suture in TKA and in additional types of orthopaedic closures.

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