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## Primary Knee

## International Delphi Study on Wound Closure and Dressing Management in Joint Arthroplasty: Part 1: Total Knee Arthroplasty



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## ABSTRACT

**Background:** The purpose of this modified Delphi study was to obtain consensus on wound closure and dressing management in total knee arthroplasty (TKA).**Methods:** The Delphi panel included 20 orthopaedic surgeons from Europe and North America. There were 26 statements identified using a targeted literature review. Consensus was developed for the statements with up to three rounds of anonymous voting per topic. Panelists ranked their agreement with each statement on a five-point Likert scale. An *a priori* threshold of  $\geq 75\%$  was required for consensus.

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dressing management  
Delphi study  
surgical best practices  
venous thromboembolism prophylaxis

**Results:** All 26 statements achieved consensus after three rounds of anonymous voting. Wound closure-related interventions that were recommended for use in TKA included: 1) closing in semi-flexion versus extension (superior range of motion); 2) using aspirin for venous thromboembolism prophylaxis over other agents (reduces wound complications); 3) barbed sutures over non-barbed sutures (lower wound complications, better cosmetic appearances, shorter closing times, and overall cost savings); 4) mesh-adhesives over other skin closure methods (lower wound complications, higher patient satisfaction scores, lower rates of readmission); 5) silver-impregnated dressings over standard dressings (lower wound complications, decreased infections, fewer dressing changes); 6) in high-risk patients, negative pressure wound therapy over other dressings (lower wound complications, decreased reoperations, fewer dressing changes); and 7) using triclosan-coated over non-antimicrobial-coated sutures (lower risks of surgical site infection).

**Conclusions:** Using a modified Delphi approach, the panel achieved consensus on 26 statements pertaining to wound closure and dressing management in TKA. This study forms the basis for identifying critical evidence supported by clinical practice for wound management to help reduce variability, advance standardization, and ultimately improve outcomes during TKA. The results presented here can serve as the foundation for knowledge, education, and improved clinical outcomes for surgeons performing TKAs.

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Optimal wound healing is extremely important when trying to avoid various complications and infections after total knee arthroplasty (TKA) and total hip arthroplasty (THA). Despite the best efforts over the past decade, the infection rates after total joint arthroplasties have remained at approximately 1 to 2% or even increasing [1–4] for primary cases and even higher for revisions [5]. Issues concerning the wound cannot be overestimated as causative for periprosthetic infections [6]. For example, in a study of 17,784 TKAs by Galat et al., they found a greater than five-fold increased risk of deep infection in patients who had wound complications following TKA (approximately 6% risk of deep infection with wound complications compared to only 0.8% in patients who did not have wound problems) [7].

Nevertheless, there are few studies concerning wound closure and dressing management after THA and TKA, with little consensus in the literature [8]. Standards of care have been mostly derived without Level 1 evidence and with few systematic reviews. An evidence-based approach is much needed [9]. For important and relevant medical issues, it is mandated that evidence-based approaches be used to make care decisions, especially in this era of health care reform with an increasing downwards-pressure on reimbursement. Therefore, consensus conferences according to Delphi methods have been increasingly utilized to get “answers” to clinically important questions throughout medicine. These types of consensus efforts can identify important gaps in the existing evidence that require further research.

To respond to this lack of evidence, a modified Delphi Panel focus group was convened to focus on issues related to wound closure and dressing management after TKA and THA. The international panel was composed of 10 orthopedic surgeons from Europe, 1 from Canada, and 9 from the United States (US). This article will focus on TKA (Part 1). Next, THA will follow separately in another report (Part 2). In addition, a separate report will present information-gathering questions, identified by the Delphi panel, about the critical evidence gaps for most of the 26 questions assessed during the comprehensive literature review and discussions will be presented in a separate report (Part 3).

## Methods

### Modified Delphi Method

The Delphi method is an iterative process that aims to collect opinions from a panel of experts to achieve consensus in a given subject area [10]. The method involves a series of structured

consensus-building rounds in which responses are collected through anonymous polling [11]. The results of each round are quantitatively and/or qualitatively summarized and shared with the panelists. This process is then repeated until consensus is reached (Figure 1) [10,11].

This study was conducted from April 1, 2023, to September 30, 2023, and used a modified Delphi method with 3 rounds of voting: (1) Round One structured electronic survey; (2) Round Two virtual face-to-face meeting; and (3) Round Three electronic survey (Figure 2.1).

### Panelist Selection and Recruitment

The Delphi panel included 20 orthopedic surgeons from Europe, Canada, and the US: three steering committee members (two from the US and one from the United Kingdom) and a working group of 17 surgeons (seven from the US, one from Canada, and nine from Europe). Panelist selection criteria included: nationally or internationally recognized expertise; high volume of publications in joint arthroplasty; familiarity with wound closure techniques or enhanced recovery after surgery; membership in key professional orthopedic organizations or international orthopedic societies; and high surgical volume (> 100 TKA or THA surgeries per year).

### Targeted Literature Review and Statement Development

An initial list of statements pertaining to key areas of interest for wound closure and dressing management in TKA and THA was generated by the steering committee over a period of 4 months. There were four published systematic reviews that formed the main initial evidence base for statements [12–15]. The steering committee focused on studies on intraoperative wound management techniques and postoperative dressing use, while intentionally neglecting certain aspects of factors that can affect wound healing that were beyond the scope of this panel, but have been covered elsewhere (eg, preoperative optimization, patient risk factors for poor wound healing, other select intraoperative techniques that may affect wound healing) [16–21].

These systematic reviews were updated to April 5, 2023 for the current Delphi work to capture newly published studies. For topics not addressed in these systematic reviews, targeted literature searches were performed to identify relevant studies.

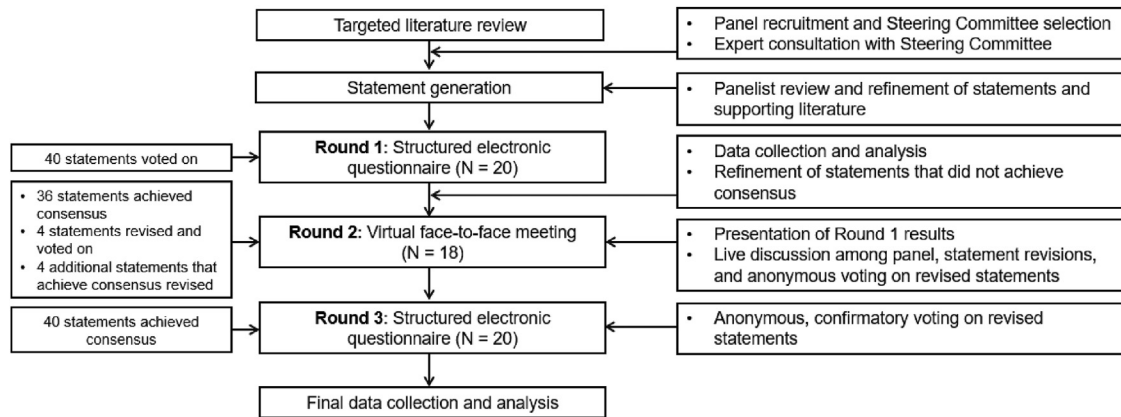
All statements underwent preliminary review by participating panelists to verify statement accuracy and completeness of

**Table 1**  
Example of Statement Flow Through the Delphi Process.

Flow Structure	Statements
Original draft statement prior to review	Tourniquets lead to less wound complications then using no tourniquets during total knee arthroplasty
After review and revision, first consensus round	The use of a tourniquet during total knee arthroplasty may be associated with a higher rate of superficial wound complications compared to no tourniquet use (70% agreement)
Final Statement	Limited evidence indicates there may be a trend toward an increase in wound complications with tourniquet use in total knee arthroplasty, and further studies are warranted (95% agreement)

**Table 2**  
Consensus Statements on Wound Closure in Total Knee Arthroplasty.

Consensus Statement	Level of Agreement, % (N/n)
Total knee arthroplasty	
Positioning and approaches	
There is superior function/range of motion outcomes for total knee arthroplasty closure in (semi-) flexion versus extension	90% (18/20)
There are no differences in wound complication rates between the mini-subvastus and medial parapatellar approaches for total knee arthroplasty	100% (20/20)
There is insufficient evidence that patella eversion and tibial translation are associated with worse wound healing in patients undergoing total knee arthroplasty	90% (18/20)
Tourniquets	
Limited evidence indicates there may be a trend toward an increase in wound complications with tourniquet use in total knee arthroplasty, and further studies are warranted	95% (19/20)
Drains	
There are no differences in wound complications rates with and without the use of a drain during total knee arthroplasty	90% (18/20)
Venous thromboembolism prophylaxis	
Aspirin leads to less wound complications than certain methods of chemoprophylaxis against venous thromboembolic disease after total knee arthroplasty	100% (20/20)
Barbed sutures	
There appears to be a lower risk of wound complications with barbed sutures compared with interrupted closure with nonbarbed sutures for total knee arthroplasty	80% (16/20)
There are significant closing time reductions with the use of barbed sutures versus interrupted closure with nonbarbed sutures for total knee arthroplasty	100% (20/20)
While barbed sutures may cost more than interrupted closure with nonbarbed sutures, closure with barbed sutures saves costs due to faster closing times and reduced operating room time in total knee arthroplasty	85% (17/20)
There are no differences in postoperative range of motion between barbed sutures and interrupted closure with nonbarbed sutures in total knee arthroplasty	95% (19/20)
There are no differences in patient-reported outcomes between barbed sutures and interrupted closure with nonbarbed sutures in total knee arthroplasty	100% (20/20)
There is better cosmesis with barbed sutures versus subcuticular sutures/staples in total knee arthroplasty	90% (18/20)
Closure methods	
There are no differences in wound complication rates between staples and sutures in patients undergoing total knee arthroplasty	90% (18/20)
There are no differences in wound complications between subcuticular sutures, staples, glue, or for the closure of the skin layer in total knee arthroplasty	90% (18/20)
There is insufficient evidence to evaluate whether there is higher patient preference for skin glue versus subcuticular sutures in total knee arthroplasty	95% (19/20)
Mesh-adhesive dressings	
Mesh-adhesives or staples are associated with faster closing times compared to subcuticular sutures in total knee arthroplasty	95% (19/20)
There may be a lower risk of wound complications with mesh-adhesive dressings versus other skin closure methods in total knee arthroplasty	80% (16/20)
Patients are more satisfied with wound closure using mesh-adhesive compared to staples in total knee arthroplasty	90% (18/20)
Closure with mesh-adhesives dressings may be associated with decreased rates of readmission compared to skin closure with staples in total knee arthroplasty	95% (19/20)
Silver-impregnated dressings	
There are decreased rates of wound complications with silver-impregnated dressings compared with standard dressings in total knee arthroplasty	85% (17/20)
Silver-impregnated dressings are associated with fewer dressing changes compared with standard dressings in total knee arthroplasty	100% (20/20)
Silver-impregnated dressings may reduce the risk of surgical site infection in total knee arthroplasty	90% (18/20)
Total knee and total hip arthroplasty	
Negative-pressure wound therapy	
In high-risk patients, there is a lower risk of wound complications with negative-pressure wound therapy compared with other dressing types in total hip and total knee arthroplasty	100% (20/20)
In high-risk patients, negative-pressure wound therapy is associated with lower rates of reoperation compared with other dressing types in total hip and total knee arthroplasty	95% (19/20)
In high-risk patients, negative-pressure wound therapy is associated with a reduction in dressing changes compared with other dressing types in total hip and total knee arthroplasty	100% (20/20)
Triclosan-coated sutures	
Based on the available evidence, triclosan-coated sutures are likely to reduce the risk of surgical site infection in total hip and knee replacement	95% (19/20)



**Fig. 1.** The Delphi process for developing consensus statements (Note that this includes TKA and THA together).

literature. Each statement was assigned to one primary panelist reviewer and two secondary panelist reviewers. Initially, they were responsible for redrafting the questions if necessary, analyzing all of the data, evaluating or updating the references if necessary, and writing a full description summary of the literature. All 20 panelists participated in the initial round of review. Statement revisions were incorporated with guidance from the steering committee and were compiled into an electronic survey for Round One of the consensus-building process.

#### Round One Electronic Survey

The Round One electronic survey consisted of 26 TKA statements. Each statement was accompanied by a link to the supporting studies in the published literature. Panelists voted on their agreement with each statement using a 5-point Likert scale ranging from 1 (strongly agree) to 5 (strongly disagree). If panelists did not agree with a statement, they were asked to explain why, and to specify how the statement would need to change in order to obtain their agreement. An *a priori* threshold of  $\geq 75\%$  was required for consensus, which was more conservative than the commonly used threshold of  $\geq 70\%$  in Delphi studies [22–26].

#### Round Two Virtual Face-To-Face Meeting

Results from the Round One questionnaire were presented to the panel at the virtual face-to-face meeting. The steering committee facilitated clinical discussions for statements that did not achieve consensus in Round One, and statements were revised and revoted on anonymously during the live meeting. Panelists also had the opportunity to discuss and revise statements that achieved consensus in Round One. In the final part of the meeting, panelists were asked to identify critical evidence gaps in wound closure.

#### Round Three Electronic Survey

Based on the results of the Round Two meeting, a third electronic survey was sent to the panel. As all statements achieved consensus ( $\geq 75\%$  of the panel in agreement) by the end of Round Two, this final round was confirmatory. Round Three also featured information-gathering questions about the critical evidence gaps identified in Round Two. Examples of statements that underwent revisions across the Delphi process are provided in Table 1.

## Results

Details discussion for all 26 TKA questions can be found in Appendix 1. The following are the summarized results. See Table 2 for full statements.

Wound closure-related interventions that were recommended for use in TKA included.

- 1) Closing in semi-flexion versus extension (superior range of motion);
- 2) Using aspirin for venous thromboembolism prophylaxis over other agents (reduces wound complications);
- 3) Deep closure with barbed sutures over non-barbed sutures (eg, lower wound complications, shorter closing times, and overall cost savings);
- 4) Mesh-adhesives over other skin closure methods (eg, lower wound complications, higher patient satisfaction scores, lower rates of readmission);
- 5) Silver-impregnated dressings over standard dressings (eg, lower wound complications, decreased infections, fewer dressing changes);
- 6) In high-risk patients, negative pressure wound therapy over other dressings (eg, lower wound complications, decreased reoperations, fewer dressing changes); and
- 7) Using Triclosan-coated versus non-antimicrobial-coated sutures (lower risks of surgical site infection).

No differences, minimal trends, or insufficient evidence for affecting wound complication rates were found for the following interventions.

- 1) Mini-subvastus versus medial parapatellar approach;
- 2) Patellar eversion and tibial translation;
- 3) Usage or nonusage of tourniquets;
- 4) Usage or nonusage of drains;
- 5) Usage of staples versus sutures for wound closure; and
- 6) Usage of subcuticular sutures, staples, or glue for skin closure

Information-gathering questions about the critical evidence gaps were identified for most questions. This will be part of a separate report (Part 3).

## Discussion

We are in critical times that incentivize the maintenance of high-quality patient care, while reducing expenditures. When

performing all aspects of orthopedic surgery, many care pathways have been instituted that enhance the value proposition. Care pathways have been instituted across many aspects of orthopaedic surgery that contribute to more efficient episodes of care and increase the overall value of these surgical procedures [27]. This has often been achieved by controlling implant costs, lengths of hospital stay, rehabilitation efforts, and trying to reduce complications, emergency room visits, and readmissions. Evaluations of wound closure techniques and dressings have often been over-looked in favor of focusing on more costly individual items. And yet, these parts of the procedure are the only ones that the patient sees and certainly can affect patient satisfaction scores. More importantly, as noted previously, wound complications can lead to increased resource utilization including: outpatient evaluations; emergency department visits; as well as readmissions. In one study, 50% of 30-day readmissions following total joint arthroplasties were attributable to wound issues (eg, erythema, hematoma, excess drainage) [28]. Therefore, based on the current emphasis on value-based care, and the increasing evidence focusing on the costly complications of wound problems, this modified Delphi approach was undertaken to further our understanding about wound closure techniques and dressings after TKA.

Through the 3-Round modified Delphi process, a 20-member panel of orthopedic experts identified 26 statements, 100% that reached consensus concerning wound closure and dressing management. This modified Delphi process displayed many benefits, including the anonymity afforded to the participants in the first 2 rounds. This consensus group process allowed the panelists to individually judge the evidence from their own frame of clinical reference. By involving all of the panelists in developing and refining statements, assessing and summarizing supportive evidence, and reviewing/critiquing the entire work-product, the members were able to express their diversity of opinions. The “virtual in-person” meeting permitted them to review, critique, and amend the study answers, opinions, and results. It was a tremendous effort that we achieved consensus on 100% of statements after 2 rounds and only needed to confirm these results in Round 3. All of the original statements were maintained with only slight modifications. We expect that this work can promote more agreement on best practices for our patients. In addition, a list of opportunities for future research to address knowledge gaps in this field have been generated (will be part of a separate report).

#### Potential Limitations

The current work has some potential limitations. The selection of the experts was not based solely on their research in the field, but sometimes on their key organizational membership and experiences including surgical volumes. Also, choosing exact wording for consensus statements could have been challenging among a cohort of surgeons who did not share English as a common first language, nevertheless, complete consensus was ultimately reached. At times, consensus was reached for statements that were not supported with strong Level 1 evidence. Some studies had small numbers and are subject to type II errors and fragility. At times, statements would be self-evident and further study would be unnecessary, but at other times they would represent a knowledge gap that was identified for future important study.

#### Conclusions

Using a modified Delphi approach, a panel of 20 orthopedic surgeons achieved consensus on 26 statements pertaining to wound closure and dressing management in TKA. This study forms the basis for identifying critical evidence supported by clinical

practice for wound management to help reduce variability, advance standardization, and ultimately improve outcomes during TKA. The results presented here can serve as the foundation for knowledge, education, and clinical practice on this topic.

#### CRediT authorship contribution statement

**Margaret Ainslie-Garcia:** Methodology, Visualization, Writing – original draft, Writing – review & editing. **Lucas A. Anderson:** Investigation, Methodology, Writing – original draft, Writing – review & editing. **Benjamin V. Bloch:** Data curation, Formal analysis, Software. **Tim N. Board:** Investigation, Project administration, Software. **Antonia F. Chen:** Formal analysis, Investigation, Software. **Samantha Craigie:** Data curation, Formal analysis, Investigation. **Walter Danker:** Investigation, Methodology, Resources. **Najmuddin Gunja:** Formal analysis, Funding acquisition, Project administration. **James Hartly:** Supervision, Validation, Visualization. **Victor H. Hernandez:** Resources, Supervision, Validation. **Kate Lebedeva:** Investigation, Methodology, Resources. **Michael A. Mont:** Writing – original draft, Writing – review & editing. **Ryan M. Nunley:** Conceptualization, Formal analysis, Investigation. **Javad Parvizi:** Conceptualization, Data curation. **Carsten Perka:** Methodology, Validation, Visualization. **Nicolas S. Piuze:** Investigation, Methodology, Validation. **Ola Rolfson:** Investigation, Supervision, Validation, Visualization. **Joshua Rychlik:** Methodology, Resources, Software, Visualization. **Emilio Romanini:** Conceptualization, Investigation. **Pablo Sanz-Ruiz:** Resources, Software, Visualization. **Rafael J. Sierra:** Methodology, Supervision, Visualization. **Linda Suleiman:** Formal analysis, Validation, Visualization. **Eleftherios Tsiridis:** Methodology, Resources, Software, Validation. **Pascal-André Vendittoli:** Formal analysis, Investigation, Project administration. **Helge Wangen:** Formal analysis, Investigation, Methodology. **Luigi Zagra:** Formal analysis, Software, Supervision.

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#### Appendix A. Supplementary Data

Supplementary data related to this article can be found at <https://doi.org/10.1016/j.arth.2023.12.032>.

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