Original Article

Continuous Barbed Suture versus Knotted Interrupted Suture for Wound Closure in Total Knee Arthroplasty: A Prospective Randomized Study

Sakdinakiattikoon M, MD[1], Tanavalee A, MD[2]

[1] Department of Orthopedic Surgery, Bangkok Metropolitan Administration General Hospital, Bangkok, Thailand

[2] Department of Orthopedics, Faculty of Medicine, Chulalongkorn University, Bangkok, Thailand

Background: Wound closure in total knee arthroplasty (TKA) is an essential part of the procedure that affects the outcome of the surgery. Traditionally, closure of capsular and subcutaneous layer is performed using absorbable sutures placed in an interrupted manner. Skin closure usually used non-absorbable sutures placed in an interrupted fashion. A bidirectional, barbed suture that is self-anchoring and that does not require to tie knots during closure have recently begun to gain more popularity.

Objective: To evaluate the efficacy of barbed suture for closure of wound in TKA as compared with traditional suture. The main outcome measures were wound-related complications, wound closure time, Knee Society Score (KSS), and cost.

Materials and Methods: The authors recruited 60 patients planned to undergo TKA. Patients were randomly divided in two groups, group 1 (conventional group; 30 patients) and group 2 (barbed group; 30 patients). In the conventional group, the capsular closure and subcutaneous closure were performed in an interrupted fashion using size 1 and size 2-0 vicryl. Skin closure was performed in running subcuticular suture using size 4-0 vicryl. In the barbed group, the capsular closure, subcutaneous closure, and skin closure were performed in running manner using size 2, size 0, and size 2-0 barbed suture. Patient demographics, preoperative KSS, and operative data were record. All patients were seen for follow-up at two and six weeks and three months postoperatively.

Results: Wound-related complications were similar in both groups. Significant shorter wound closure time in barbed group (12.35 minutes versus 24.45 minutes, p<0.001). Both groups demonstrated improvement in KSS after surgery, but no significant difference was found between the two groups. The average cost of barbed sutures was found to be 2,420 baht more than the conventional sutures per arthroplasty (3,300 baht versus 880 baht, p<0.001).

Conclusion: Use of barbed suture for closure of surgical wounds in TKA leads to satisfied outcomes without adverse effect to wound security and healing process. Wound-related complications were comparable to conventional sutures. Use of barbed suture was associated with shorten wound closure time. The average cost of barbed sutures was found to be more expensive than the conventional sutures.

Keywords: Barbed suture, Quill™, Closure, Total knee arthroplasty

J Med Assoc Thai 2019;102(3):361-7
Website: http://www.jmatonline.com

Wound closure in total knee arthroplasty (TKA) is an essential part of the procedure and affects the outcome of the surgery. Wound-related complications such as wound dehiscence, prolonged drainage, and wound healing problems may cause patient morbidity. Traditionally, closure of the capsular and subcutaneous layers is performed using absorbable sutures placed in an interrupted manner. The surgeon needs to tie knots to secure each stitch. Skin closure is usually accomplished using staples or non-absorbable sutures placed in an interrupted fashion. Drawbacks of knot tying include local tissue ischemia, increased operative time, scar prominence in subcutaneous layers in thinner patients, and stitch abscess[1,2].

A bidirectional, barbed suture that is self-anchoring and requires no knot tying during closure has recently begun to gain popularity. The Quill™

Correspondence to:

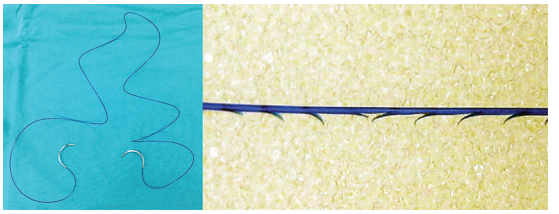
Sakdinakiattikoon M.

Department of Orthopedic Surgery, Bangkok Metropolitan Administration General Hospital, Bangkok 10100, Thailand.

Phone: +66-81-7395165

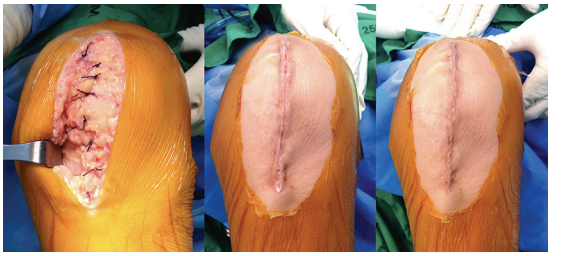
Email: manoonsakdina@gmail.com

How to cite this article: Sakdinakiattikoon M, Tanavalee A. Continuous Barbed Suture versus Knotted Interrupted Suture for Wound Closure in Total Knee Arthroplasty: A Prospective Randomized Study. J Med Assoc Thai 2019;102:361-7.



A B

Figure 1. Bidirectional barbed suture. (A) A bi-directional barbed suture with needle crimped onto both ends. (B) Magnified barbed suture (courtesy of DeLorenzi CL, Aesthetic Surgery Journal, 1 March 2006).



A B C

Figure 2. Three-layer closure using conventional suture. (A) Capsular layer using size 1 vicryl, interrupted suture. (B) Subcutaneous layer using size 2-0 vicryl, interrupted suture. (C) Subcuticular layer using size 4-0 vicryl, running suture.

Knotless-Tissue Closure Device has tiny barbs on its surface, which are helically arrayed in opposing directions on either side of a transitional, un-barbed segment. To facilitate tissue insertion and suturing, a needle is crimped onto both ends of the suture (Figure 1A, B). This suture provides the ability to close the incision using a running stitch without the need for knot tying. Other potential benefits of using a barbed suture include increased resistance to failure when disrupted, a more watertight closure, better distribution of tension along the wound, and improved mechanical strength[3-5].

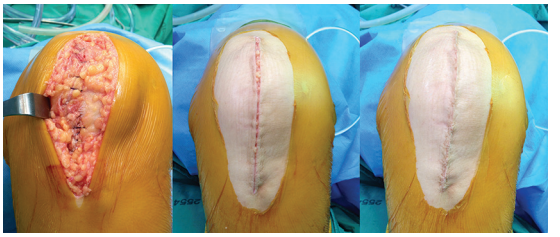
The objective of the present study was to prospectively evaluate the efficacy of bidirectional barbed sutures compared with conventional sutures. The main outcome measures were wound-related complications, wound closure time, Knee Society Score (KSS), and cost.

Materials and Methods

Following receipt of Institution Review Board approval, 60 consecutive patients scheduled to undergo unilateral primary TKA were recruited between June 1, 2013 and March 31, 2015. Patients were randomly divided in two groups using sealed envelopes, group 1 (conventional suture group; 30 patients) and group 2 (barbed suture group; 30 patients). Exclusion criteria for both groups included patients who had prior major knee surgery or previous septic arthritis of the affected knee, patients underwent simultaneous bilateral TKA or revision TKA, and patients with diseases that would adversely affect wound healing, e.g., end stage renal disease requiring dialysis, steroid dependence (defined as an uninterrupted steroid intake for more than a year at a dosage of 0.3 mg/kg/day), metastatic cancer, or malnutrition (indicated by defined as either serum albumin of less than 3.5 g/dL or total lymphocyte count of less than 1,500/mm^3).

All TKA surgeries and wound closures were performed by a single surgeon. The authors used the mini-midvastus approach under and a pneumatic tourniquet in all patients. Before skin incision, a single dose of 1 gram of tranexamic acid was given intravenously. Spinal anesthesia was undertaken in most cases. General anesthesia was only used when spinal anesthesia had failed. No local anesthetic injections were used in the present study. All patients received a cemented posterior stabilized knee prosthesis (NexGen Legacy LPS-Flex, Zimmer, Warsaw, IN, USA). A Hemovac suction drain was used in all cases and was removed on postoperative day 1. For postoperative pain management, all patients received intravenous opioid infusion and intravenous ketorolac or Dynastat for two days. Subsequently, Ultracet or tramadol and selective NSAID COX-2 inhibitors (or COX-1 inhibitors) were administered orally. For venous thromboembolism prophylaxis, the authors encouraged the patients to perform calf pumping exercises and to use elastic compression for two days. No pharmacological prophylaxis was used in the present study. All patients had the same postoperative rehabilitation protocol.

Knees were placed at 45 degrees of flexion for closure of both the capsular and subcutaneous layers, and at 90 degrees of flexion for skin closure. In the conventional suture group, capsular layer closure was performed in an interrupted fashion using size 1 braided absorbable sutures (Coated Vicryl Plus, Ethicon; Johnson & Johnson, Somerville, NJ, USA). The subcutaneous layer was then closed with simple interrupted stitches and knots using size 2-0 braided absorbable sutures, and skin closure was performed with a running stitch subcuticular suture using size 4-0 braided absorbable sutures (Figure 2A-C). In



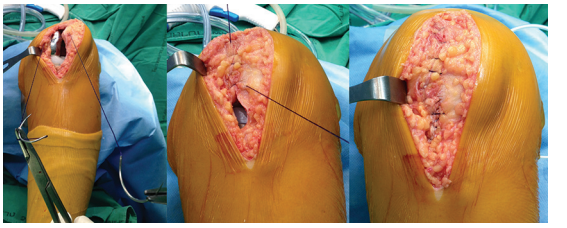
A B C

Figure 3. Three-layer closure using barbed suture with a running stitch in all layers. (A) Capsular layer using size 2 barbed suture. (B) Subcutaneous layer using size 0 barbed suture. (C) Subcuticular layer using size 2-0 barbed suture.

Figure 4. After skin closure, the incision was covered with sterile adhesive strips.

the barbed suture group, capsular layer closure was performed with a running stitch using size 2 polydioxanone (PDO) suture (Quill™; Angiotech Vancouver, BC, Canada). Subcutaneous layer closure was then performed with a running stitch using size 0 polydioxanone suture, and skin closure was performed with a subcuticular running stitch using size 2-0 Monoderm suture (Figure 3A-C). Following skin closure, all incisions were covered with sterile adhesive strips (Leukostrip, Smith & Nephew) (Figure 4).

The technique used for wound closure with barbed suture is as follows. The authors started at the midpoint of the incision by passing the suture through both sides of the incision with the lengths



A B C

Figure 5. Closure technique using barbed suture. (A) At the center of the incision, we passed the barbed suture through both sides of the incision, then pulled it through until a slight resistance was felt at the midpoint of the suture. Sewing was started from that point. (B) After every 2 to 3 stitches in each direction, the suture was pulled tight. Sewing was continued both proximally and distally. (C) Once the end of the incision was reached, the suture direction was reversed for 3 to 4 stitches to provide additional reinforcement.

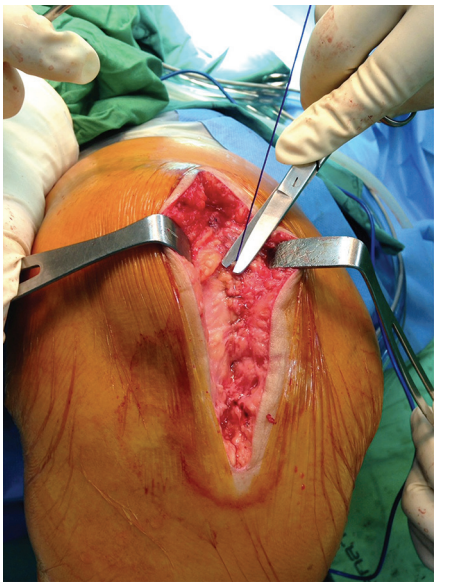


Figure 6. Suture ends were cut flush with the tissue at the free ends without tying knots.

equalized until the authors felt a slight resistance. This allowed both ends to be run in opposite directions (Figure 5A-C). When the authors reached the end of the incision, the suture direction was reversed for 3 to 4 throws stitches to further provide additional reinforcement. The suture ends were then cut flush with the tissue at the free ends without tying knots and with the knee in full flexion (Figure 6).

All patients were seen for clinical follow-ups at two and six weeks and at three months postoperatively, at which time wound condition and KSS were

Table 1. Patient demographic data and preoperative KSS

Variable	Conventional suture group (n = 30) Mean (range)	Barbed suture group (n = 30) Mean (range)	p-value
Age (years)	65.7 (56 to 83)	64.8 (55 to 82)	0.73
BMI (kg/m^2)	26.6 (21.1 to 34.8)	24.7 (21.5 to 34.2)	0.46
Sex (male/female), n	5/25	7/23	0.96
Preoperative KSS	63.7 (58.5 to 69.2)	68 (62.6 to 71.7)	0.35

BMI=body mass index; KSS=Knee Society Score

Table 2. Wound closure time, tourniquet time, and skin incision length

Variable	Conventional suture group Mean (range)	Barbed suture group Mean (range)	p-value
Tourniquet time (minutes)	98.55 (82.32 to 118.34)	92.78 (78.10 to 115.56)	0.14
Skin incision length (cm)	12.35 (9.25 to 16.84)	12.68 (9.34 to 15.43)	0.87
Wound closure time (minutes)	24.45 (19.30 to 29.25)	12.35 (10.86 to 14.67)	<0.001

recorded. Sterile adhesive strips were removed two weeks postoperatively.

Operative data included skin incision length, tourniquet time, and wound closure time. A stopwatch was used to record wound closure time, beginning with the first suture stitch of the capsular layer and ending with complete closure of the skin layer. Skin incision length was measured at the knee in full extension. Patient demographics including sex, gender, and body mass index (BMI) were recorded. Preoperative KSS were obtained for all patients.

A cost analysis was performed based on the cost of the suture materials, operating room charges, and anesthetic fees for each closure technique. A pilot study performed by the authors found the mean wound in the conventional group was 24 minutes (±6 minutes) and in barbed suture group was 13 minutes (±4 minutes). The caclulated sample size needed to detect an operating time difference of 10 minutes (alpha 0.05, power 0.8) was 29 patients per group. Data were collected, recorded, and analyzed using SPSS. Student's t-test was used for assessment of parametric data; nonparametric categorical variables were analyzed with the Chi-square test to make comparisons between the two groups. The p-values smaller than 0.05 were considered statistically significant.

Results

Patient demographic data (age, gender, and BMI) were similar in both groups (Table 1).

Wound-related complications

No patients in either the conventional suture group or the barbed suture group developed a superficial infection, deep infection, or wound dehiscence. Five patients experienced postoperative drainage from the incision (three in the conventional suture group and two in the barbed suture group; p=0.75). All drainage ceased without incident within one week of the operation without surgical intervention.

Wound closure time

There was a significant difference in wound closure time between patients closed with a barbed suture and those closed with a conventional suture, although there was no significant difference in either the mean length of skin incision or tourniquet time (Table 2). The mean wound closure time with a barbed suture was 12.35 minutes compared with 24.45 minutes in the conventional suture group (p<0.001).

Cost assessment

Details of the cost of sutures for both groups were shown in Table 3. The average cost per arthroplasty of barbed sutures was 2,420 baht more than the average cost of conventional sutures (3,300 baht versus 880 baht, p<0.001). The combined operating room charges and anesthesiologist fees at our institution were estimated to be 25,000 baht per TKA for an operative time of not more than two hours. As surgery in neither group lasted in excess of two hours, there was no significant difference in operating room charges between the two groups.

Post-operative Knee Society Score

Post-operative KSS scores at two and six weeks,

Table 3. Cost of sutures by group

Type of suture	Price per suture (baht)	Average amount of suture number of sutures per TKA	Average total suture cost per TKA (baht)
Conventional group			880
Coated Vicryl Plus size 1	200	2	
Coated Vicryl Plus size 2-0	150	2	
Coated Vicryl Plus size 4-0	180	1	
Barbed suture group			3,300
PDO size 2	1,100	1	
PDO size 0	1,100	1	
Monoderm size 2-0	1,100	1	

TKA=total knee arthroplasty; PDO=polydioxanone

Table 4. Post-operative KSS

Post-operative KSS*	Conventional suture group Mean (range)	Barbed suture group Mean (range)	p-value
2 weeks	79 (72.5 to 86.4)	81 (73.5 to 89.5)	0.25
6 weeks	83 (77.7 to 89.3)	84 (77.4 to 91.6)	0.64
3 months	89 (81.6 to 96.2)	91 (85.5 to 97.4)	0.28

KSS=Knee Society Score

and three months were not significantly different between the two groups (Table 4).

Discussion

The unique bidirectional barbed suture design has several advantages including eliminating the need to tie knots and thus avoiding potential knot-related complications, facilitating more rapid wound closure, allowing two surgeons to work on one closure at the same time as well as not requiring an assistant to follow the suture (self-anchoring) and achieving more uniform distribution of tension across the entire length of the wound. In dynamic testing, barbed suture closures have been shown to be as strong as conventional interrupted closures and to be more resistant to failure when disrupted[2].

The authors results demonstrate that the use of barbed sutures for closure of surgical wounds in primary TKA leads to satisfactory outcomes with no adverse effect on wound security or the healing process and no change in the incidence or type of wound-related complications, results similar to reports in previous studies[6-9]. For example, Gililland et al[6] performed a multicenter prospective randomized trial of barbed sutures in TKA. In the present study, patients undergoing primary TKA were randomized to either the barbed running suture group (n = 191) or the knotted interrupted suture group (n = 203). They found similar rates and types of perioperative closure-related complications as well as a trend toward fewer needle pricks of surgical staff in the barbed suture group. Recently, Chan et at[10] performed a randomized controlled study comparing the efficacy of barbed sutures and traditional sutures in TKA. They reported more positive leak tests, more wound complications, and longer wound closure times in the traditional suture group compared with barbed suture group. However, Campbell et al[11] reported a higher rate of wound complications using barbed sutures and suggested that the use of barbed sutures for skin closure after knee arthroplasty should be avoided. Similarly, Smith et al[12] enrolled 34 patients in a prospective randomized controlled trial and found increased frequency and severity of wound complications associated with barbed sutures compared with traditional sutures; the use of barbed sutures was discontinued by the attending surgeon involved as a result.

A study of Maheshwari et al[13] found no significant differences in either wound closure time or total operative time between conventional sutures and barbed sutures, while several other studies have reported shorter wound closure times with barbed sutures[6,10], similar to the authors results. The authors found an average savings of 12 minutes in total operating time per case, which represents a 50%

reduction in closure time, obviously a time saving for us. The authors realized that it was easier closing of the difficult capsular layer at the corner of the incision in obese patients.

Although the materials cost of barbed sutures was higher than that of conventional sutures, many studies revealed a total cost saving with the barbed suture closure method[9,10,12,13]. The incremental cost savings in operative time was likewise significant for the faster barbed closures than for the conventional closures. At the hospital, the cost of operating room charges and anesthesiologist fees is estimated to be 25,000 baht per TKA if the operative time is not more than two hours, so the cost difference between the two groups comes only from the cost of the suture materials. It should be noted that the cost of operating room time, including operating room charges and anesthesiologist fees, at many institutions is much higher than at the hospital. The present study found the average cost of barbed sutures to be 2,420 baht more than conventional sutures per TKA (3,300 baht versus 880 baht).

Strengths of the present study include that it was performed as a prospective randomized study and that a single surgeon performed all the surgeries and closed the wounds in both groups. However, there were some limitations. First, with the relatively low number of patients, the low wound complication rates in each group may not provide adequate power for comparison. Second, the present study covered only a short period of time. Large, well-controlled randomized trials with long-term follow-up are needed to validate the advantages of barbed sutures for wound closure in TKA.

Conclusion

Bidirectional barbed sutures provide an alternative to conventional sutures in wound closure of primary TKA. The present study found that efficacy and safety outcomes are similar to conventional sutures, although barbed sutures require significantly shorter wound closure time. The material cost of the barbed sutures was greater than that of conventional sutures, but operative times were shorter. As operative time charges vary among institutes, the total savings with the barbed suture will depend on the specific institution.

What is already known on this topic?

Bidirectional barbed sutures provide an alternative to conventional sutures in wound closure of primary TKA. Most studies demonstrated that this kind of suture could shorter wound closure time significantly. The major concern was the safety of using barbed suture. Does it increased the wound-related complications? Previous studies showed conflicting outcomes regarding this issue.

What this study adds?

The present study confirmed the efficacy and safety outcomes of barbed suture. Use of barbed suture was associated with shorten wound closure time while the wound-related complications were similar to the conventional method. Many studies revealed cost saving for barbed suture closure method because the cost of operating room time including operating room charges and anesthesiologist fees of their institutes is very costly. Thus, the incremental cost savings in operative time was significant for the faster barbed closures. Unlike the government hospital in Thailand including our hospital, where the cost of operating room charges and anesthesiologist fees is much cheaper, a faster wound closure time and less operative time does not save on cost.

Conflicts of interest

The authors declare no conflict of interest.

References

1. Levine BR, Ting N, Della Valle CJ. Use of a barbed suture in the closure of hip and knee arthroplasty wounds. Orthopedics 2011;34:e473-5.
2. Murtha AP, Kaplan AL, Paglia MJ, Mills BB, Feldstein ML, Ruff GL. Evaluation of a novel technique for wound closure using a barbed suture. Plast Reconstr Surg 2006;117:1769-80.
3. Vakil JJ, O'Reilly MP, Sutter EG, Mears SC, Belkoff SM, Khanuja HS. Knee arthrotomy repair with a continuous barbed suture: a biomechanical study. J Arthroplasty 2011;26:710-3.
4. Nett M, Avelar R, Sheehan M, Cushner F. Water-tight knee arthrotomy closure: comparison of a novel single bidirectional barbed self-retaining running suture versus conventional interrupted sutures. J Knee Surg 2011;24:55-9.
5. Leung JC, Ruff GL, Batchelor SD. Performance enhancement of a knotless suture via barb geometry modifications. In: 7th World Biomaterials Congress 2004 Proceedings of a meeting held 17-21 May 2004, Sydney, Australia; 2004, Transactions #1587.
6. Gililland JM, Anderson LA, Barney JK, Ross HL, Pelt CE, Peters CL. Barbed versus standard sutures for closure in total knee arthroplasty: a multicenter prospective randomized trial. J Arthroplasty 2014; 29:135-8.
7. Eickmann T, Quane E. Total knee arthroplasty closure with barbed sutures. J Knee Surg 2010;23:163-7.

8. Gililland JM, Anderson LA, Sun G, Erickson JA, Peters CL. Perioperative closure-related complication rates and cost analysis of barbed suture for closure in TKA. Clin Orthop Relat Res 2012;470:125-9.
9. Ting NT, Moric MM, Della Valle CJ, Levine BR. Use of knotless suture for closure of total hip and knee arthroplasties: a prospective, randomized clinical trial. J Arthroplasty 2012;27:1783-8.
10. Chan VWK, Chan PK, Chiu KY, Yan CH, Ng FY. Does barbed suture lower cost and improve outcome in total knee arthroplasty? A randomized controlled trial. J Arthroplasty 2017;32:1474-7.
11. Campbell AL, Patrick DA Jr, Liabaud B, Geller JA. Superficial wound closure complications with barbed sutures following knee arthroplasty. J Arthroplasty 2014;29:966-9.
12. Smith EL, DiSegna ST, Shukla PY, Matzkin EG. Barbed versus traditional sutures: closure time, cost, and wound related outcomes in total joint arthroplasty. J Arthroplasty 2014;29:283-7.
13. Maheshwari AV, Naziri Q, Wong A, Burko I, Mont MA, Rasquinha VJ. Barbed sutures in total knee arthroplasty: Are these safe, efficacious, and cost-effective? J Knee Surg 2015;28:151-6.