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ORIGINAL ARTICLE

The Examination of the Benefits of the Usage of Barbed, Knotless Suture in Capsule Repair During Total Knee Arthroplasty: A Prospective, Double-Blind, Randomized Controlled Study

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Abstract

Introduction In today's world, high-cost procedures are being examined, and alternative procedures are being developed. In this context, one frequently examined procedure is total knee replacement.

Purpose This study aims to examine the three different closure techniques used in total knee replacement.

Methods This study is a prospective randomized controlled study. Two hundred participants who underwent total knee replacement surgery, were included in the study. Participants were randomly divided into three groups. Arthrotomy was performed using a medial parapatellar approach with a midline incision. Standard femoral and tibial cuts were followed by the implantation of a Smith and Nephew genesis II implant for all participants. Complications, joint range of motion, pain scores, certain movement degrees, and functional scores were investigated.

Results Pre-op and post-op range of motion, knee society score, oxford knee score, certain movement degree values have shown no significant difference. Visual analogue scale values were different significantly between the groups. There is a statistical difference between the range of motion, knee society score, oxford knee score, certain movement degree and visual analogue scale values in repeated measurements. The most common complication was a hematoma. This was observed most frequently in the continuous vicryl suture group. The closure time in the Barbed group was significantly lower than in the other groups.

Discussion Treatment for total knee replacement is a heavy economic burden. Health systems and hospitals are under pressure. The results obtained in our study show that there is no superiority of one closure technique over the other.

Keywords Total knee replacement · Closure techniques · Barbed knotless sutures · Continuous vicryl suture · Arthrotomy · Pain Scores · Functional Scores

Introduction

In today's world, efforts to reduce the cost of health services have gained momentum [1]. High-cost procedures are being examined, and alternative procedures and applications are being developed. The dynamic state of the healthcare system has highlighted the importance of financial review and accountability policies [1].

In this context, one frequently examined procedure is total knee replacement (TKR). Different results from cost-effectiveness studies on TKR applications have been obtained in the literature. Some studies have reported that the cost of TKR operations in the US has approximately doubled in the last two decades [2]. TKR and similar surgeries have brought both patient satisfaction and economic burden [3, 4].

TKR is often examined in terms of operation time [5–7], material costs [8, 9], developing complications [6, 10], and hospitalization costs [6]. Recent cost-reduction studies have focused on shortening the hospital stay and intraoperative time [6–8].

Closing the surgical wound is crucial in increasing the effectiveness and shortening the operation time of TKR [11]. Traditional methods used in closing surgical wounds involve using time-consuming sutures that include many knots [12]. In recent years, barbed knotless sutures have been developed

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[13]. These sutures, which self-lock after passing through soft tissue, shorten the surgical time as they do not require knots [14]. However, the cost of barbed knotless sutures is approximately ten times higher than that of standard sutures, raising questions about the cost–benefit of time savings [14].

This study aims to examine the three different closure techniques used in TKR operations in three randomly created groups.

Materials and Methods

Study Population

The study population is composed of those diagnosed with end-stage (Kellgren-Lawrence stage 4) knee osteoarthritis who were not responsive to conservative treatment and accepted to undergo TKR surgery among those who were examined in the center where the study was conducted.

Sample Size

The sample size of the study was calculated using the G*Power 3.1.9.6 (Frans Foul, Universitat Kiel, Germany) program. The sample size was calculated as 72.

Study Design and Participants

This study is a prospective randomized controlled and doubled blinded study. Two hundred participants who applied to a tertiary healthcare institution in Turkey between May 2021 and May 2022, were diagnosed with knee osteoarthritis, and underwent TKR surgery, were included in the study. Participants were randomly divided into three groups. The selection of participants was completely random. Sealed-envelope method was employed for the allocation of participants into groups. Accordingly, participants were asked to select one sealed envelope containing the name of a group without having any knowledge of the group assignments. All procedures were conducted under the supervision of the researchers. The study is conducted as a double-blind trial, wherein participants were not provided with information about the group they were assigned to, and the assistant surgeon was also kept uninformed. The assistant surgeon serves as the principal investigator and is blind to the treatment assignments. However, the senior surgeon performing the operation is not blinded. The physical examinations of the participants were repeated one week before the operation, and the surgery schedule performed preoperative anesthesia examinations. At this stage, the inclusion criteria of the participants were questioned, and those who did not meet the criteria were not included in the study. Twenty participants who did not meet the study criteria or did not regularly participate in the controls were excluded from the study. With the exclusion of those who did not meet the criteria, the study continued with 180 participants. The joint range of motion (ROM), pain scores (VAS), and functional scores [Knee Society Score (KSS) and Oxford Knee Score (OKS)] of the patients were recorded in the service examination room before the operation.

Groups

- Group 1: The joint capsule was closed with locking knotless (barbed knotless suture) sutures, while the soft tissue was closed with conventional interrupted (interrupt suture) sutures.
- Group 2: The joint capsule was closed with continuous vicryl suture, while the soft tissue was closed with conventional interrupted (interrupt suture) sutures.
- Group 3: The joint capsule and the soft tissue were closed with interrupted (interrupt suture) sutures.

Surgical Technique

All participants in the study were prepared for surgery under spinal anesthesia, in the supine position, with lateral support. After standard sterilization, an arthrotomy was performed using a medial parapatellar approach with a midline incision, followed by skin and subcutaneous dissection. Standard femoral and tibial cuts were followed by the implantation of a Smith and Nephew genesis II implant for all participants. The knee brace that was prepared for preoperative preparation was not used at the beginning of the surgery, and it was inflated when the incisions were completed, and the washing process was started. Then, the implantation was done, and after the cement reaction, the knee brace was lowered, and bleeding control was done. The patellar surface replacement was not routinely performed in the cases. After patellar denervation, osteophytes were removed, and the surface preparation was completed during the waiting time for the cement freezing reaction. No drain was used. After implantation, the capsule and soft tissue were closed. Subcutaneous closure was done in the same way in all groups. The deep and superficial subcutaneous tissue was closed with "0," and "2.0" Coated VICRYL® (polyglactin 910) interrupted suture, respectively. The knee was kept in 60° semi-flexion during the closure time. An integrated operating room system calculated the capsule and soft tissue closure times. The number and type of suture used to close the capsule and soft tissue were recorded after the subcutaneous suture was completed. Standard wire sutures were used for skin sutures in all groups. The same surgeon performed all procedures in the groups. In the postoperative period, standard bedside evaluations were made for participants on the first, second,

and third days. Then, controls were made on the 10th, 20th, 45th, and 90th days.

The first group: The capsule area is closed with STRATAFIX™ Knotless Tissue Control Devices. The first entry of the capsule is made from the proximal and medial sides, and then it progresses distally with 5 mm intervals. After the last suture is passed on the distal side, the suture is cut so that at least three stitches remain open, thus completing the capsule repair.

The second group: The capsulotomy area was closed with "2.0" Coated VICRYL® (polyglactin 910). The capsule closure procedure began on the proximal and medial sides of the capsule. Then, both sides were tied with three knots, and the procedure was continued by transitioning to a continuous suture that joins the medial and lateral capsules, starting from the medial capsule. The sutures were locked in the same order and shape. The capsule was repaired by progressing to the distal side in intervals of 5 mm, with one locked and one unlocked.

The third group: The capsule repair area was closed using "2.0" Coated VICRYL® (polyglactin 910). The capsule repair process began on the proximal and medial sides of the capsule, then continued on the lateral side. Two sutures were tied with three knots, with the third reversed. Then, same suture was independently repeated at 5mm intervals (interrupt suture). The repair of the capsule was completed by reaching the most distal part of the joint.

Data

- The participant's age and the side on which the operation was performed,
- The complications. Superficial infections (STI), deep joint infections (PJI), hematomas, and tissue separations were examined, and the timing and treatment processes of these were recorded, and any developing complications were recorded.
- The VAS values were recorded by measuring the participants' pre-op, post-op on the third and tenth day, and post-op 12th week.
- Rehabilitation parameters include the KSS and OKS. KSS was measured pre-op and post-op 12th week; OKS was measured pre-op, post-op 10th day, and post-op 12th week.
- Joint movement range (ROM). Measured pre-op, post-op on the third, 10th day, and post-op 12th week.
- Continuous physical therapy measuring patient's endurance at certain movement degrees (CPM). The angle tolerated by the participants and how long they could tolerate it was recorded on the 1st, second, and third days. Ongoing rehabilitation was started on the first day after the surgery by setting the device to 45 degrees. In those who tolerated this rehabilitation for 60 min, the angle was gradually increased to 75, 90, 105, and 120 degrees. On the first day, up to 90 degrees were allowed. On the second day, those who could tolerate it was moved to 105 and 120 degrees.
- The duration of joint capsule closure.

In the event of prolonged hospital stays and additional costs arising independently of complications in the surgical field, the participant's exclusion from the study was based on. However, no participant was excluded from the study for this reason.

Ethics

The ethical permissions related to the study were obtained from the ethical committee affiliated with the institution where the researchers were working. Participation in the study was voluntary, and there was no coercion involved. Participants were informed that their information would be used in the study but that their identities would be kept confidential, and their informed consent was obtained. All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008.

Statistical Analysis

The data analysis for the research was conducted using SPSS 26 software. The distribution of the data for the variables was evaluated using the Kolmogorov–Smirnov test. The Wilcoxon Signed Ranks test was used to analyze two repeated measurements. The Kruskal–Wallis test was used for comparing more than two independent groups, and the Friedman test was used for more than two repeated measurements. When a significant difference was found, multiple comparison tests were performed, and the Bonferroni corrected significance values were considered in the findings. The relationship between categorical variables was examined using chi-square tests. In the analysis, a p value of < 0.05 was considered statistically significant.

Results

According to the research groups, it was examined whether there was a statistical difference in terms of the age of the participants and the side to which TKR was applied. It was determined that there was no significant difference between the groups ($p > 0.05$).

The study has investigated whether there are statistical differences in pre-op and post-op ROM, KSS, OKS,

duration, and degree of CPM values regarding closure techniques used among the research groups. The data obtained have shown no significant difference in the parameters investigated ($p > 0.05$).

In the analyzes performed to determine whether there was a difference in VAS values according to the research groups, it was determined that there was a significant difference between the groups at the post-op third and 10th days and post-op 12th weeks (Table 1). Bonferroni corrected multiple comparisons analyzes were performed to determine the source of the difference. It was found that the difference was caused by the following:

- The mean VAS score of the Cont Vic group was higher than that of the Barbed group at the post-op 3rd and 12th weeks,
- The mean VAS score of the Cont Vic group was higher than that of the Interrupt and Barbed groups on the post-op 10th day.

Table 2 shows the findings of the analyzes performed to determine whether there is a statistical difference between the ROM values in repeated measurements. Multiple comparisons analyze were performed to identify the source of the difference. As a result of the analysis showed that the difference between the groups was due to the lower pre-op values compared to the post-op values and the higher post-op 12th-week value compared to the other values. Accordingly, it was determined that there were significant differences between the ROM values.

In repeated measurements, the groups were compared in terms of pre-op and post-op 12th-week KSS values. The results are given in Table 3. Post-op 12th-week KSS values were significantly higher than pre-op values in all groups.

The groups were compared within themselves regarding OKS values at pre-op and post-op day ten and post-op week 12. The results are given in Table 4. Post-op OKS values were significantly higher than pre-op values in all groups. As a result of the analysis to determine the source of the difference, it was determined that the difference between the groups was due to the lower pre-op values compared to

Table 1 VAS values according to study groups*

VAS Scores	Group	*n*	Mean	Standard Deviation	X^2	*p*	Source of difference
Pre-op	Barbed	60	8.93	1.233	0.955	0.620	–
	Cont Vic	60	8.95	1.241			
	Interrupt	60	8.85	1.087			
Post-op 3. Day	Barbed	60	5.65	1.338	13.238	0.001	1 < 3
	Cont Vic	60	6.48	1.112			
	Interrupt	60	6.12	1.303			
Post-op 10. Day	Barbed	60	3.55	1.213	18.329	< 0.001	1 < 3 2 < 3
	Cont Vic	60	4.63	1.426			
	Interrupt	60	3.95	1.383			
Post-op 12. Weeks	Barbed	60	1.57	0.831	6.469	0.039	1 < 3
	Cont Vic	60	1.95	0.852			
	Interrupt	60	1.85	0.917			

*Kruskal–Wallis Test

Table 2 ROM values in repeated measurements*

Group	Variable	*n*	Mean	Standard Deviation	X^2	*p*	Source of difference
Barbed	Pre-op	60	92.48	11.623	163.503	< 0.001	1 < 3 1 < 4 2 < 3 2 < 4 3 < 4
	Post-op 3. Day	60	97.75	4.261			
	Post-op 10. Day	60	105.83	2.787			
	Post-op 12. Week	60	116.92	5.607			
Cont Vic	Pre-op	60	95.50	7.518	144.232	< 0.001	1 < 3 1 < 4 2 < 3 2 < 4 3 < 4
	Post-op 3. Day	60	99.50	6.155			
	Post-op 10. Day	60	105.00	7.535			
	Post-op 12. Week	60	118.25	3.776			

*Friedman Test

the post-op values and the higher post-op 12th-week value compared to the other values.

In repeated measurements, the groups were compared regarding VAS values at pre-op, post-op third and 10th days, and post-op 12th weeks (Table 5). The pre-op VAS value was statistically significantly higher than the post-op values in all groups. The VAS value decreases with time. It was seen that the difference between the groups was due to the lower post-op values compared to the pre-op values.

Table 3 Comparison of pre-op and post-op KSS values*

Group	Variable	*n*	Mean	Standard Deviation	*Z*	*p*
Barbed	KSS Pre-op	60	45.97	11.146	– 6.732	< 0.001
	KSS Post-op 12. Week	60	89.47	6.366		
Cont Vic	KSS Pre-op	60	45.05	10.503	– 6.740	< 0.001
	KSS Post-op 12. Week	60	90.02	5.774		
Interrupt	KSS Pre-op	60	44.65	10.973	– 6.679	< 0.001
	KSS Post-op 12. Week	60	87.80	11.728		

*Wilcoxon Signed-rank Test

Table 4 Comparison of pre-op and post-op OKSvalues*

Group	Variable	*n*	Mean	Standard Deviation	X^2	*p*	Source of difference
Barbed	OKS Pre-op	60	11.53	4.241	120.000	< 0.001	1 < 2 1 < 3 2 < 3
	OKS Post-op 10. Day	60	24.58	4.458			
	OKS Post-op 12. Week	60	38.18	4.347			
Cont Vic	OKS Pre-op	60	11.18	4.424	120.000	< 0.001	1 < 2 1 < 3 2 < 3
	OKS Post-op 10. Day	60	23.93	3.931			
	OKS Post-op 12. Week	60	36.98	3.397			
Interrupt	OKS Pre-op	60	10.73	3.746	120.000	< 0.001	1 < 2 1 < 3 2 < 3
	OKS Post-op 10. Day	60	24.93	5.262			
	OKS Post-op 12. Week	60	36.95	4.090			

*Friedman Test

Table 5 Comparison of pre-op and post-op VAS values*

Group	VAS Values	*n*	Mean	Standard Deviation	X^2	*p*	Source of difference
Barbed	Pre-op	60	8.93	1.233	176.737	< 0.001	2 < 1 3 < 1 4 < 1 3 < 2 4 < 2 4 < 3
	Post-op 3. Day	60	5.65	1.338			
	Post-op 10. Day	60	3.55	1.213			
	Post-op 12. Week	60	1.57	0.831			
Cont Vic	Pre-op	60	8.95	1.241	170.527	< 0.001	2 < 1 3 < 1 4 < 1 3 < 2 4 < 2 4 < 3
	Post-op 3. Day	60	6.48	1.112			
	Post-op 10. Day	60	4.63	1.426			
	Post-op 12. Week	60	1.95	0.852			
Interrupt	Pre-op	60	8.85	1.087	179.705	< 0.001	2 < 1 3 < 1 4 < 1 3 < 2 4 < 2 4 < 3
	Post-op 3. Day	60	6.12	1.303			
	Post-op 10. Day	60	3.95	1.383			
	Post-op 12. Week	60	1.85	0.917			

*Friedman Test

Table 6 Comparison of post-op CPM data*

Group	CPM Values (time)	*n*	Mean	Standard deviation	X^2	*p*	Source of difference
Barbed	Post-op 1. Day	60	51.00	14.867	22.164	< 0.001	1 < 3
	Post-op 2. Day	60	53.42	13.885			
	Post-op 3. Day	60	57.00	9.881			
Cont Vic	Post-op 1. Day	60	52.17	15.578	17.196	< 0.001	1 < 3
	Post-op 2. Day	60	52.92	16.294			
	Post-op 3. Day	60	56.42	11.611			
Interrupt	Post-op 1. Day	60	51.83	16.208	12.783	0.002	1 < 3
	Post-op 2. Day	60	54.67	15.754			
	Post-op 3. Day	60	56.92	19.356			
Group	CPM values (degree)	*n*	Mean	Standard deviation	X^2	*p*	Source of difference
Barbed	Post-op 1. Day	60	82.67	16.861	110.186	< 0.001	1 < 2
	Post-op 2. Day	60	94.83	18.843			1 < 3
	Post-op 3. Day	60	102.33	14.857			2 < 3
Cont Vic	Post-op 1. Day	60	85.25	8.508	95.685	< 0.001	1 < 2
	Post-op 2. Day	60	92.83	22.424			1 < 3
	Post-op 3. Day	60	100.58	19.530			2 < 3
Interrupt	Post-op 1. Day	60	83.58	13.873	90.416	< 0.001	1 < 2
	Post-op 2. Day	60	93.67	19.870			1 < 3
	Post-op 3. Day	60	97.00	27.250			2 < 3

*Friedman Test

The groups were compared among themselves regarding the CPM values determined in the first three post-op days (Table 6). In all groups, CPM values have statistically significantly increased as the days progressed. As a result of multiple comparison analyses, it was found that:

- The difference between the groups in terms of duration is due to the difference in CPM values between the third and 12th weeks;
- The difference between the groups in degree is due to the difference in CPM values among all weeks.

Research groups have been compared in terms of developing complications. The analysis, done using the chi-square test, revealed no statistically significant difference between the groups regarding the development of complications ($p > 0.05$). The most common complication was a hematoma. This was observed most frequently in the Cont Vic group. In this group, 20% developed a superficial hematoma. The hematomas that developed were at a minimal effusion level that did not require intervention and resolved spontaneously. Eight participants detected mild redness and increased heat in the soft tissue as STI. All of them resolved spontaneously. The rarest complication was determined to be PJI. PJI was not observed in the Interrupt and Cont Vic groups but was seen in only one (1.7%) participant in the Barbed group (Table 7).

Table 7 Analysis of the groups in terms of complications*

	Group			X^2	*p*
	Barbed	Interrapt	Cont Vic		
Complication					
No	48 (%80.0)	51 (%85.0)	46 (%76.7)	5.185	0.542
Hematoma	7 (11.7)	7 (11.7)	12 (20.0)		
STI	4 (%6.7)	2 (%3.3)	2 (%3.3)		
PJI	1 (%1.6)	0 (%0.0)	0 (%0.0)		

*Chi-squared test

In our study, capsule closure times were measured, and the values obtained were compared between groups. According to this, the closure time in the Barbed group was significantly lower than in the other groups (Table 8).

Table 8 Analysis findings on capsule closing times*

Group	*n*	Mean	Standard deviation	X^2	*p*	Source of difference
Capsule						
Barbed	60	212.28	46.060	108.856	< 0.001	1 < 2 1 < 3
Interrapt	60	430.65	119.840			
Cont Vic	60	374.18	76.737			

*Kruskal–Wallis Test

Discussion

The data from our research shows that ROM, KSS, OKS, and CPM values in terms of time and degree are similar, and there is no difference between the closure techniques used. Regarding VAS values, significant differences were detected in terms of closure techniques between the values obtained on the third and 10th post-op days and the 12th post-op week. Similarly, the capsule closure time also differs significantly between the groups.

The closure techniques were compared with each other regarding pre-op and post-op ROM, KSS, OKS, VAS, and CPM values in terms of time and degree. It was determined that there was a significant difference between the pre-op and post-op values in all of the parameters examined. As the post-op period progressed, the values were observed to change positively.

Nowadays, it is recorded that the demand for TKR is constantly increasing. This increasing demand is related to the aging of the population, the increase in the expected life span, the demand for a more active physical life, and the development of surgical techniques. In addition, the decrease in some complications, such as infection, seen in the past applications of TKR, supports the increasing demand [15, 16]. How to support the increase in TKR with limited medical resources is a topic that is frequently discussed among experts. The solution to the issue is to increase the cost-effectiveness of TKR. Otherwise, it will not be easy to support the increase in TKR financially. In this regard, examining different closure techniques from different angles is essential in giving ideas on cost-effectiveness [17, 18].

Previous studies have compared traditional interrupted sutures with barbed knotless sutures and analyzed their differences in cost-effectiveness [10, 14, 19, 20]. In our research, one more group has been added to these groups. Three groups were created according to the closure of the joint capsule and soft tissue with different suture techniques. The comparisons and analyses were carried out with three different closure techniques. This is evaluated as providing a broader perspective and a source for new research ideas. A study designed similarly to ours also analyzed different closure techniques in three groups [21]. The groups in the study are similar to ours. The study results were similar to ours, but unlike ours, there was a significant difference between the groups in the distribution of complications. This might be because the number of participants in the studied study was higher than in our study.

Different studies are conducted to evaluate the procedures and results of TKR. These studies aim to investigate how much the expected result of TKR is achieved and to evaluate the criteria such as functionality and patient satisfaction [22]. In research on closure techniques used in TKR, variables such as knee range of movements (degrees) [23], KSS [23], OKS [24], considering operation time [23] and suture material cost [19, 20, 23], wound closure time [19, 20, 23–27], suture type for closure by layer [28], comparative surgical details and closure times [28] and total operative time [19, 27, 29] are frequently analyzed. One frequently analyzed parameter is the complications that occur [19, 20, 23, 24, 28].

The variables studied in our study are different from those in previous studies. Our study analyzed pain levels determined by VAS, KSS, OKS, ROM, CPM, complications development, and other variables. The closure techniques used in TKR were compared in terms of scores, rehabilitation parameters, complications, and capsule closure times. This shows the uniqueness of our study.

What makes our research different from others and stands out in terms of originality is that some variables that were less studied in previous studies have been studied. The amount of pain felt by the participants was analyzed using the VAS method. This way, pain progression was followed, and intensity was compared between groups. ROM measurements were used to determine the knee joint's range and limits of motion. KSS and OKS are functional scores in our research. KSS and OKS measurement tools based on scoring systems are used to evaluate the benefits obtained from the surgical procedure. These tools are considered the best methods for analyzing surgical results [30].

Our study results indicate that the VAS values are significantly lower in the post-op period compared to the pre-op period in the groups where different closure techniques were applied. The lowest VAS value in the post-op period is in the Barbed group. The group where the pain is most commonly encountered is the Cont Vic group. When the results of some studies related to the subject are examined, it is seen

that many studies do not examine pain. The results obtained from a study where post-op pain examination was made, it is emphasized that pain was detected in one participant in the Barbed group, and no pain was encountered in the groups where other closure techniques were used [31]. The results are contradictory to the results obtained in our study. The difference in the design of the studies may be the reason for the contradiction of the results. In our study, the pain was examined as a different variable, pre-op period and different times of the post-op period, by the VAS method. The reliability of our data in terms of pain variables is high. Our study is a prospective study, while the other study is retrospective. The results of prospective studies are more reliable than retrospective studies conducted on records [32]. From this point of view, the data of our study stand out.

Rehabilitation parameters of closure techniques, KSS, and ROM values were compared in a study, and KSS and ROM values were examined post-op sixth week and third month [23]. The three different techniques examined have similar values. No difference between Barbed and traditional techniques was found in terms of KSS and ROM values. Our study results are consistent with these results.

Our study analyzed the OKS values before and after the surgery in different closure techniques. We have compared the obtained OKS values and found no significant difference between the groups. Our findings are similar to the data from another study, in which they also found no difference in pre and postoperative OKS values among the different closure techniques [24].

CPM is a part of the standard postoperative management protocol recommended worldwide for TKR [33]. Our study analyzed the pre-op and post-op CPM values in terms of duration and degree. We have analyzed the groups in terms of CPM values. We could not find any similar analysis in previous studies, which highlights the originality of our study.

In our research, the complications identified to develop post-operatively are hematoma, STI, and PJI. Data on complications is a whole area of investigation in TKR studies. The most common and investigated complications are wound complications [14, 20, 23, 27, 34], superficial or deep infection [21], wound dehiscence [27, 35], arthrofibrosis [26, 36], hematoma [21, 26, 37], and suture abscess [7, 26, 38]. It has been recorded that the use of barbed sutures reduces the risk of wound complications [20] but delays soft tissue healing [14] and causes inflammation [39]. According to our results, the most common complication is a hematoma. The frequency of this is 20% in the Cont vic group. The frequency of superficial infection is lower than that of hematoma. The frequency of deep infection is the lowest. No other complications were encountered in our study. The frequency of infection is similar between groups. According to the results of a study that examined TKR closure techniques through meta-analysis, the frequency of complications is a superficial infection, deep infection, wound dehiscence, arthrofibrosis, and hematoma [26]. In another study, the frequency of complications is a superficial infection, hematoma, and deep infection [21]. In our study and the study conducted by Zhang and colleagues [26], no difference is seen between closure techniques in terms of complications, whereas in the study by Feng and colleagues [21], a statistically significant difference is identified. These differences in the development of complications may be due to differences between the centers where the studies were conducted or differences in the number of participants in the studies. According to some researchers, the frequency of superficial infection that develops during barbed sutures decreases as the surgeon's experience increases [14, 40]. This may also be the reason for the differences in the development of complications.

Our study found no significant differences in the duration of capsule closure when using different closure techniques. This is supported by the findings of other studies on the topic, such as Gamba et al.'s study [41], which found that the closure time in the Barbed group was shorter than in the other group, but there was no statistically significant difference when closing the subcutaneous tissues. Another study [42] also found that the closure time in the Barbed group was shorter than in the other group and that this difference was statistically significant. The study also reported that using a Barbed suture is associated with shorter hospital stays.

Conclusion

Treatment for TKR is a heavy economic burden. Health systems and hospitals are under pressure to reduce this economic burden. Efforts are being made to reduce the duration of surgery, material costs, and the frequency of complications to reduce this economic burden. Some publications claim that using barbed sutures reduces the duration of surgery and the frequency of complications, thus reducing costs, but some claim the opposite.

Many cost analysis studies have been carried out on the economic burden of TKR. Instead, our study aimed to investigate various closure techniques in terms of scores, rehabilitation parameters, and complications. Such an examination provides the opportunity to make a more comprehensive assessment by looking at the subject from a different angle. Additionally, it can also be a guide for planned new studies.

The results obtained in our study show that there is no superiority of one closure technique over the other. Although the capsule closure time in the Barbed group was shorter than in the other groups, no data was found that would make the Barbed group a preferred choice in other parameters. As a result of these evaluations, it was concluded that it would

be meaningless to increase costs by moving towards more expensive techniques.

There are some limitations to our study. The sample size is sufficient for statistical analysis. However, the detection of complications, especially wound complications, may be limited. In addition to the scores examined, the inclusion of the Hollander Wound Evaluation Score in the analyses could have enriched our results. However, due to concerns regarding the increase in the volume of the study and the potential difficulty in comprehension, this was not implemented. Instead, data pertaining to certain side effects were incorporated into the analyses. Some side effects, such as arthrofibrosis, can occur after 90 days, and some complications may have gone undetected.

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Declarations

Conflict of Interest None.

Ethical Approval This article does not contain any studies with human or animal subjects performed by any of the authors.

Informed Consent For this type of study informed consent is not required.

References

1. Sturmberg, J. P., & Bircher, J. (2019). Better and fulfilling healthcare at lower costs: The need to manage health systems as complex adaptive systems. *F1000Research., 8*, 789.
2. Molloy, I. B., Martin, B. I., Moschetti, W. E., & Jevsevar, D. S. (2017). Effects of the length of stay on the cost of total knee and total hip arthroplasty from 2002 to 2013. *Journal of Bone and Joint Surgery American, 99*(5), 402–407.
3. Marsh, J., Joshi, I., Somerville, L., Vasarhelyi, E., & Lanting, B. (2022). Health care costs after total knee arthroplasty for satisfied and dissatisfied patients. *Canadian Journal of Surgery, 65*(5), E562–E566.
4. Bhandari, M., Smith, J., Miller, L. E., & Block, J. E. (2012). Clinical and economic burden of revision knee arthroplasty. *Clinical Medicine Insights: Arthritis and Musculoskeletal Disorders, 5*, 89–94.
5. Eickmann, T., & Quane, E. (2010). Total knee arthroplasty closure with barbed sutures. *The Journal of Knee Surgery, 23*(3), 163–167.
6. Raja, B. S., Gowda, A. K. S., Choudhury, A. K., Paul, S., & Kalia, R. B. (2022). Barbed sutures for total hip and knee arthroplasty have shorter wound closure time and are cost-effective in comparison to traditional sutures: A systematic review and meta-analysis of 16 randomized controlled trials. *Indian Journal of Orthopaedics, 56*(7), 1156–1173.
7. Sun, C., Chen, L., Du, R., Wu, S., Ma, Q., & Cai, X. (2021). Barbed sutures in total knee arthroplasty: A meta-analysis of randomized-controlled trials. *The Journal of Knee Surgery, 34*(14), 1516–1526.
8. Li, P., Zhang, W., Wang, Y., Li, J., Yan, P., Guo, S., et al. (2020). Barbed suture versus traditional suture in primary total knee arthroplasty: A systematic review and meta-analysis of randomized controlled studies. *Medicine (Baltimore), 99*(21), e19945.
9. Elmallah, R. K., Khlopas, A., Faour, M., Chughtai, M., Malkani, A. L., Bonutti, P. M., et al. (2017). Economic evaluation of different suture closure methods: Barbed versus traditional interrupted sutures. *Annals of Translational Medicine, 5*(Suppl 3), S26.
10. Campbell, A. L., Patrick, D. A. J., Liabaud, B., & Geller, J. A. (2014). Superficial wound closure complications with barbed sutures following knee arthroplasty. *Journal of Arthroplasty, 29*(5), 966–969.
11. Khan, M. A., Memon, M. W., Chinoy, A., Javed, S., Barkat, R., & Jiwani, A. (2022). Wound closure after total knee replacement: Comparison between staples and sutures. *Pakistan Journal of Medical Sciences, 38*(2), 340–344.
12. Wang, W., Yan, S., Liu, F., Chai, W., Zuo, J., Xiao, J., et al. (2020). A symmetric anchor designed barbed suture versus conventional interrupted sutures in total knee arthroplasty: A multicenter, randomized controlled trial. *Journal of Orthopaedic Surgery (Hong Kong), 28*(3), 2309499020965681.
13. Byrne, M., & Aly, A. (2019). The surgical suture. *Aesthetic Surgery Journal, 39*(Suppl_2), S67-72.
14. Smith, E. L., DiSegna, S. T., Shukla, P. Y., & Matzkin, E. G. (2014). Barbed versus traditional sutures: Closure time, cost, and wound related outcomes in total joint arthroplasty. *Journal of Arthroplasty, 29*(2), 283–287.
15. Guo, E. W., Sayeed, Z., Padela, M. T., Qazi, M., Zekaj, M., Schaefer, P., et al. (2018). Improving total joint replacement with continuous quality improvement methods and tools. *Orthopedic Clinics of North America, 49*(4), 397–403.
16. Ghosh, A., & Chatterji, U. (2019). An evidence-based review of enhanced recovery after surgery in total knee replacement surgery. *Journal of Perioperative Practice, 29*(9), 281–290.
17. Chen, K. K., Harty, J. H., & Bosco, J. A. (2017). It is a brave new world: Alternative payment models and value creation in total joint arthroplasty: Creating value for TJR quality and cost-effectiveness programs. *Journal of Arthroplasty, 32*(6), 1717–1719.
18. Kim, K., & Iorio, R. (2017). The 5 clinical pillars of value for total joint arthroplasty in a bundled payment paradigm. *Journal of Arthroplasty, 32*(6), 1712–1716.
19. Sah, A. P. (2015). Is there an advantage to knotless barbed suture in TKA wound closure? A randomized trial in simultaneous bilateral TKAs. *Clinical Orthopaedics and Related Research, 473*(6), 2019–2027.
20. Gililland, J. M., Anderson, L. A., Barney, J. K., Ross, H. L., Pelt, C. E., & Peters, C. L. (2014). Barbed versus standard sutures for closure in total knee arthroplasty: A multicenter prospective randomized trial. *Journal of Arthroplasty, 29*(9 Suppl), 135–138.
21. Feng, S., Zhang, Y., Zhang, F., Yang, Z., Chen, X.-Y., & Zha, G.-C. (2020). Are there lower complication rates with bidirectional barbed suture in total knee arthroplasty incision closure? A randomized clinical trial. *Medical Science Monitor: International Medical Journal of Experimental and Clinical Research, 26*, e922783.
22. Marx, R. G. (2003). Knee rating scales. *Arthroscopy: The Journal of Arthroscopic & Related Surgery, 19*(10), 1103–1108.
23. Chan, V. W. K., Chan, P.-K., Chiu, K.-Y., Yan, C.-H., & Ng, F.-Y. (2017). Does barbed suture lower cost and improve outcome in total knee arthroplasty? A randomized controlled trial. *The Journal of Arthroplasty, 32*(5), 1474–1477.
24. Malhotra, R., Jain, V., Kumar, V., & Gautam, D. (2017). Evaluation of running knotless barbed suture for capsular closure in primary total knee arthroplasty for osteoarthritis-a prospective randomized study. *International Orthopaedics, 41*(10), 2061–2066.

25. Gill, B. S., Bernard, M. E., Lin, J. F., Balasubramani, G. K., Rajagopalan, M. S., Sukumvanich, P., et al. (2015). Impact of adjuvant chemotherapy with radiation for node-positive vulvar cancer: A national cancer data base (NCDB) analysis. *Gynecologic Oncology, 137*(3), 365–372.
26. Zhang, W., Xue, D., Yin, H., Xie, H., Ma, H., Chen, E., et al. (2016). Barbed versus traditional sutures for wound closure in knee arthroplasty: A systematic review and meta-analysis. *Science and Reports, 6*, 19764.
27. Maheshwari, A. V., Naziri, Q., Wong, A., Burko, I., Mont, M. A., & Rasquinha, V. J. (2015). Barbed sutures in total knee arthroplasty: Are these safe, efficacious, and cost-effective? *The Journal of Knee Surgery, 28*(2), 151–156.
28. Sundaram, K., Warren, J. A., Klika, A., Piuzzi, N. S., Mont, M. A., & Krebs, V. (2021). Barbed sutures reduce arthrotomy closure duration compared to interrupted conventional sutures for total knee arthroplasty: A randomized controlled trial. *Musculoskeletal Surgery, 105*(3), 275–281.
29. Ma, X., Zhang, L., Wang, J., & Luo, Y. (2019). Knowledge domain and emerging trends on echinococcosis research: A scientometric analysis. *International Journal of Environmental Research and Public Health, 16*(5), 842.
30. Pollard, B., Johnston, M., & Dieppe, P. (2006). What do osteoarthritis health outcome instruments measure? Impairment, activity limitation, or participation restriction? *Journal of Rheumatology, 33*(4), 757–763.
31. Austin, D. C., Keeney, B. J., Dempsey, B. E., & Koenig, K. M. (2017). Are barbed sutures associated with 90-day reoperation rates after primary TKA? *Clinical Orthopaedics and Related Research, 475*(11), 2655–2665.
32. Euser, A. M., Zoccali, C., Jager, K. J., & Dekker, F. W. (2009). Cohort studies: Prospective versus retrospective. *Nephron Clinical Practice, 113*(3), c214–c217.
33. Salter, R. B. (2004). Continuous passive motion: From origination to research to clinical applications. *Journal of Rheumatology, 31*(11), 2104–2105.
34. Chawla, H., van der List, J. P., Fein, N. B., Henry, M. W., & Pearle, A. D. (2016). Barbed suture is associated with increased risk of wound infection after unicompartmental knee arthroplasty. *Journal of Arthroplasty, 31*(7), 1561–1567.
35. Villa, M. T., White, L. E., Alam, M., Yoo, S. S., & Walton, R. L. (2008). Barbed sutures: A review of the literature. *Plastic and Reconstructive Surgery, 121*(3), 102e–108e.
36. Meena, S., Gangary, S., Sharma, P., & Chowdhury, B. (2015). Barbed versus standard sutures in total knee arthroplasty: A meta-analysis. *European Journal of Orthopaedic Surgery & Traumatology, 25*(6), 1105–1110.
37. Ye, Z., Zhu, W., Xi, X., & Wu, Q. (2020). The efficacy of bidirectional barbed sutures for incision closure in total knee replacement: A protocol of randomized controlled trial. *Medicine (Baltimore), 99*(34), e21867.
38. Xin, W.-Q., Zhao, Y., Wang, H., Wu, J., Wang, H.-Y., Gao, Y.-K., et al. (2019). A better strategy using barbed sutures for wound closure in total knee arthroplasty. *Journal of Comparative Effectiveness Research, 8*(10), 799–814.
39. Shermak, M. A., Mallalieu, J., & Chang, D. (2010). Barbed suture impact on wound closure in body contouring surgery. *Plastic and Reconstructive Surgery, 126*(5), 1735–1741.
40. Williams, S. B., Alemozaffar, M., Lei, Y., Hevelone, N., Lipsitz, S. R., Plaster, B. A., et al. (2010). Randomized controlled trial of barbed polyglyconate versus polyglactin suture for robot-assisted laparoscopic prostatectomy anastomosis: Technique and outcomes. *European Urology, 58*(6), 875–881.
41. Gamba, C., Hinarejos, P., Serrano-Chinchilla, P., Leal-Blanquet, J., Torres-Claramunt, R., Sánchez-Soler, J., et al. (2020). Barbed Sutures in total knee arthroplasty: Are they really useful? A randomized controlled trial. *The Journal of Knee Surgery, 33*(9), 927–930.
42. Zhao, L., Su, W., Huang, Z., Zeng, Z., Di, Z., & Tao, K. (2022). The impact of novel anchored barbed suture for capsular closure on hospital length of stay after total knee arthroplasty: A retrospective cohort study. *BMC Musculoskeletal Disorders, 23*(1), 349.