

Outcomes of Deep Wound Management Methods During Total Knee Arthroplasty: A Systematic Review and Meta-Analysis

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ABSTRACT

Wound closure for total knee arthroplasty (TKA) typically focuses on promoting the most optimal healing, while preventing infection, allowing for functionality and immediate ambulation, as well as providing for excellent cosmesis. We have previously described four aspects of closure for TKA including the: (1) deep fascial layer; (2) subdermal layer; (3) intradermal layer, including the subcuticular region; and (4) a specific dressing. In this systematic review and meta-analysis of the literature, we will focus on closure of the deep fascial layer. Specifically, we assessed: (1) wound complication risks of different techniques; (2) closing times of different sutures; and (3) postoperative ranges of motion depending on varying levels of knee flexion or extension. There were 12 reports on wound complication risks, closing times, and positionings. The meta-analysis demonstrated overall lower wound complication risks with the use of barbed sutures (6 versus 13%, $p < 0.05$). It also demonstrated overall significant closing time reductions with the use of barbed sutures ($p < 0.05$). Additionally, three out of four reports showed the positive effects of closure in flexion for TKAs, while one report was inconclusive. In conclusion, this systematic review and meta-analysis demonstrated lower wound complications, decreased closing times for barbed sutures, as well as superior outcomes for closures in a semi-flexed knee position.

INTRODUCTION

Excellent wound healing is a major factor when it comes to avoiding infection complications after total knee arthroplasty (TKA). Despite substantial prevention efforts, the deep infection rates in total joint arthroplasties appear to be remaining at approximately 1.5% or even increasing.¹⁻⁴ Achieving adequate exposure during a TKA requires a sufficient arthrotomy, typically extending from the quadriceps tendon to the medial or lateral tibial tubercle, depending on the approach. Subsequently, the normally enclosed synovial capsule, which contributes synovial fluid and lubrication to the newly performed arthroplasty, requires a watertight closure.

Poor deep closure is an obvious factor that can lead to complications such as seromas, draining postoperative TKAs, infections, or chronic soft tissue defects in some cases, which may necessitate local or even regional flap coverage, and compromise successful procedures.⁵⁻⁷ Therefore, every attempt should be undertaken to ensure both a secure and watertight seal upon initial surgical closure. Galat et al. demonstrated a greater than five-fold increased risk of deep infection in patients who have wound complications following TKA versus those who do not. They found that by two years, physicians should expect a nearly 7% (4 out of 59) risk of

deep infection in patients who undergo TKAs and have wound complications compared to only a 0.8% (14 out of 17,725) risk in patients who do not have wound problems.⁷

A number of reports have focused on the optimal technique for deep closure after total knee arthroplasty.⁸⁻¹² While interrupted absorbable sutures have historically been used for the deep fascia, some recent reports describe different methods.^{8,13,14} Specifically, absorbable braided sutures—which are amenable to being tied either by instrument or by hand—have been utilized for deep fascial closures. Extensile exposures or alternative approaches often utilize a combination of regular absorbable and heavy non-absorbable interrupted sutures.^{15,16} The suggested advantages of solely interrupted suture closure include more sizing and microstructure options as well as the capacity to secure the arthrotomy with numerous independent sutures versus a single running suture. Furthermore, interrupted sutures remove the theoretical increase in tensile stress upon the suture during progressive flexion, as would be seen if a running suture technique is utilized. More recently, there have been a number of reports evaluating barbed sutures compared to some of the methods mentioned above.^{8,17-20}

Surgeons should strive to maximize TKA postoperative knee flexion and over-

all range of motion (ROM) due to their impact on patients' qualities of life.⁹⁻¹¹ With this in mind, there has been increased focus on examining whether the deep fascial closure should be performed with the knee in extension or in varying degrees of flexion.¹² For example, there has been increasing debate over whether or not to close in a semi-flexed position, as some suggest that this allows for optimal wound tension through a full range of motion (ROM) and the easier identification of weak areas in the closure.¹²

Therefore, we performed a systematic review and meta-analysis to evaluate all studies of deep wound closure during total knee arthroplasties. Specifically, we assessed: (1) wound complication risks of different techniques; (2) closing times of different sutures; and (3) postoperative ranges of motion depending on varying levels of knee flexion or extension.

MATERIALS AND METHODS

We performed systematic reviews and meta-analysis of deep wound closure during total knee arthroplasty according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines utilizing PubMed, Cochrane Library, Medline, and Embase electronic databases up to February 1, 2022.

Criteria

A literature search was performed using search terms that included “knee,” “arthroplasty,” “replacement,” “wound closure,” “wound closure review,” “arthrotomy closure,” “closure technique,” “suture,” “deep,” “fascia,” “barbed suture,” “knee position,” “flexion,” “extension,” “postoperative outcomes,” “function,” and “range of motion.” In addition to studying the initially collected reports, references from within those studies were cross referenced and searched as well. Studies of lower evidence were used for the systematic review for completeness; however, higher Level of Evidence studies, especially randomized control trials were reviewed for the meta-analysis (i.e., Level of Evidence I and II).²¹ Inclusion criteria included full text manuscripts that were written in the English language. Exclusion criteria consisted of any conference abstracts, conference reviews, or letters to the editor. Duplicate reports were removed (Fig. 1).

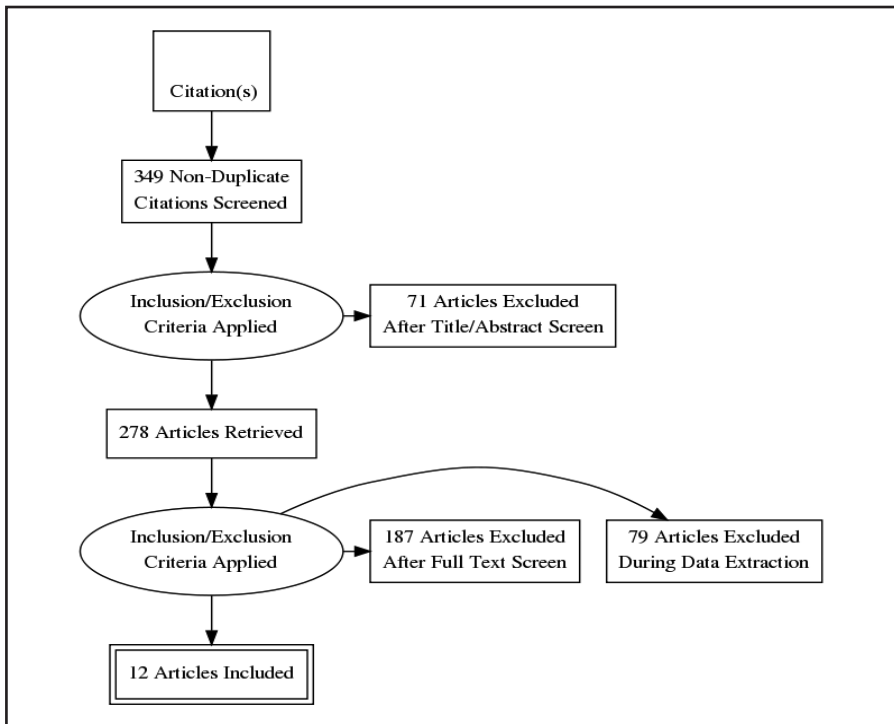


Figure 1. Strobe diagram for study selection.

Table I
Results of wound complication reports

Report	LOE	Subjects	Results
Gililland et al. ²³	III	191	Perioperative complication rates were lower in barbed suture cohort (7%) versus the standard interrupted figure-eight suture (13%), though not statistically different (p=0.197)
Chan et al. ²⁴	I	109	Found that traditional suture group displayed more positive leak tests (10 versus 2, p<0.05) and wound complications (11 vs. 2, p<0.05)
Sakdinakiattikoon et al. ²⁵	II	60	Found that wound-related complications were similar in both groups
Sah ⁸	I	50	There were three wound complications with traditional sutures versus none for barbed
Maheshwari et al. ²⁷	II	333	Found no statistical difference between complication rates (p>0.05)
Smith et al. ²⁶	I	80	Found wound complications in the barbed suture group (11.5%) to be similar to the traditional suture group (10.5%)
Sah ¹³	I	1,000	Postoperative wound complications were found to have occurred more often with standard monofilament sutures than with running barbed sutures (16 vs. 5 times, p<0.025)

LOE, level of evidence

Two authors (ZC and SSB) independently conducted the initial query by applying search criteria to identify appropriate reports among the aforementioned databases. A third author (MAM) reconciled any differences for the initial reports collected.

A total of 12 studies met inclusion and exclusion criteria for studies assessing the effectiveness of TKA deep wound closure. Studies were classified by their level of evidence. They were stratified into level of evidence: I (randomized controlled trials with adequate power, systematic reviews, or meta-analyses); II (prospective cohort studies or retrospective cohort studies); III (case-control studies); IV (case series); and V (expert opinions, case reports or clinical examples, or evidence based on physiology, bench research, or “first principles”).²¹

Summary statements

A summary statement for each comparative cohort was provided following critical review of each section in the results. This served to provide readers with brief take-home messages for each section.

Study methodology

Studies were stratified according to outcomes of interest. Sub-analyses of

studies compiling closing times and wound complication risks were completed. To qualify, any study examining these topics and providing numerical results were separately analyzed.

Data analyses

Data were separated by outcomes of interest and extracted, compiled in a database, as well as analyzed using Microsoft Excel[®] (Microsoft Corporation, Redmond, Washington). Mean continuous variables were compared using Student’s *t*-tests due to it being inherently robust for outliers.²² Potential differences between categorical variables were analyzed using Pearson’s *chi*-squared tests.

RESULTS

Wound complication risk

The following section will evaluate the wound complication risk of total knee arthroplasties utilizing various sutures for deep closure. There was a total of seven studies, four were Level of Evidence I reports, two were Level of Evidence II, and one was a Level of Evidence III study.

In a study by Gililland et al., perioperative complication rates were lower in the barbed suture cohort versus the standard interrupted figure-eight suture,

though not statistically different.²³ A total of seven out of the 104 barbed suture patients (7%), while 11 out of 87 standard suture patients (13%), had a complication related to their wound (p=0.197). In the Chan et al. assessment, including wound complications, they found that the traditional suture cohort displayed more positive leak tests when compared to a barbed suture cohort (10 vs. 2, p<0.05), as well as wound complications (11 vs. 2, p<0.05).²⁴ Sakdinakiattikoon et al. found that wound-related complications were similar in both groups (absorbable sutures placed in interrupted fashion vs. running barbed suture).²⁵ In the study by Sah and co-authors, they sought to determine the relationship of barbed sutures and postoperative wound complications versus interrupted standard sutures.^{8,26} While there were no incidences of postoperative wound dehiscence of the arthrotomy closure with either closure technique, there were three wound complications with traditional sutures versus none for barbed (p=0.24). Maheshwari et al. found no statistical difference between complication rates (p>0.05).²⁷

Smith et al. specifically compared barbed to traditional sutures in the domain of wound-related outcomes in TKAs.²⁶ They conducted a retrospective

Study	Number of barbed patients	Number of comparison patients	Wound complication (%)
Gililland et al. ²³	104	87	7 vs. 13
Chan et al. ²⁴	55	54	4 vs. 20
Sah ⁸	50	50	0 vs. 6
Smith et al. ²⁶	61	19	11.5 vs. 10.5
Pooled data	256	239	6 vs. 13 (p<0.05)

chart review that included 80 TKA patients (61 barbed, 19 traditional). They found 11.5% complications in the barbed group compared to 10.5% in the traditional group. However, the authors stated that they did not have sufficient data to statistically comment on the safety of barbed sutures. In a more recent study by Sah et al. the quality of running knotless barbed suture was compared versus standard monofilament suture wound closure with respect to wound drainage and healing complications.¹³ A total of 1,000 cases were prospectively randomized to have fascial closure with knotless barbed suture or standard suture during the period from 2016 to

2018. Postoperative wound complications were found to have occurred more often with standard monofilament sutures than with running barbed sutures (16 vs. 5 times, p<0.025). Therefore, it was concluded that the positive results shown for the running barbed suture of the prospective study indicated the difference in quality of wound closure between the standard monofilament suture and the running barbed suture in knee arthroplasty surgical sites.

In summary, of seven reports focusing on wound-related complications, four showed improved results with barbed sutures and three showed similar outcomes (Table I).

A meta-analysis was conducted in an attempt to provide enough power to assess for any difference between barbed versus traditional sutures. It included four studies (480 patients) and demonstrated overall lower wound complication risks with the use of barbed sutures (6 vs. 13%, p<0.05) (Table II).

Closing times

A total of six articles (three Level of Evidence I, two Level of Evidence II, and one Level of Evidence III studies), detailed below, evaluated deep closure of total knee arthroplasties with barbed sutures from a closing time standpoint.

Gililland et al. conducted an investigation described above of 191 TKA arthrotomies.²³ The authors compared the use of barbed sutures to absorbable monofilament sutures. The barbed cohort was found to have reduced closing times compared to the absorbable monofilament cohort (17 vs. 22 minutes, p=0.009). Chan et al. assessed arthrotomy closure time, wound complications, and rehabilitation parameters that included Knee Society Scores (KSS) as well as ROM.²⁴ A total of 109 patients were randomized into one of two groups: a barbed suture versus a traditional group consisting of patients who received absorbable sutures for the arthrotomy closure. They found that arthrotomy closure times were significantly shorter for the barbed suture

Report	LOE	Subjects	Results
Gililland et al. ²³	III	191	Barbed cohort found to have reduced closing times compared to absorbable monofilament cohort (17 vs. 22 minutes, p=0.009)
Chan et al. ²⁴	I	109	Arthrotomy closure times significantly shorter for barbed suture group (325 vs. 491 seconds, p<0.05)
Sakdinakiattikoon et al. ²⁵	II	60	Found significantly shorter wound closure times in barbed group (12 vs. 24 minutes, p<0.001)
Ting et al. ¹⁷	I	35	Found closure was significantly faster (9 vs. 14 minutes, p<0.005) in barbed suture group
Sah ⁸	I	50	Mean wound closure time found to be less using barbed sutures (11 vs. 16 minutes, p<0.001)
Maheshwari et al. ²⁷	II	333	Found no statistical difference in closure time (31 vs. 30 minutes, p=0.26) between groups
LOE, level of evidence; N/A, not applicable			

group (325 vs. 491 seconds, $p < 0.05$).

Sakdinakiattikoon et al. compared the efficacy of barbed suture to traditional suture for deep closure in TKAs between 60 randomly and equally divided patients.²⁵ Outcome measures included wound closure times, KSS, and costs. They found significantly shorter wound closure times in the barbed group (12 vs. 24 minutes, $p < 0.001$). While both barbed and traditional suture groups demonstrated improvement in KSS after surgery, no significant differences in final scores were found between the two cohorts ($p > 0.05$). Ting et al. performed a prospective, randomized clinical trial to evaluate the time to closure of using a bidirectional barbed suture compared with traditional sutures in the deep closure of 35 (17 barbed, 18 traditional) primary total knee arthroplasties.¹⁷ They found that closure was significantly faster (9 vs. 14 minutes, $p < 0.005$) in the barbed suture group.

Sah et al., in a prospective, randomized, controlled study, compared wound closure performed with bidirectional barbed sutures in one knee of 50 bilateral TKAs with those performed with standard sutures in the other knee to investigate closure times, clinical outcomes, and operative costs.⁸ Mean

Study	Number of barbed patients	Number of comparison patients	Wound Complication (%)
Gililland et al. ²³	104	87	20 vs. 22
Chan et al. ²⁴	55	54	5 vs. 8
Sakdinakiattikoon et al. ²⁵	30	30	12 vs. 24
Ting et al. ¹⁷	17	18	9 vs. 13
Sah ⁸	50	50	11 vs. 16
Pooled effect	256	239	13 vs. 17 ($p < 0.05$)

wound closure times were found to be less using barbed sutures (11 vs. 16 minutes, $p < 0.001$). Final ROM was not significantly different between the barbed-suture ($126.7 \pm 6.9^\circ$) and standard-suture ($125.6 \pm 7.0^\circ$) groups at one year ($p = 0.4$). There were no significant differences in one-year KSS (barbed mean, 92.8 ± 6.69 vs. standard mean, 93.3 ± 6.2 , $p = 0.6$). There was a mean cost savings of \$175 per case when using barbed suture.

In the review of 333 primary TKA arthroscopy closures with barbed versus standard sutures, Maheshwari et al. assessed closing time and total operative time as well as overall cost between arthroscopy closures.²⁷ In the barbed suture group, a combination of one non-barbed non-absorbable braided suture and one barbed absorbable suture was used to close the arthroscopy. In the standard suture group, closure consisted of a combination of interrupted and

Report	LOE	Subjects	Results
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Sakdinakiattikoon et al. ²⁵	II	60	Found that wound-related complications were similar in both groups
Sah ⁸	I	50	There were three wound complications with traditional sutures versus none for barbed
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Sah ¹³	I	1,000	Postoperative wound complications were found to have occurred more often with standard monofilament sutures than with running barbed sutures (16 vs. 5 times, $p < 0.025$)
LOE, level of evidence			

Study or Subgroup	Experimental			Control			Weight	Mean Difference
	Mean	SD	Total	Mean	SD	Total		
Chan (2017)	5	1	55	8	2	54	37.5%	-3.00 [-3.60, -2.40]
Gilliland (2012)	20	2	104	22	2	87	40.9%	-2.00 [-2.57, -1.43]
Sah (2015)	11	2	50	16	2	50	21.6%	-5.00 [-5.78, -4.22]
Sakdinakittikoon (2019)	12	0	30	24	0	30		Not estimable
Ting (2012)	9	0	17	13	0	18		Not estimable
Total (95% CI)			256			239	100.0%	-3.02 [-3.39, -2.66]
Heterogeneity: Chi ² = 36.83, df = 2 (P < 0.00001); I ² = 95%								
Test for overall effect: Z = 16.26 (P < 0.00001)								

Figure 2. Forest plot for closing time, barbed versus traditional sutures.

continuous absorbable braided sutures for the arthrotomy. The authors found no statistical differences between closure times (31 vs. 30 minutes, $p=0.26$) or total operative times (115 vs. 114 minutes, $p=0.71$) between groups. However, the material costs were greater in the traditional suture group (\$82.59 vs. \$66.78).

In summary, five of six closing time reports (Level of Evidence I, three studies, Level of Evidence II, one study, Level of Evidence III, one study) demonstrated decreased closure times using barbed sutures versus traditional sutures, while one other Level of Evidence II study suggested no differences (Table III).

A meta-analysis included five studies (445 patients) and demonstrated overall significant closing time reductions with the use of barbed sutures (13 vs. 17 minutes, $p<0.05$) (Table IV and Fig. 2).

Flexion and extension ranges of motion

In the following section, we will review the ROM outcomes from three Level of Evidence I reports and one Level of Evidence II study on position of total knee arthroplasty closure.

In a literature search that included a total of 516 patients, Faour et al. evaluated outcomes of knee position during TKA wound closure.⁹ When compared to wound closure in knee extension, they determined that knee position in flexion during surgical closure was associated with improved ROM recovery, decreased short-term postoperative pain scores, and increased muscle strength with quicker functional recovery. Emerson et al. evaluated the knee position during closure in 108 consecutive patients undergoing primary TKA, determining that the flexion group had better flexion at mean six-month follow ups.²⁸ Furthermore, the authors determined that compared to the extension group, the flexion group required less home physical therapy and demonstrated a more rapid functional recovery.

Cerciello et al. conducted a review in

an attempt to analyze and determine if closing the knee in flexion or extension influences postoperative ROM, clinical outcomes, and complications following TKA.²⁹ While the initial cohort included 202 TKAs in the flexion group and 201 in the extension group, 397 TKAs were evaluated at a mean follow up of eight months. The authors found no statistical difference between the two groups in terms of the mean postoperative flexion ($p>0.05$). Additionally, there were no statistical differences between the two groups regarding postoperative functional scores and visual analog scale (VAS) pain scores ($p>0.05$). Therefore, they concluded that there was no clear advantage to either closure method and this choice should be based on surgeon preference.

Lu et al. also undertook a review to study whether different wound closure positions affect clinical outcomes after TKA.³⁰ A total of 389 patients were included and they found that closure at 90° flexion was associated with higher postoperative ROM at four weeks postoperatively. Additionally, they demonstrated lower postoperative VAS pain scores at four weeks and three months. The KSS scores did not show any significant differences between flexion or extension ($p>0.05$) and no complications were described in the review. Therefore, the authors concluded that wound closure in 90° flexion during TKA may provide better postoperative ROM, higher pain relief, and no increase in the risks of wound complications.

In summary, two Level of Evidence I reports and one Level of Evidence II report showed the positive effect of closure in flexion for TKAs, while another Level of Evidence I report was inconclusive (Table V).

DISCUSSION

Deep wound closure is one of the most important aspects of total knee arthroplasty. A defective closure in this layer can lead to complications following

an otherwise successful surgery. The technique for closure during TKA offers both similar and unique anatomic considerations. The arthrotomy closure provides containment of the implant and reconstitution of the synovial joint, preventing both fluid extravasation, or worse, fluid intrusion. Additionally, seven studies analyzing barbed sutures and their relationship with wound complications after deep knee arthroplasty closure were evaluated and four found improved results with barbed sutures and three showed similar rates of wound complications (Table I). Furthermore, a meta-analysis was conducted in an attempt to provide enough power (4 studies, 480 patients) to elucidate a difference and demonstrated overall lower wound complication risk with the use of barbed sutures (6 vs. 13%, $p<0.05$) (Table II). Five of six closing time reports (Level of Evidence I, three studies, Level of Evidence II, one study, Level of Evidence III, one study) demonstrated the positive results of barbed sutures (Table III).^{20,23} A subsequent meta-analysis included five studies (445 patients) that demonstrated overall significant closing time reductions with the use of barbed sutures (13 vs. 17 minutes, $p<0.05$). Closing the arthrotomy in a semi-flexed position, followed by gentle ROM may help avoid early wound complications.^{28,31} In total, two Level of Evidence I reports and one Level of Evidence II report showed the positive effect of closure in flexion for TKAs, while another Level of Evidence I report was inconclusive (Table V).

The findings are similar to review articles by Khlopas et al. and Krebs et al. who found similar postoperative complication rates and cosmetic outcomes as well as significantly shorter closing times ($p<0.05$)¹⁴ when barbed sutures were compared with traditional sutures.²⁰

This study is not without limitations. As previously mentioned, some reports were under-powered. Therefore, there is still the need for more studies in this field. Preference should be placed on Level of Evidence I investigations, when possible.

With the continuous development of deep wound closure techniques, future prospective work should examine more specific comparisons including the economic impact, complications, and resource utilizations. The authors believe that this would be an appropriate topic for a consensus conference.

CONCLUSION

The literature remains variable regarding the best results concerning the optimal closure of the arthrotomy of total knee arthroplasties. Nevertheless, multiple recent studies report encouraging results using barbed suture and closing in a flexed knee position. Barbed sutures remain an attractive option to obtain a predictable watertight closure, while typically reducing the operative case length. Closure in flexion also theoretically pre-tensions the sutures providing reassurance to both the patient and surgeon that increasing knee motion will create tensile forces that have already been confirmed in the operating suite. **STI**

AUTHORS' DISCLOSURES

Dr. Mont is a board or committee member for The Knee Society and The Hip Society, receives research support from National Institutes of Health, and is on the editorial board for the Journal of Arthroplasty, Journal of Knee Surgery, Surgical Technology International, and Orthopaedics. Dr. Mont also receives company support from 3M, Centrexion, Ceras Health, Flexion Therapeutics, Johnson & Johnson, Kolon TissueGene, NXSCI, Pacira, Pfizer-Lily, Skye Biologics, SOLVD Health, Smith & Nephew, Stryker, CERAS Health, MirrorAR, Peerwell, US Medical Innovations, RegenLab, TissueGene, Medicus Works LLC, Up-To-Date, Wolters Kluwer Health, Lippincott Williams & Wilkins, Journal of Arthroplasty, Journal of Knee Surgery, Orthopedics, Surgical Technology International, AAHKS, Knee Society, Hip Society.

All other authors have no conflicts of interest to disclose.

REFERENCES

1. Bozic KJ, Lau E, Kurtz S, et al. Patient-related risk factors for periprosthetic joint infection and postoperative mortality following total hip arthroplasty in medicare patients. *J Bone Jt Surg - Ser A* 2012;94(9):794–800.
2. Bozic KJ, Ong K, Lau E, et al. Estimating risk in medicare patients with THA: An electronic risk calculator for periprosthetic joint infection and mortality hip. *Clin Orthop Relat Res* 2013;471(2):574–83.
3. Kurtz S, Ong K, Lau E, et al. Projections of primary and revision hip and knee arthroplasty in the United States from 2005 to 2030. *J Bone Jt Surg - Ser A* 2007;89(4):780–5.
4. Kurtz SM, Lau E, Watson H, et al. Economic burden of periprosthetic joint infection in the united states. *J Arthroplasty* 2012;27(8 Suppl):61–5.e1.
5. Plate JF, Seyler TM, Halvorson JJ, et al. Non-anatomical capsular closure of a standard parapatellar knee arthrotomy leads to patellar maltracking and decreased range of motion: A cadaver study. *Knee Surgery, Sport Traumatol Arthrosc* 2014;22(3):543–9.
6. Osei DA, Rebehn KA, Boyer MI. Soft-tissue defects after total knee arthroplasty: Management and reconstruction. *J Am Acad Orthop Surg* 2016;24(11):769–79.
7. Galat DD, McGovern SC, Larson DR, et al. Surgical treatment of early wound complications following primary total knee arthroplasty. *J Bone Jt Surg - Ser A* 2009;91(1):48–54.
8. Sah AP. Is there an advantage to knotless barbed suture in TKA wound closure? A randomized trial in simultaneous bilateral TKAs. *Clin Orthop Relat Res* 2015;473(6):2019–27.
9. Faour M, Sodhi N, Khlopas A, et al. Knee position during surgical wound closure in total knee arthroplasty: A review. *J Knee Surg* 2018;31(1):6–12.
10. Komnik I, Weiss S, Fantini Pagani CH, et al. Motion analysis of patients after knee arthroplasty during activities of daily living - A systematic review. *Gait Posture* 2015;41(2):370–7.
11. Dennis DA, Komistek RD, Scuderi GR, et al. Factors affecting flexion after total knee arthroplasty. *Clin Orthop Relat Res* 2007;464:53–60.
12. King TV, Kish G, Eberhart RE, et al. The “genuflex” skin closure for total knee arthroplasty. *Orthopedics* 1992;15(9):1057–8.
13. Sah AP. A prospective, randomized evaluation of the quality of wound closure with barbed versus standard suture after total joint arthroplasty. *Orthopedics* 2021;44(4):216–22.
14. Khlopas A, Sodhi N, Anis HK, et al. A systematic review of suture technologies in total knee arthroplasty. *Surg Technol Int* 2019;34:391–6.
15. Meek RMD, Greidanus NV, McGraw RW, et al. The extensile rectus snip exposure in revision of total knee arthroplasty. *J Bone Jt Surg - Ser B* 2003;85(8):1120–2.
16. Nestor BJ, Toulson CE, Backus SI, et al. Mini-mid-vastus vs standard medial parapatellar approach: A prospective, randomized, double-blinded study in patients undergoing bilateral total knee arthroplasty. *J Arthroplasty* 2010;25(6 Suppl):5–11, 11.e1.
17. Ting NT, Moric MM, Della Valle CJ, et al. Use of knotless suture for closure of total hip and knee arthroplasties. A prospective, randomized clinical trial. *J Arthroplasty* 2012;27(10):1783–8.
18. Morris MR, Bergum C, Jackson N, et al. Decreased bacterial adherence, biofilm formation, and tissue reactivity of barbed monofilament suture in an in vivo contaminated wound model. *J Arthroplasty* 2017;32(4):1272–9.
19. Levine BR, Ting N, Della Valle CJ. Use of a barbed suture in the closure of hip and knee arthroplasty wounds. *Orthopedics* 2011;34(9):e473–5.
20. Vakili JJ, O'Reilly MP, Sutter EG, et al. Knee arthrotomy repair with a continuous barbed suture. A Biomechanical Study *J Arthroplasty* 2011;26(5):710–3.
21. Burns PB, Rohrich RJ, Chung KC. The levels of evidence and their role in evidence-based medicine. *Plast Reconstr Surg* 2011;128(1):305–10.
22. Kruschke JK. Bayesian estimation supersedes the t test. *J Exp Psychol Gen* 2013;142(2):e473–603.
23. Gililland JM, Anderson LA, Sun G, et al. Perioperative closure-related complication rates and cost analysis of barbed suture for closure in TKA. *Clin Orthop Relat Res* 2012;470(1):125–9.
24. Chan VWK, Chan PK, Chiu KY, et al. Does barbed suture lower cost and improve outcome in total knee arthroplasty? A randomized controlled trial. *J Arthroplasty* 2017;32(5):1474–7.
25. Sakdinakittikoon 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(3):361–7.
26. Smith EL, DiSegna ST, Shukla PY, et al. Barbed versus traditional sutures: Closure time, cost, and wound related outcomes in total joint arthroplasty. *J Arthroplasty* 2014;29(2):283–7.
27. Maheshwari AV, Naziri Q, Wong A, et al. Barbed sutures in total knee arthroplasty: are these safe, efficacious, and cost-effective? *J Knee Surg* 2015;28(2):151–6.
28. Emerson RH, Ayers C, Head WC, et al. Surgical closing in primary total knee arthroplasties: Flexion versus extension. *Clin Orthop Relat Res* 1996;(331):74–80.
29. Cerciello S, Morris BJ, Lustig S, et al. The role of wound closure in total knee arthroplasty: a systematic review on knee position. *Knee Surgery, Sport Traumatol Arthrosc* 2016;24(10):3306–12.
30. Lu X, Zhong L, Cao X, et al. Wound closure position in total knee arthroplasty: flexion versus extension—a meta-analysis of randomized controlled trials. *Arch Orthop Trauma Surg* 2021;141(11):1971–82.
31. Kobayashi S, Niki Y, Harato K, et al. The effects of barbed suture on watertightness after knee arthrotomy closure: A cadaveric study. *J Orthop Surg Res* 2018;13(1):323.



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