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# A Modified Strategy Using Barbed Sutures for Wound Closure in Total Joint Arthroplasty: A Prospective, Randomized, Double-Blind, Self-Controlled Clinical Trial

Authors' Contribution:  
Study Design A  
Data Collection B  
Statistical Analysis C  
Data Interpretation D  
Manuscript Preparation E  
Literature Search F  
Funds Collection G

ABCDEF 1 **Rui Li\***  
ABCDEF 1 **Ming Ni\***  
BDEF 2 **Jing Zhao**  
BCDE 1 **Xiang Li**  
BCEF 1 **Zhuo Zhang**  
BEF 1 **Peng Ren**  
BCE 1 **Chi Xu**  
ADE 1 **Ji-Ying Chen**

1 Department of Orthopedics, Chinese People's Liberation Army (PLA) General Hospital, Beijing, P.R. China  
2 Department of Anesthesia/Surgery Center, Chinese People's Liberation Army (PLA) General Hospital, Beijing, P.R. China

\* Rui Li and Ming Ni contributed equally to this work  
Ji-Ying Chen, e-mail: [chenjiying\\_301@163.com](mailto:chenjiying_301@163.com)  
Departmental sources

**Corresponding Author:**  
**Source of support:**

**Background:** Barbed suture has reported time-saving and safety benefits for wound closure in total joint arthroplasty (TJA). However, this technique requires further investigation. The aim of this study was to use a prospective, randomized, self-controlled study to further determine the efficiency and safety of this technology and to introduce our modified suturing method through a randomized, self-controlled trial.





**Material/Methods:** From August 2015 to December 2016, 84 patients (hip 46, knee 38) who had undergone primary simultaneous bilateral total knee or hip arthroplasties were enrolled in this study. Barbed sutures were randomized and used on one side, and traditional sutures (Vicryl) were used on the other side.

**Results:** Closure time was shorter with the barbed sutures: 6.25 min (12.00 min vs. 18.25 min,  $p=0.000$ ) for hip and 5.54 min (13.18 min vs. 18.71 min,  $p=0.000$ ) for knee. There was no difference in the complication rate for the 2 groups. The total cost of our suturing strategy (Quill) was 872.3 RMB, which is 375.1 RMB higher than the total cost of the standard suture method (Vicryl). However, the traditional barbed suturing method (Quill) cost 2195.6 RMB.

**Conclusions:** Barbed suturing was a fast and safe method for wound closure in TJA. We also recommend our modified suturing strategy, especially in countries where operation cost was not associated with operation time.

**MeSH Keywords:** **Arthroplasty, Replacement, Hip • Arthroplasty, Replacement, Knee • Sutures • Wound Closure Techniques**

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## Background

Total joint arthroplasty (TJA) rates have consistently risen in recent years and will continue to rise in the future [1,2]. Improving surgical efficiency is an important factor that surgeons should consider. Among various options, reducing closure time is a good method of improving surgical efficiency. In addition, with reduced operation times, anesthesia times, bleeding, tourniquet times, and even infection rates can also be reduced [3–5].

Barbed suturing is characterized by knotless fixation. It has been widely used in plastic, urologic, obstetric, and laparoscopic gynecologic surgery for several years [6–9]. It has also become increasingly prevalent in TJA in recent years. Several studies have demonstrated its advantages in efficiency, safety, and cost savings for wound closure in TJA [10–14]. However, some authors remain skeptical of this method. Austin et al. reported that although there were no differences in the overall and wound-related 90-day reoperation rates, they observed a higher frequency of arthrotomy failures when barbed sutures were used for arthrotomy closure during TKA [15]. In 2012, Wright et al. reported suture breakages when using barbed sutures [16]. Other articles have reported that using barbed sutures may increase superficial infection rates [17–19]. The reason for these inconsistent results may be the existence of bias, including different patient conditions, as well as the different surgical and suturing techniques of surgeons. A randomized, self-controlled study would minimize these biases. However, only Sah has reported a self-controlled study, including 50 TKA cases, and to date, no hip study has been published [20].

In addition, previous studies have shown that using barbed sutures resulted in cost savings [11,13,17,20]. This finding was based on the premise that operation time was associated with operation cost, but in countries like China this is not true. Using the method described in previous studies would greatly increase costs. Thus, we adapted a modified suturing strategy to achieve a better cost-performance ratio. The purpose of this study was to introduce our modified method and to further confirm the reliability of using barbed sutures in TJA.

## Material and Methods

### Patients and design

This study was approved by the Medical Ethics Committee of our hospital (S2015-031-02) and was registered in the Chinese Clinical Trial Registry. From August 2015 to December 2016, one surgeon at our center performed 99 primary simultaneous bilateral total knee or hip arthroplasties. The following exclusion criteria were applied: 1) a prior surgical incision or

scar near the proposed incision site (1 case); 2) skin problems around the incision (1 case); 3) due to the different surgical difficulties of the 2 sides, we could not make the difference in the incision length <1 cm (2 cases); and 4) the patient refused to enroll in the study (11 cases). Finally, 84 patients remained (Figure 1).

There were 2 suturing method categories. For each patient, one side was randomized to the barbed group, the other side was correspondingly divided into the control group. Moreover, we also randomized the surgical priority for each side. These determinations were performed by one doctor who did not participate in the surgery and postoperative observation.

### Surgical technique

A lateral position and posterior lateral approach were used for THA. While a supine position and patellar medial approach were used for TKA. For a certain patient, the same type of prosthesis was used for both sides, and the incisions on the 2 sides were closed by the same 2 assistants. Both assistants had experience using barbed sutures in at least 50 cases. Four layers needed to be closed for each patient, including the fascia (hip)/joint capsular(knee), fat, subcutaneous and skin. Wound closure of the knee was performed with the patient in a 30° flexion position.

For the barbed group, we used running knotless #2 Quill for the fascia (hip)/joint capsular (knee). After finishing this layer, we did not cut the suture; on the contrary, we made a “U turn”, suturing back towards the middle of the deep fat layer (Figure 2). After reaching the middle of the deep fat layer, we cut the suture and then used #2-0 Vicryl for 2 or 3 interrupted sutures. If the length of the #2 Quill was insufficient, more interrupted #2-0 Vicryl was used to fill up the blank. Interrupted suturing (#2-0 Vicryl) was performed in the subcutaneous layer, and we sutured this layer combined with the superficial fat layer (approximately 0.5 cm). Finally, we used skin staples (Table 1).

For the control group, we used the traditional method, #1 Vicryl for successive chain-shaped suturing in the fascia (hip)/joint capsular(knee). We used #2-0 Vicryl for inverted interrupted suturing in the fat and subcutaneous layers. Then, staples were used for the skin (Table 1).

### Data collection

Time was recorded from the placement of the first stitch to the time that the fascia (hip)/joint capsular (knee) layer was closed. The time required to close all layers of the wound was also recorded. The incision length was controlled by the surgeon and was the same (as much as possible) on both sides.

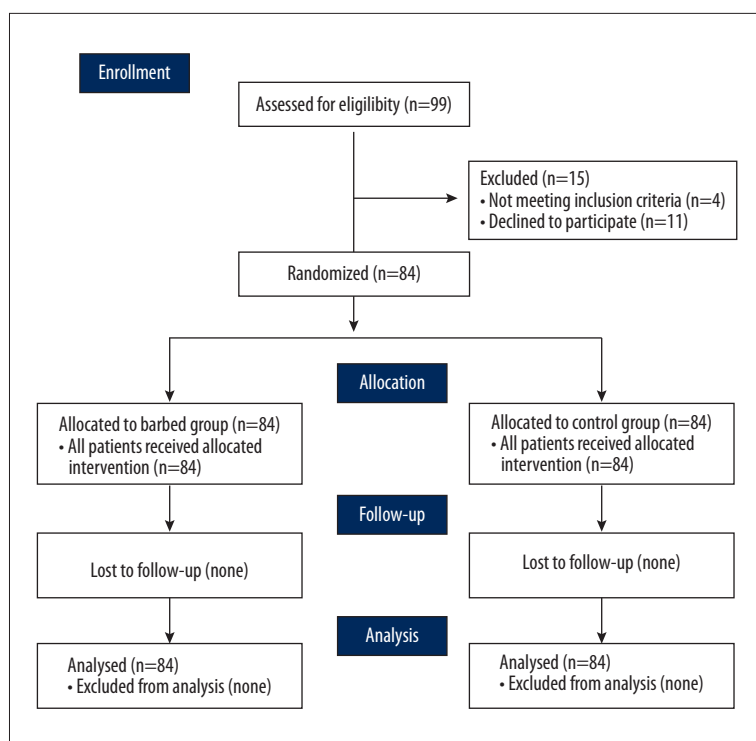


Figure 1. Flow chart of enrollment.

Data were recorded by a medical student or a nurse who was present in the operating room during the wound closure.

The surgical incision was inspected daily by an observer after the operation until patient discharge (usually on the 5<sup>th</sup> post-operative day). The observer was a resident doctor who did not participate in the operation or the trial design and did not know which side was in the barbed group. The patients were unconscious during surgery, and, because the incisions appeared to be the same (the staples were used for the skin in both sides), they did not know which side was in the barbed group. Each patient underwent 2 postoperative follow-ups (at the second week and the sixth week, respectively). Any complication related to the wound was recorded and divided into 2 categories. Minor complications were defined as any complication related to the surgical incision that could be handled in the ward, such as redness, swelling, continuous exudation, stitch abscess, and superficial infection. Major complications were defined as any complication requiring a return to the operating room for a second procedure, such as incision suture crack or deep infection. In addition, for the TKA patients, we also recorded the range of motion (ROM) at the second-week follow-up.

### Statistical methods

For statistical analysis,  $p < 0.05$  was considered to be significant. We used the  $t$  test for continuous variables, and the chi-squared test or Fisher's exact probability test were used for

categorical variables. IBM SPSS Statistics (version 21.0.0.0) was used for all analyses.

## Results

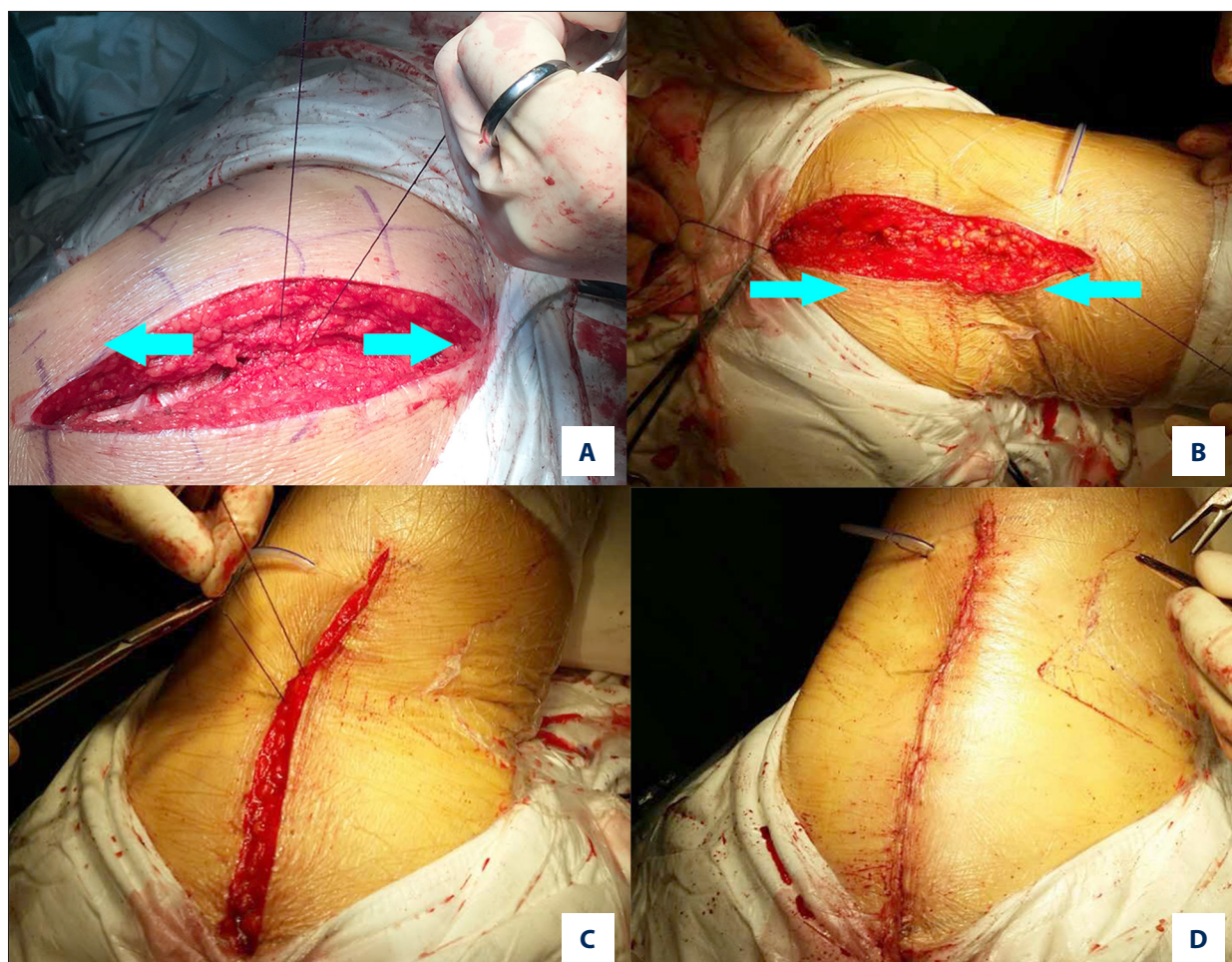
There were 46 patients (32 males, 14 females; mean age, 43.76 years, range 22 to 70 years; BMI  $23.78 \pm 2.98$  kg/m<sup>2</sup>) in the THA group. The incision length was  $14.29 \pm 1.03$  cm and  $14.31 \pm 1.02$  cm,  $p = 0.803$ . The patient diagnoses included osteonecrosis of the femoral head (27), osteoarthritis (12), ankylosing spondylitis (4), and developmental dysplasia of the hip (3). There were 38 patients (8 males, 30 females; mean age, 60.11 years, range 37 to 70 years; BMI  $26.76 \pm 3.22$  kg/m<sup>2</sup>) in the TKA group. The incision length was  $14.82 \pm 1.31$  cm and  $14.78 \pm 1.34$  cm,  $p = 0.628$ . The patient diagnoses included osteoarthritis (35), rheumatoid arthritis (2), and ankylosing spondylitis (1).

### Efficiency

Suturing time of the fascia and total wound closure are detailed in Table 2. There was a significant difference between the barbed and control groups for THA ( $p < 0.001$ ) as well as for TKA ( $p < 0.001$ ).

### Safety and function

None of the patients enrolled in this study experienced major complications.



**Figure 2.** Suturing method for the barbed group. (A) We used running knotless #2 Quill for the fascia (hip)/joint capsular(knee) from the center to the sides. (B) After finishing the final layer, we did not cut the suture; on the contrary, we made a “U turn”, suturing back towards the middle of the deep fat layer. (C) After reaching the middle of the deep fat layer, we cut the suture and then used #2-0 Vicryl for 2 or 3 interrupted sutures. (D) Ready to use staples after performing interrupted suturing (#2-0 Vicryl) in the subcutaneous layer.

For the THA patients, 4 minor complications (8.7%) were observed in the barbed group, including redness (2 cases), continuous exudation (1 case), severe skin allergy (both sides, 1 case); and 3 minor complications (6.5%) were observed in the traditional group, including local redness (1 case), continuous exudation (1 case), and severe skin allergy (1 case, both sides). The results of a paired chi-square test revealed no significant difference between them ( $p=1$ ). One patient may have been allergic to medical alcohol. Both sides showed massive swelling, liquefied incision, and massive exudation. After changing the dressing method (Povidone-iodine), the incision improved in 4 days.

For TKA, 3 minor complications (8.1%) were observed in the barbed group (1 redness, 1 swelling, and 1 continuous exudation), and 3 minor complications (8.1%) were observed in the traditional group (1 swelling, 1 continuous exudation, and 1

stitch abscess). A paired chi-square test revealed no significant difference between them ( $p=1$ ). All patients with minor complications improved after continuous dressing changes and none required further surgical intervention or excessive antibiotic usage.

Moreover, for the TKA patients, after 14 postoperative days, the difference in the range of motion (ROM) of the 2 sides was  $0.39 \pm 7.83$  ( $p=0.758$ ). There was no statistically significant difference between the 2 groups.

#### Cost

For the fascia layer, we often needed 2 #1 Vicryl sutures to finish successive chain-shaped suturing, which costs 173.8 (86.9\*2) RMB (approximately \$25.56, with an exchange rate of 6.8). In addition, one barbed suture costs 548.9 RMB (approximately



**Table 1.** Suturing strategy.

Layer	Control group	Barbed group
Fascia (hip)/joint capsular (knee)	#1 Vicryl, successive chain shaped suturing	#2 Quill running
Fat*	#2-0 Vicryl, (VCP751D) interrupted suturing	#2 Quill running**
Subcutaneous***	#2-0 Vicryl, (VCP751D) interrupted suturing	#2-0 Vicryl, (VCP751D) interrupted suturing
Skin	Staples	Staples

\* In a few patients who were extremely thin, particularly in the knee, we skipped this layer; \*\* In the barbed group, after reaching the middle of the fat layer, we cut the suture and then used #2-0 Vicryl for 2 or 3 interrupted sutures. If the length of the #2 Quill was insufficient, more interrupted #2-0 Vicryl was used to fill the blank; \*\*\* When we sutured this layer, we usually combined approximately a 0.5 cm of the superficial fat layer together.

**Table 2.** THA and TKA wound closure times.

Layer	Barbed group		Control group		Difference		
	Mean time (Min)	Standard deviation (Min)	Mean time (Min)	Standard deviation (Min)	Mean time (Min)	Standard deviation (Min)	P value
Fascia (THA)	4.86	0.93	9.06	1.02	4.21	0.86	<0.001
Total (THA)	12.00	1.65	18.25	2.41	6.25	2.11	<0.001
Fascia (TKA)	5.27	0.60	9.18	1.12	3.91	0.78	<0.001
Total (TKA)	13.18	1.12	18.71	1.59	5.54	1.41	<0.001

**Table 3.** Cost details.

Group	Materials				Total cost
	Fascia (hip)/joint capsular (knee)	Fat	Subcutaneous	Skin	
Traditional group (VICRYL)	#1 VICYL*2 86.9*2=173.8 RMB		#2-0 VICYL 217.8 RMB	Staples 105.6 RMB	497.2 RMB
Barbed suture group		#2 Quill 548.9 RMB	#2-0 VICYL 217.8 RMB	Staples 105.6 RMB	872.3 RMB
Barbed suture method used in previous studies	#2 Quill 548.9 RMB	#1 Quill 548.9 RMB	#0 Quill 548.9 RMB	2-0 Quill 548.9 RMB	2195.6 RMB

\$80.72), and staples cost 105.6 RMB (approximately \$15.53). Thus, the traditional method (control group) would cost 497.2 RMB (approximately \$73.23), while our modified method would cost 872.3 RMB (approximately \$128.28), as shown in Table 3.

## Discussion

Recently, barbed suturing has become increasingly popular as a simple and fast method for wound closure, particularly in TJA. Several researchers have reported that barbed suturing

has a shorter closure time, lower cost, and similar outcomes and complications compared with standard sutures [10–14]. The conventional barbed suturing method usually uses one suture to close one layer. The first suture was performed at the center of the wound, and 2 surgeons simultaneously ran the suture towards opposite sides. When reaching the end of the wound, a few redundant throws were inserted back towards the center to ensure that the suture was in place, and the ends were cut. The next layer was closed using the same procedure. Although using this method will increase the material cost, the decreased operation time could save costs.

However, in some countries, for example China, the operation cost is not associated with the operation time. Thus, using the method mentioned above would greatly increase patient costs. Moreover, in clinical practice, due to the heterogeneity of surgeon levels, including attending physicians, residents, and even medical students, suturing speed on one side can be much lower than the other side when they simultaneously run the suture towards opposite sides. The Buckets Effect will block the procedure from moving to the next layer and prolong the entire suturing time.

Considering these issues, we adopted a compromise method. As previously mentioned, instead of a few redundant throws inserted back, we made a “U” turn and directly moved to the next layer (the deep fat layer), using the remaining length of the suture to finish the next layer. This method used one suture to finish the closure of 2 layers and could save more time because there was no need to cut, change stitches, and suture or wait for the slower surgeon if the 2 surgeons worked at different speeds.

Some may be skeptical of the safety of this method. In theory, deep fascia is more compact than fat, and it supports more tension. Moreover, the 2 or 3 interrupted #2-0 Vicryl sutures in the middle of the fat layer will enhance the tension. Even if the fat layer cracked, it would not influence the fascia layer. The most important evidence was, in practice, that we did not observe any significant difference between the 2 groups in the present study.

Some researchers believe that using the barbed suture method will increase the superficial infection rate in total knee arthroplasty [18,19], which is why our modified method used #2-0 Vicryl rather than barbed suture for subcutaneous layers. Our results showed the complications in the 2 groups were not significantly different when using our modified strategy, which means that this method may avoid adverse complications, and our findings support the conclusion of these 2 previous studies.

The results in the deep fascia layer demonstrated a mean time savings  $4.21 \pm 0.86$  for knees and  $3.91 \pm 0.78$  for hips, which are in line with previous studies [10–14]. For the entire closure time, the 2 groups were treated with a compound strategy by using our modified method. In the present study, the mean time savings were 5.54 min (13.18 min vs. 18.71 min) for knees and

6.25 min (12.00 min vs. 18.25 min) for hips. A meta-analysis has shown that for knee arthroplasties, the time savings was 4.3 min (10.1 vs. 14.4 min), and for hip arthroplasty, the time savings was 5.4 min (9.6 vs. 15.0 min) [13]. The entire suturing time using our strategy was slightly slower than the reported results, which may be because we used interrupted suturing for the subcutaneous layer. However, the time savings was still considerable, especially in the fascia layer.

Based on the charging standards of our center, the traditional method (control group) will cost 497.2 RMB (approximately \$73.23, if the exchange rate is 6.8), while our modified method will cost 872.3 RMB (approximately \$128.28). However, the method used in previous studies (4 barbed sutured for 4 layers) could cost as much as 2195.6 RMB (approximately \$322.88), which could place a huge burden on patients in countries where the operation costs are not associated with the operation time.

There are 2 limitations in this study. First, the sample size of this study was not sufficient large, and more studies are needed to further confirm our conclusion. Second, this study did not directly evaluate the difference between our modified strategy and the methods mentioned in previous studies because our self-controlled study could only set up 2 groups (2 sides of the patients' joints). Future studies are needed to evaluate this issue.

## Conclusions

Use of barbed suture was a fast and safe wound closure method for TJA. We recommend our modified suturing strategy, particularly in countries where the operation costs are not associated with the operation time.

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## Conflict of interest

None.

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