Surgical Management of Osteoarthritis of the Knee

Evidence-Based Clinical Practice Guideline

Adapted by:
The American Academy of Orthopaedic Surgeons Board of Directors
December 2, 2022

Endorsed by:

View background material via the SMOAK CPG eAppendix 1
View data summaries via the SMOAK CPG eAppendix 2

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Disclaimer

This clinical practice guideline (CPG) was developed by a physician volunteer clinical practice guideline development group based on a formal systematic review of the available scientific and clinical information and accepted approaches to treatment and/or diagnosis. This clinical practice guideline is not intended to be a fixed protocol, as some patients may require more or less treatment or different means of diagnosis. Clinical patients may not necessarily be the same as those found in a clinical trial. Patient care and treatment should always be based on a clinician's independent medical judgment, given the individual patient's specific clinical circumstances.

Disclosure Requirement
In accordance with AAOS policy, all individuals whose names appear as authors or contributors to the clinical practice guideline filed a disclosure statement as part of the submission process. All panel members provided full disclosure of potential conflicts of interest prior to voting on the recommendations contained within this clinical practice guideline.

Funding Source
This clinical practice guideline was funded exclusively by the American Academy of Orthopaedic Surgeons who received no funding from outside commercial sources to support the development of this document.

FDA Clearance
Some drugs or medical devices referenced or described in this clinical practice guideline may not have been cleared by the Food and Drug Administration (FDA) or may have been cleared for a specific use only. The FDA has stated that it is the responsibility of the physician to determine the FDA clearance status of each drug or device he or she wishes to use in clinical practice.

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Contents

SUMMARY OF RECOMMENDATIONS

Recommendations are formed when there is sufficient evidence by which to create a directional statement. This is defined as evidence from two or more high quality studies (i.e., a strong recommendation), two or more moderate quality studies (i.e., a moderate recommendation), or statements resulting in a strong or moderate strength following Evidence to Decision Framework upgrading and/or downgrading.

DRAINS

Drains should not be used with total knee arthroplasty because there is no significant difference in complications or outcomes.

Strength of Evidence: Strong

Strength of Recommendation: Moderate ★★★☆ (downgraded)

Evidence from two or more "Moderate" quality studies with consistent findings, or evidence from a single "High" quality study for recommending for or against the intervention. Also, higher strength evidence can be downgraded to limited due to major concerns addressed in the EtD Framework.

CEMENTLESS FIXATION: CEMENTED FEMORAL &TIBIAL COMPONENTS VS. CEMENTLESS FEMORAL & TIBIAL COMPONENTS

Cemented femoral and tibial components or cementless femoral and tibial components in knee arthroplasty show similar rates of functional outcomes, complications, and reoperations, and conflicting evidence in comparative studies.

Strength of Evidence: Strong

Strength of Recommendation: Moderate ★★★☆ (downgraded)

Evidence from two or more "Moderate" quality studies with consistent findings, or evidence from a single "High" quality study for recommending for or against the intervention. Also, higher strength evidence can be downgraded to limited due to major concerns addressed in the EtD Framework.

CEMENTLESS FIXATION: ALL CEMENTED COMPONENTS VS. HYBRID FIXATION (CEMENTLESS FEMORAL COMPONENT)

Cemented femoral and tibial components or hybrid fixation (cementless femur) in total knee arthroplasty show similar functional outcomes and rates of complications and reoperations.

Strength of Evidence: Strong

Strength of Recommendation: Moderate ★★★☆ (downgraded)

Evidence from two or more "Moderate" quality studies with consistent findings, or evidence from a single "High" quality study for recommending for or against the intervention. Also, higher strength evidence can be downgraded to limited due to major concerns addressed in the EtD Framework.

UNICOMPARTMENTAL VS. TOTAL KNEE ARTHROPLASTY

The practitioner can use unicompartmental arthroplasty vs total knee arthroplasty for patients with predominantly medial compartment osteoarthritis, as evidence reports improved patient reported and functional outcomes in the short term; however, long-term rates of revision in unicompartmental knee arthroplasty may be higher than total knee arthroplasty.

Strength of Evidence: Strong

Strength of Recommendation: Moderate ★★★☆ (downgraded)

Evidence from two or more "Moderate" quality studies with consistent findings, or evidence from a single "High" quality study for recommending for or against the intervention. Also, higher strength evidence can be downgraded to limited due to major concerns addressed in the EtD Framework.

PERIPHERAL NERVE BLOCKADE (PNB)

Peripheral nerve blockades for total knee arthroplasty lead to decreased postoperative pain and opioid requirements with no difference in complications or outcomes.

Strength of Evidence: Strong

Strength of Recommendation: Strong ★★★★

Evidence from two or more "High" quality studies with consistent findings for recommending for or against the intervention.

PERIARTICULAR LOCAL INFILTRATION

Periarticular injections used in total knee arthroplasty lead to decreased postoperative pain.

Strength of Evidence: Strong

Strength of Recommendation: Strong ★★★★

Evidence from two or more "High" quality studies with consistent findings for recommending for or against the intervention.

TRANEXAMIC ACID

In patients with no known contraindications, tranexamic acid (TXA) should be used because its use decreases postoperative blood loss, postoperative drain collection, and reduces the necessity of postoperative transfusions following total knee arthroplasty (TKA).

Strength of Evidence: Strong

Strength of Recommendation: Strong ★★★★

Evidence from two or more "High" quality studies with consistent findings for recommending for or against the intervention.

SURGICAL NAVIGATION

There is no difference in outcomes, function, or pain between navigation and conventional techniques.

Strength of Evidence: Strong

Strength of Recommendation: Moderate ★★★☆ (downgraded)

Evidence from two or more "Moderate" quality studies with consistent findings, or evidence from a single "High" *quality study for recommending for or against the intervention. Also, higher strength evidence can be downgraded to limited due to major concerns addressed in the EtD Framework.*

RISK FACTORS: BODY MASS INDEX (BMI)

There is no difference in postoperative functional scores between patients with a BMI < 30 and obese patients (BMI 30-39.9); however, there may be increased risk of complications in morbidly obese patients (≥40), in particular, surgical site infections.

Strength of Evidence: Strong

Strength of Recommendation: Strong ★★★★

Evidence from two or more "High" quality studies with consistent findings for recommending for or against the intervention.

RISK FACTORS: DIABETES / HYPERGLYCEMIA

Optimization of perioperative glucose control (<126mg/dl) after total knee arthroplasty should be attempted in diabetic and non-diabetic patients with HgbA1C <6.5, as hyperglycemia can lead to less favorable postoperative outcomes and higher complication rates.

Strength of Evidence: Strong

Strength of Recommendation: Strong ★★★★

Evidence from two or more "High" quality studies with consistent findings for recommending for or against the intervention.

TOURNIQUETS

Evidence reports that there is no difference in outcomes, function, pain, or blood transfusions between the use of tourniquets and nonuse of tourniquets.

Strength of Evidence: Strong

Strength of Recommendation: Strong ★★★★

Evidence from two or more "High" quality studies with consistent findings for recommending for or against the intervention.

PATELLAR RESURFACING

Evidence reports that there is no difference between patellar resurfacing or non-patellar resurfacing in total knee arthroplasty.

Strength of Evidence: Strong

Strength of Recommendation: Strong ★★★★

Evidence from two or more "High" quality studies with consistent findings for recommending for or against the intervention.

CRUCIATE RETAINING ARTHROPLASTY

Cruciate retaining (CR) and posterior stabilized (PS) total knee arthroplasty (TKA) designs have similarly efficacious/favorable postoperative outcomes.

Strength of Evidence: Strong

Strength of Recommendation: Strong ★★★★

Evidence from two or more "High" quality studies with consistent findings for recommending for or against the intervention.

PATIENT SPECIFIC TECHNOLOGY

The practitioner should not use patient specific technology (e.g., guides, cutting blocks) because there is no significant difference in patient outcomes, function, or pain as compared to conventional total knee arthroplasty (TKA). Additionally, it does not reduce operating time, blood loss, length of stay, and/or complications.

Strength of Evidence: Strong

Strength of Recommendation: Strong ★★★★

Evidence from two or more "High" quality studies with consistent findings for recommending for or against the intervention.

KINEMATIC VS. MECHANICAL ALIGNMENT

There is no difference in composite/functional outcomes or complications between kinematic or mechanical alignment principles in total knee arthroplasty.

Strength of Evidence: Strong

Strength of Recommendation: Strong ★★★★

Evidence from two or more "High" quality studies with consistent findings for recommending for or against the intervention.

PRE-OPERATIVE OPIOID USE

Cessation of preoperative opioids should be attempted for total knee arthroplasty (TKA), as preoperative opioid use demonstrates decreased postoperative functional scores and increased pain scores and complications.

Strength of Evidence: Low

Strength of Recommendation: Moderate ★★★☆ (Upgraded)

Evidence from one or more "Low" quality studies with consistent findings or evidence from a single "Moderate" quality study recommending for or against the intervention. Also, lower strength evidence can be upgraded to moderate due to concerns addressed in the EtD Framework.

SUMMARY OF OPTIONS

Options are formed when there is little or no evidence on a topic. This is defined as low quality evidence or a single moderate quality study (i.e., a limited strength option), no evidence or only conflicting evidence (i.e., a consensus option), or statements resulting in a limited or consensus strength following Evidence to Decision Framework upgrading and/or downgrading.

CEMENTLESS FIXATION: ALL CEMENTLESS COMPONENTS VS. HYBRID FIXATION (CEMENTLESS TIBIAL COMPONENT)

All cementless components or hybrid fixation (cementless femur) in total knee arthroplasty show similar functional outcomes and rates of complications and reoperations.

Strength of Evidence: Moderate

Strength of Option: Limited ★★☆☆ (downgraded)

Evidence from two or more "Moderate" quality studies with consistent findings, or evidence from a single "High" quality study for recommending for or against the intervention. Also, higher strength evidence can be downgraded to limited due to major concerns addressed in the EtD Framework.

UNICOMPARTMENTAL KNEE ARTHROPLASTY VS. HIGH/PROXIMAL TIBIAL OSTEOTOMY

The practitioner could use unicompartmental knee arthroplasty or tibial osteotomy for the treatment of knee osteoarthritis.

Strength of Evidence: Moderate

Strength of Option: Limited ★★☆☆ (downgraded)

Evidence from two or more "Moderate" quality studies with consistent findings, or evidence from a single "High" quality study for recommending for or against the intervention. Also, higher strength evidence can be downgraded to limited due to major concerns addressed in the EtD Framework.

BILATERAL SIMULTANEOUS TOTAL KNEE ARTHROPLASTY VS. STAGED

In the absence of reliable evidence, it is the opinion of the workgroup that simultaneous bilateral total knee arthroplasty (TKA) could be performed vs. staged (>90 days) bilateral TKA in appropriately selected patients but should be performed with caution and should be avoided with patients who are at high risk of cardiopulmonary complications.

Strength of Evidence: Low

Strength of Option: Consensus ★☆☆☆ (downgraded)

Description: Evidence there is no supporting evidence, or limited level evidence was downgraded due to major concerns addressed in the EtD framework. In the absence of reliable evidence, the guideline work group is making a recommendation based on their clinical opinion.

RISK FACTORS: SMOKING

Smoking cessation should be attempted before total knee arthroplasty, as a history of smoking may result in higher complications, lower functional scores, higher pain scores, and SSIs.

Strength of Evidence: Low
Strength of Option: Consensus ★☆☆☆ (downgraded)
Description: Evidence there is no supporting evidence, or limited level evidence was downgraded due to major concerns addressed in the EtD framework. In the absence of reliable evidence, the guideline work group is making a recommendation based on their clinical opinion.

DISCHARGE FACILITIES / DISPOSITION

Discharge to home, with or without home services, is associated with fewer adverse events compared to discharge to acute rehabilitation facility or skilled nursing facility.

Strength of Evidence: Low
Strength of Option: Limited ★★☆☆
Description: Evidence from one or more "Low" quality studies with consistent findings or evidence from a single "Moderate" quality study recommending for or against the intervention.

ROBOTICS IN TOTAL KNEE ARTHROPLASTY

Evidence suggests no significant difference in function, outcomes, or complications in the short term between robotic assisted and conventional total knee arthroplasty (TKA).

Strength of Evidence: High
Strength of Option: Limited ★★☆☆ (downgraded)
Description: Evidence from one or more "Low" quality studies with consistent findings or evidence from a single "Moderate" quality study recommending for or against the intervention.

ROBOTICS IN UNICOMPARTMENTAL KNEE ARTHROPLASTY

Evidence suggests no significant difference in function, outcomes, or complications in the short term between robotic assisted and conventional unicompartmental knee arthroplasty.

Strength of Evidence: High
Strength of Option: Limited ★★☆☆ (downgraded)
Description: Evidence from one or more "Low" quality studies with consistent findings or evidence from a single "Moderate" quality study recommending for or against the intervention.

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INTRODUCTION

OVERVIEW

This clinical practice guideline is based on a systematic review of published studies examining the surgical management of osteoarthritis (OA) of the knee in skeletally mature patients. It provides recommendations that will help practitioners integrate the current evidence into clinical practice, and it highlights gaps in the literature in need of future research. This guideline is intended to be used by surgeons and clinicians who incorporate surgical management of OA of the knee into their practice. This guideline also serves as an information resource for developers and applied users of clinical practice guidelines.

GOALS AND RATIONALE

The purpose of this clinical practice guideline is to evaluate the current best evidence associated with surgical management of osteoarthritis (OA) of the knee. Evidence-based medicine (EBM) standards advocate for use of empirical evidence by physicians in their clinical decision-making. To assist with access to the vast resources of information, a systematic review of the literature was conducted between September 2020 and January 2022. It highlights where there is good evidence, where evidence is lacking, and what topics future research will need to target in order to help facilitate evidence-based decision-making in the surgical management of patients with OA of the knee. AAOS staff methodologists assisted the physician/clinician work group in evaluating the existing literature so that they could formulate the following recommendations based on a rigorous systematic process.

Musculoskeletal care is provided in many different settings and by a variety of providers. We created this guideline as an educational tool to guide qualified physicians and clinicians in making treatment decisions that improve the quality and efficacy of care. This guideline should not be construed as including all possible methods of care or excluding acceptable interventions similarly directed at obtaining favorable outcomes. The final decision to use a specific procedure must be made after assessing all concerns presented by the patient and consideration of locality-specific resources.

INTENDED USERS

This guideline is intended to be used by orthopaedic surgeons and other healthcare providers managing knee OA. It serves as an information resource for medical practitioners. In general, practicing physicians and clinicians do not have the resources required to complete a project of comparable scope and duration involving the evaluation of an extensive literature base. In April 2019, the AAOS adopted the use of the GRADE Evidence-to-Decision Framework into its clinical practice guideline development methodology. This framework enables work group members to incorporate additional factors into the strength of each recommendation and move away from the rigidity of previous AAOS recommendation language stems. The AAOS intends for this guideline to assist treatment providers not only in making shared clinical decisions with their patients, but also in describing to patients and their loved ones why a selected intervention represents the best available course of treatment. This guideline is not intended for use as a benefits determination document. It does not cover allocation of resources, business and ethical considerations, and other factors needed to determine the material value of orthopaedic care. Users of this guideline may also want to consider the appropriate use criteria (AUC) related to the surgical management of knee OA.

PATIENT POPULATION

This guideline is intended for use with skeletally mature patients who have been diagnosed by a trained healthcare provider with knee osteoarthritis.

SCOPE

The scope of this guideline includes surgical interventions for symptomatic osteoarthritis of the knee as well as operative procedures less invasive than knee replacement (arthroplasty). It does not provide recommendations for patients diagnosed with rheumatoid arthritis, osteoarthritis of other joints, or other inflammatory arthropathies.

ETIOLOGY

Osteoarthritis arises from complex biological processes. which starts with abnormal tissue metabolism leading to cartilage degradation. Various cytokinin are responsible for the progressive destruction and remodeling of the joint through the stimulation of matrix-degrading enzymes, including the matrix metalloproteinases. The disease process ultimately involves cartilage, bone, synovium, ligaments, periarticular fat, meniscus, and muscle. Risk factors include trauma, overuse, and genetic predisposition.

INCIDENCE AND PREVALENCE

Two hundred and forty million people worldwide have symptomatic, activity-limiting OA. The incidence of knee osteoarthritis in the United States is estimated at 240 persons per 100,000 per year. Approximately 30% of individuals greater than 45 years old have radiographic evidence of knee OA (Zhang 2013). Worldwide prevalence of radiographically confirmed symptomatic knee OA is estimated to be 3.8% overall, increasing with age to over 10% in the population over the age of 60 (Palazzo 2016). Depending on studies, the prevalence of symptomatic radiographic knee OA ranges from 11-18% in women and 6-13% in men (Katz 2021).

BURDEN OF DISEASE

Osteoarthritis (of any joint) was the primary diagnosis for 23.7 million ambulatory care visits in 2013. Out of an estimated 32.5 million adults in America, 14% of that population suffered from symptomatic knee osteoarthritis between 2008 and 2014 (boneandjointburden.org). Lifetime costs for persons diagnosed with knee OA were $140,300 in 2015 (Losina 2015). As compared to males with OA, women have more severe radiographic findings and symptoms (Jeffery Katz 2021). Women represent 78% of the patients diagnosed with osteoarthritis between 2008 and 2014. Wage losses due to OA (knee and hip) amount to $65 billion and direct medical costs exceed $100 billion (Losina 2015).

EMOTIONAL AND PHYSICAL IMPACT

A third of patients with OA tend to have multiple comorbidities and have approximately 20% increased mortality as compared with age matched controls, partly due to decreased physical activity. Anxiety and depression are prevalent in approximately 19% of patients with osteoarthritis. Older adults with self-reported osteoarthritis visit their physicians more frequently and experience greater functional limitations than others in the same age group. The aging of the baby boomers, rise in rates of obesity, and greater emphasis on staying active suggest that the social and physical impact of knee osteoarthritis will continue to be widespread.

POTENTIAL BENEFITS, HARM, AND CONTRAINDICATIONS

Individuals with osteoarthritis of the knee often complain of joint pain, stiffness, and difficulty with purposeful movement. The aim of treatment is to provide pain relief and improve the patient's functioning. Most interventions are associated with some potential for adverse outcomes, especially if invasive or operative. Because the clinical research does not differentiate between the sexes, possible future research may result in a better understanding of how a patient's sex alters treatment benefits and harms. Contraindications vary widely by procedure. Reducing risks improves treatment efficacy and is accomplished through collaboration between patient and physician.

DIFFERENCES BETWEEN THE PRESENT AND PREVIOUS GUIDELINES

This updated clinical practice guideline replaces the second edition that was completed in 2015, "Surgical Management of Osteoarthritis of the Knee." This update considered the literature that we previously examined as well as the empirical evidence published since the 2015 guideline. In April 2019, the AAOS adopted the use of the GRADE Evidence-to-Decision Framework into its clinical practice guideline development methodology. This Framework enables work group members to incorporate additional factors into the strength of each recommendation and move away from the rigidity of previous AAOS recommendation language stems. The complete listing of inclusion criteria for this guideline is detailed in the section, "Study Selection Criteria," (eAppendix 1).

METHODS

The methods used to perform this systematic review were employed to minimize bias and enhance transparency in the selection, appraisal, and analysis of the available evidence. These processes are vital to the development of reliable, transparent, and accurate clinical recommendations. To view the full AAOS clinical practice guideline methodology please visit https://www.aaos.org/quality/research-resources/methodology/.

This clinical practice guideline evaluates the surgical management of osteoarthritis of the knee. The AAOS approach incorporates practicing physicians (clinical experts) and methodologists who are free of potential conflicts of interest relevant to the topic under study, as recommended by clinical practice guideline development experts.

This clinical practice guideline was prepared by the AAOS Surgical Management of Osteoarthritis of the Knee Guideline physician development group (clinical experts) with the assistance of the AAOS Clinical Quality and Value (CQV) Department (methodologists). To develop this clinical practice guideline, the clinical practice guideline development group held an introductory meeting on September 19th, 2020, to establish the scope of the clinical practice guideline. As physician experts, the clinical practice guideline development group defined the scope of the clinical practice guideline by creating PICO Questions (i.e., population, intervention, comparison, and outcome) that directed the literature search. The AAOS Medical Librarian created and executed the search (see Appendix III for search strategy).

LITERATURE SEARCHES

The systematic review begins with a comprehensive search of the literature. Articles considered were published prior to the start date of the search in a minimum of three electronic databases; PubMed, EMBASE, and the Cochrane Central Register of Controlled Trials. The medical librarian conducts the search using key terms determined from the guideline development group's PICO questions. The initial literature search was conducted December 4th, 2020 and a final literature search was conducted on September 24th, 2021.

A CQV methodologist will review/include only primary literature but will supplement the electronic search with a manual search of the bibliographies of secondary literature sources, such as systematic reviews, as available. The methodologist will then evaluate all recalled articles for possible inclusion based on the study selection criteria and will summarize the evidence for the guideline work group who assist with reconciling possible errors and omissions.
A study attrition diagram is provided in the appendix of each document that details the numbers of identified abstracts, recalled and selected studies, and excluded studies that were evaluated in the CPG. The search strategies used to identify the abstracts is also included in the appendix of each CPG document.

DEFINING THE STRENGTH OF RECOMMENDATION

Judging the quality of evidence is only a steppingstone towards arriving at the strength of a CPG recommendation. The strength of recommendation also takes into account the quality, quantity, and the trade-off between the benefits and harms of a treatment, the magnitude of a treatment's effect, and whether data exists on critical outcomes.

Strength of recommendation expresses the degree of confidence one can have in a recommendation. As such, the strength expresses how possible it is that a recommendation will be overturned by future evidence. It is very difficult for future evidence to overturn a recommendation that is based on many high quality randomized controlled trials that show a large effect. It is much more likely that future evidence will overturn recommendations derived from a few small retrospective comparative studies. Consequently, recommendations based on the former kind of evidence are given a "strong" strength of recommendation and statement based on the latter kind of evidence are presented as options to the practicing clinician, rather than a directional recommendation, with either a "limited" strength or, in the event of no supporting or only conflicting evidence, a "consensus" strength.

VOTING ON THE RECOMMENDATIONS

The recommendations and their strength were voted on by the guideline development group members during the final meeting. If disagreement between the guideline development group occurred, there was further discussion to see whether the disagreement(s) could be resolved.

Recommendations were approved and adopted in instances where a simple majority (60%) of the guideline development group voted to approve; however, the guideline development group had consensus (100% approval) when voting on every recommendation for this guideline. Any recommendation strength upgrade or downgrade based on the Evidence-to-Decision Framework requires a super majority (75%) approval of the work group.

INTERPRETING THE STRENGTH OF EVIDENCE

Table I. Level of Evidence Descriptions

Strength	Overall Strength of Evidence	Description of Evidence Quality	Strength Visual
Strong	Strong or Moderate	Evidence from two or more "High" quality studies with consistent findings for recommending for or against the intervention. Or Rec is upgrade from Moderate using the EtD framework.	
Moderate	Strong, Moderate or Limited	Evidence from two or more "Moderate" quality studies with consistent findings, or evidence from a single "High" quality study for recommending for or against the intervention. Or Rec is upgraded or downgraded from Limited or Strong using the EtD framework.	
Limited	Limited or Moderate	Evidence from one or more "Low" quality studies with consistent findings or evidence from a single "Moderate" quality study recommending for or against the intervention. Or Rec is downgraded from Strong or Moderate using the EtD Framework.	
Consensus*	No Evidence	There is no supporting evidence, or higher quality evidence was downgraded due to major concerns addressed in the EtD framework. In the absence of reliable evidence, the guideline work group is making a recommendation based on their clinical opinion.	

Table II. Interpreting the Strength of a Recommendation or Option

Strength of Recommendation	Patient Counseling (Time)	Decision Aids	Impact of Future Research
Strong	Least	Least Important, unless the evidence supports no difference between two alternative interventions	Not likely to change
Moderate	Less	Less Important	Less likely to change
Limited	More	Important	Change possible/anticipated
Consensus	Most	Most Important	Impact unknown

REVIEW PERIOD

Following the final meeting, the CPG draft undergoes a 3-week review period for additional input from external content experts. Written comments are provided on the structured review form. All reviewers are required to disclose their conflicts of interest.

Specialty societies relevant to the topic are solicited for nominations of individual reviewers approximately six weeks before the final meeting. The review period is announced as it approaches, and others interested are able to volunteer to review the draft. The chairs of the guideline work group review the draft of the guideline prior to dissemination.

Some specialty societies (both orthopaedic and non-orthopaedic) ask their evidence-based practice (EBP) committee to provide review of the guideline. The organization is responsible for coordinating the distribution of our materials and consolidating their comments onto one form. The chair of the external EBP committees provides disclosure of their conflicts of interest (COI) and manages the potential conflicts of their members.

Again, the AAOS asks for comments to be assembled into a single response form by the specialty society and for the individual submitting the review to provide disclosure of potentially conflicting interests. The review stage gives external stakeholders an opportunity to provide evidence-based direction for modifications that they believe have been overlooked. Since the draft is subject to revisions until its approval by the AAOS Board of Directors as the final step in the guideline development process, confidentiality of all working drafts is essential.

The CPG is also provided to members of the AAOS Board of Directors (BOD), members of the Research and Quality Council (RQC), members of the Board of Councilors (BOC), and members of the Board of Specialty Societies (BOS) and members of the Committee on Evidence-Based Quality and Value (EBQV) for review and comment. The CPG is automatically forwarded to the AAOS BOD, RQC, and EBQV so that they may review it and provide comment prior to being asked to approve the document. Based on these bodies, over 200 commentators have the opportunity to provide input into each CPG.

The chairs of the guideline work group, the manager of the AAOS CQV unit, and the Director of AAOS CQV draft the initial responses to comments that address methodology. These responses are then reviewed by the chair and co-chair, who respond to questions concerning clinical practice and techniques. All comments received and the initial drafts of the responses are also reviewed by all members of the guideline development group. All proposed changes to recommendation language as a result of the review period are based on the evidence. Final revisions are summarized in a report that is provided alongside the guideline document throughout the remainder of the approval processes and final publication.

The AAOS believes in the importance of demonstrating responsiveness to input received during the review process and welcomes the critiques of external specialty societies. Following final approval of the guideline, all individual responses are posted on our website http://www.aaos.org/quality with a point-by-point reply to each non-editorial comment. Reviewers who wish to remain anonymous notify the AAOS to have their names de-identified; their comments, our responses, and their COI disclosures are still posted.

THE AAOS CPG APPROVAL PROCESS

This final clinical practice guideline draft must be approved by the AAOS Committee on Evidence Based Quality and Value, and subsequently the AAOS Research and Quality Council, and the AAOS Board of Directors. These decision-making bodies are described in the Anterior Cruciate Ligament Injury CPG eAppendix. Their charge is to approve or reject its publication by majority vote.

REVISION PLANS

This clinical practice guideline represents a cross-sectional view of current treatment and may become outdated as new evidence becomes available. This clinical practice guideline will be revised in accordance with new evidence, changing practice, rapidly emerging treatment options, and new technology. This clinical practice guideline will be updated or withdrawn in five years.

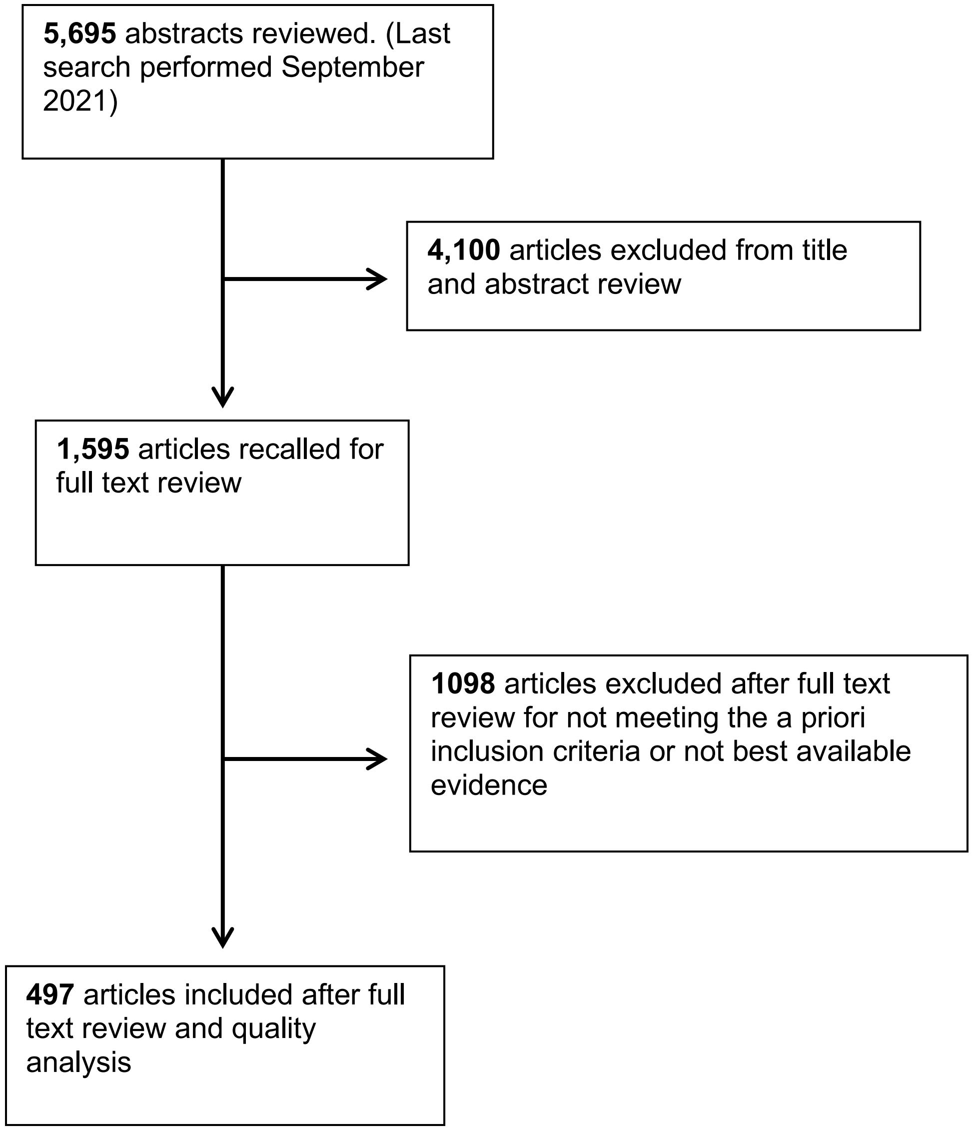
CPG DISSEMINATION PLANS

The primary purpose of the present document is to provide interested readers with full documentation of the best available evidence for various procedures associated with the topic of this review. Publication of most clinical practice guidelines is announced by an Academy press release, articles authored by the clinical practice guideline development group and published in the Journal of the American Academy of Orthopaedic Surgeons, and articles published in AAOS *Now*. Most clinical practice guidelines are also distributed at the AAOS Annual Meeting in the Resource Center. he final guideline recommendations and their supporting rationales will be hosted on www.OrthoGuidelines.org.

Selected clinical practice guidelines are disseminated by webinar, the AAOS Learning Management Systems (LMS), Media Briefings, and by distributing them at relevant Continuing Medical Education (CME) courses.

1

STUDY ATTRITION FLOWCHART



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DRAINS

Drains should not be used with total knee arthroplasty because there is no significant difference in complications or outcomes.

Strength of Evidence: Strong

Strength of Recommendation: Moderate ★★★☆ (downgraded)

Evidence from two or more “Moderate” quality studies with consistent findings, or evidence from a single “High” quality study for recommending for or against the intervention. Also, higher strength evidence can be downgraded to limited due to major concerns addressed in the EtD Framework.

Rationale

This recommendation has been downgraded due to potential benefits to patients. Four high quality studies (Zhou 2017, Li 2011, Esler 2003, and Omonbude 2010) and two moderate quality studies (Maniar 2019, Jenny 2001) were reviewed. There is no difference in composite functional score between two groups. Zhou (2017) showed that despite an increase in range of motion by 7.1 degrees at discharge and 5.2 degrees at six months in patents with drain, patients without drain after tourniquet-free TKA were associated with less decrease in Hb, less use of hematopoietic medication, earlier time to ambulation, and shorter length of stay in the early postoperative period. Maniar (2019) demonstrated reduced opioid consumption in the first 6 hours but no difference in opioid consumption at 6-24 hours and no difference in patient outcome at 1 year. Elser (2003) showed increased blood loss in patients with drain however there was no statistical difference in the swelling, pain score, time at which flexion was regained, the need for manipulation, or in the incidence of infection. Omonbude (2010) demonstrated that there was increased hematoma in no-drain group which was clinically not significant because it did not result in difference in post-operative hemoglobin. Overall, the studies have been unable to provide evidence to support the routine use of a closed suction drain in TKA.

Benefits/ Harms of Implementation

Drains may benefit a slight decrease in swelling and increase in range of motion, but it can interfere with early mobilization. There is a possibility of increased manipulation in patients without drains. Patients with drains could result in a longer length of stay leading to increased cost of care.

Outcome Importance

Placement of drains does not improve functional outcome. The overall benefit does not appear sufficient to advise use.

Cost Effectiveness/ Resource Utilization

Drain utilization may increase the cost of care due to the possibility of increased length of stay.

Acceptability

Literature supports that use of drains does not improve outcome or decrease complications. This recommendation should be acceptable to medical providers. It is important to emphasize that this recommendation applies to primary knee arthroplasty. Physicians should use their judgment in patients with revision knee arthroplasty.

Feasibility
There are no significant barriers to implementation of recommendation. Eliminating drain use will decrease cost and improved patient experience.

Future Research
There is a possibility that slightly better range of motion in patients with drains could decrease manipulation under anesthesia. A well-designed prospective study would be helpful to see if the use of drains could decrease the incidence of arthrofibrosis. Tranexamic acid has been very effective in reducing blood loss after knee arthroplasty. Further research is needed to see if tranexamic acid use alone can reduce the hematoma formation and increase range of motion which will completely eliminate the perceived need for use of the drain.

CEMENTLESS FIXATION: CEMENTED FEMORAL &TIBIAL COMPONENTS VS. CEMENTLESS FEMORAL & TIBIAL COMPONENTS

Cemented femoral and tibial components or cementless femoral and tibial components in knee arthroplasty show similar rates of functional outcomes, complications, and reoperations, and conflicting evidence in comparative studies.

Strength of Evidence: Strong

Strength of Recommendation: Moderate ★★★☆ (downgraded)

Evidence from two or more "Moderate" quality studies with consistent findings, or evidence from a single "High" quality study for recommending for or against the intervention. Also, higher strength evidence can be downgraded to limited due to major concerns addressed in the EtD Framework.

Rationale

In general, the body of evidence was notable for heterogeneity in study design, comparative study groups (including cementless, hybrid, and cemented fixation), and confounding results. As such, the recommendation has been downgraded.

There were twelve high quality studies (Demey 2011, Fernandez-Fairen 2013, Kim 2014, Lizaur-Utrilla 2014, Kendrick 2015, Pulido 2015, Van Hamersveld 2017, Nam 2019, Batailler 2020, Hampton 2020, Kim 2020, Murylev 2020) and seventeen low quality studies (Khaw 2002, Carlsson 2005, Baker 2007, Park 2011, Pandit 2013, Bagsby 2016, Kerens 2017, Boyle 2018, Nugent 2019, Manoli 2019, Deroche 2020, Irmola 2020, Lizaur-Utrilla 2020, Mohammad 2020, Gifstad 2021, Silverstein 2021, Quispel 2021) evaluating the use of various combinations of cemented versus cementless fixation of components (tibia, femur, patella) in total knee arthroplasty.

Registry data from the American Joint Replacement Registry (AJRR 2020) has shown that fully cementless fixation was found to have a significant decrease in cumulative percent revision compared to cemented fixation in males ≥65 years of age (HR=0.755, CI 0.631-0.905) and in patients <65 years of age reported to AJRR (HR=0.785, CI 0.664-0.927). Literature comparing complications and revision rates between fully cemented and uncemented fixation included one high quality study (Kim 2020) and nine low quality studies (Bagsby 2016, Kerens 2017, Boyle 2018, Manoli 2019, Nugent 2019, Irmola 2020, Deroche 2020, Mohammad 2020, Quispel 2020). Studies varied with respect to follow-up, ranging from 53 months to 25 years. Irmola (2020) showed a higher rate of all-cause revisions at 5 years in the cementless group, and Nugent (2019) showed higher rates of revision in the cementless group at 10 years. Two studies (Nugent 2019, Mohammad 2020) showed a significantly increased rate of fracture and revision in the cementless group at 5 and 10 years, respectively. Mohammad (2020) also showed higher rates of aseptic loosening in the cemented groups. However, Manoli (2019) and Bagsby (2016) showed higher revision rates with cemented fixation at 90 days and 6 years, respectively. Nevertheless, across comparative groups, no major differences existed between cemented and cementless fixation in any other studies with respect to rates of complications and re-operations, including studies with longer follow up.

Only small differences were seen with respect to outcome measures, depending on the particular comparative groups, length of follow up, and scoring instruments. Three high quality studies (Kim 2020, Hampton 2020, Murylev 2020) showed improved functional scores at 1 year and 25 years postoperatively in the uncemented group. Two low quality studies (Nugent 2019, Deroche 2020) showed better functional scores with cementless fixation at 6 months, 2 years, and 5 years. However, three high quality studies (Kendrick 2015, Van Hamersveld 2017, Nam 2019) and five low quality studies (Kerens 2017, Stempin 2017, Karachalios 2018, Mohammad 2020, Pacoret 2020) showed no significant difference in functional scores between groups at short-, mid-, and long-term follow-up, respectively.

Benefits/ Harms of Implementation

There are no known harms associated with implementing this recommendation. The decision to use cementless versus cementless fixation may be influenced by individual patient situations. The practitioner should be aware of the advantages and disadvantages of a variety of treatment methods. For example, intra-operative fracture during component insertion or failure of ingrowth may be of concern with certain cementless designs in patients with poor bone quality.

Future Research

Continued long term comparative studies between modern cemented and cementless component fixation options in knee arthroplasty will help to further define the utility of these component types, durability of fixation, and effect of evolving component designs (e.g., modular and monolithic) on patient-reported outcomes. Certainly, newer fixation materials (e.g., porous metals) should be evaluated in long term follow up. Identifying patient-specific factors that may inform the decision to utilize a particular fixation technique, or to avoid complications associated with particular fixation strategies, is important. Registry data. Long term studies (greater than ten years clinical follow up) should inform durability of specific components and may serve to analyze implant-specific complications and revision risk. Given some variability in the patient-reported outcome measures between treatment groups, particularly in high quality studies, more clinical data may discern subtle differences in clinical outcomes based on the use of cemented or cementless component fixation. Issues of cost and cost-effectiveness should also be incorporated into future clinical studies.

CEMENTLESS FIXATION: ALL CEMENTED COMPONENTS VS. HYBRID FIXATION (CEMENTLESS FEMORAL COMPONENT)

Cemented femoral and tibial components or hybrid fixation (cementless femur) in total knee arthroplasty show similar functional outcomes and rates of complications and reoperations.

Strength of Evidence: Strong

Strength of Recommendation: Moderate ★★★☆ (downgraded)

Evidence from two or more "Moderate" quality studies with consistent findings, or evidence from a single "High" quality study for recommending for or against the intervention. Also, higher strength evidence can be downgraded to limited due to major concerns addressed in the EtD Framework.

Rationale

In general, the body of evidence was notable for heterogeneity in study design and comparative study groups (including cementless, hybrid, and cemented fixation). As such, the recommendation has been downgraded.

There were twelve high quality studies (Demey 2011, Fernandez-Fairen 2013, Kim 2014, Lizaur-Utrilla 2014, Kendrick 2015, Pulido 2015, Van Hamersveld 2017, Nam 2019, Batailler 2020, Hampton 2020, Kim 2020, Murylev 2020) and seventeen low quality (Khaw 2002, Carlsson 2005, Baker 2007, Park 2011, Pandit 2013, Bagsby 2016, Kerens 2017, Boyle 2018, Nugent 2019, Manoli 2019, Deroche 2020, Irmola 2020, Lizaur-Utrilla 2020, Mohammad 2020, Gifstad 2021, Silverstein 2021, Quispel 2021) evaluating the use of various combinations of cemented versus cementless fixation of components (tibia, femur, patella) in total knee arthroplasty.

One high quality (Batailler 2020) and four low quality studies (Nugent 2019, Irmola 2020, Lizaur-Utrilla 2020, Quispel 2021) specifically compared cemented and hybrid fixation. Nugent (2019) showed significantly better functional outcomes and lower rates of revision with all cemented fixation, and Lizaur-Utrilla (2020) showed significantly better functional outcomes and lower rates of revision with hybrid fixation. Additional low quality studies showed no significant difference in revision rates between the two fixation types. Like the cemented versus cementless comparisons, only small differences were seen with respect to outcome measures, depending on the particular study comparative groups, length of follow up, and scoring instruments.

Benefits/ Harms of Implementation

There are no known harms associated with implementing this recommendation. The decision to use cementless versus cementless fixation may be influenced by particular patient situations. The practitioner should be aware of the advantages and disadvantages of particular treatments methods. For example, intra-operative fracture during component insertion or failure of ingrowth may be of concern with certain cementless designs in patients with poor bone quality.

Future Research

Continued long term comparative studies between modern cemented and cementless component fixation options in knee arthroplasty will help to further define the utility of these component types, durability of fixation, and effect of evolving component designs (e.g., modular and monolithic) on patient-reported outcomes. Certainly, newer fixation materials (e.g., porous metals) should be evaluated in long term follow up. Identifying patient-specific factors that may inform the decision to utilize a particular fixation technique, or to avoid complications associated with particular fixation strategies, is important. Registry data and long-term studies (greater than ten years clinical follow up) should inform durability of particular components and may serve to analyze implant-specific complications and revision risk. Given some variability in the patient-reported outcome measures between treatment groups, particularly in high quality studies, more clinical data may discern subtle differences in clinical outcomes based on the use of cemented or cementless component fixation. Issues of cost and cost-effectiveness should also be incorporated into future clinical studies.

UNICOMPARTMENTAL VS. TOTAL KNEE ARTHROPLASTY

The practitioner can use unicompartmental arthroplasty vs total knee arthroplasty for patients with predominantly medial compartment osteoarthritis, as evidence reports improved patient reported and functional outcomes in the short term; however, long-term rates of revision in unicompartmental knee arthroplasty may be higher than total knee arthroplasty.

Strength of Evidence: Strong

Strength of Recommendation: Moderate ★★★☆ (downgraded)

Evidence from two or more "Moderate" quality studies with consistent findings, or evidence from a single "High" quality study for recommending for or against the intervention. Also, higher strength evidence can be downgraded to limited due to major concerns addressed in the EtD Framework.

Rationale

This recommendation has been downgraded due to differing outcomes at long term versus short term. Unicompartmental knee arthroplasty (UKA) provides similar or higher patient-reported outcome measure scores of pain, function, and performance compared to total knee arthroplasty (TKA) at short to mid-term follow up when performed for the appropriate indication of isolated unicompartmental osteoarthritis. Among this patient population, UKA was also found to be associated with a higher forgotten joint score. Notably, performing UKA in this population is associated with the advantage of shorter operative time, shorter hospital stay, lower intraoperative estimated blood loss, lower postoperative transfusions, greater postoperative range of motion, higher level of activity at time of discharge, and mitigated overall minor and major 30-day complication rates. Some long-term outcomes in favor of TKA were observed; Kulshrestha (2017) found functional outcomes in favor of TKA at 2 years, Ellis (2021) found TKA was associated with less disease progression, and van der List (2016, 2017) found that 3-year post op WOMAC scores favored TKA patients.

Benefits/ Harms of Implementation

Performing UKA in an appropriately selected population affords the advantages of mitigated invasiveness, shorter operative time, length of stay, greater preservation of bone stock, knee biomechanics that are more aligned with those of the native knee and similar or superior pain and function metrics compared to TKA. Conversely, the main concern is the higher revision rates, especially at in mid-to-long term follow-up. It should also be noted that UKA to TKA conversions have been observed to be inferior in outcome versus primary total knee arthroplasty (Pearse 2012).

Cost Effectiveness/ Resource Utilization

Short term metrics indicate superior cost-effectiveness for UKA compared to TKA in appropriately selected patients. Such a difference stems from the shorter operative time, length of hospital stay, and perioperative complications in UKA versus TKA while affording similar improvement in patient-reported pain, activity and functional outcomes. A recent study (Shankar 2016) demonstrated that hospital direct costs were lower for UKA ($7893 vs. $11,156; $p < 0.001$) as were total costs (hospital direct costs plus overhead; $11,397 vs. $16,243; $p < 0.001$). Supply costs and implant costs were similarly lower for UKA ($701 vs. $781; $p < 0.001$, and $3448 vs. $5006; $p < 0.001$). This advantage extended up to the 5-year follow up according to a recent randomized controlled trial. Further investigations are required to evaluate long term cost effectiveness.

Acceptability and Feasibility

Overall, UKA has fair acceptability and feasibility among surgeons and patients. American Joint Replacement Registry (AJRR) data indicates diminishing rates reaching 2.7% of all primary knee arthroplasties reported to AJRR for 2017. However, such rates rebounded with numbers increasing to 4.2% in 2020 (AJRR 2020).

Future Research

Recent AJRR data highlighting revision risk curves show that when stratified by sex, males 65 years and above had UKA revision rates that were comparable to their TKA counterparts. Conversely, females of the same age group had statistically and clinically significant higher rates of revision UKA up to 108 months compared to TKA. Such sex-based difference after age adjustment warrants further research into factors influencing UKA survivorship including activity levels, bone quality and other patient determinants. This will aid in identifying the optimal patient subset for which UKA would be recommended for greatest survivorship and functional benefit.

Additional References:

Pearse, A. J., Hooper, G. J., Rothwell, A. G., & Frampton, C. (2012). Osteotomy and unicompartmental knee arthroplasty converted to total knee arthroplasty: data from the New Zealand Joint Registry. *The Journal of Arthroplasty*, *27*(10), 1827-1831.

Shankar S, Tetreault MW, Jegier BJ, Andersson GB, Della Valle CJ. A cost comparison of unicompartmental and total knee arthroplasty. Knee. 2016;23(6):1016-1019. doi:10.1016/j.knee.2015.11.012

PERIPHERAL NERVE BLOCKADE (PNB)

Peripheral nerve blockades for total knee arthroplasty lead to decreased postoperative pain and opioid requirements with no difference in complications or outcomes.

Strength of Evidence: Strong

Strength of Recommendation: Strong ★★★★

Evidence from two or more "High" quality studies with consistent findings for recommending for or against the intervention.

Rationale

There were nine high quality studies (Chan 2012, Liu 2014, Sahin 2014, Hinarejos 2016, Ortiz-Gomez 2017, Biswas 2018, Leung 2018, Rousseau-Saines 2018, Dimaculangan 2019) and one low quality study (Wyatt 2015) evaluating whether the use of peripheral nerve blockade reduces complications or improves outcomes in adult patients undergoing knee arthroplasty compared to no peripheral nerve block use. The included literature investigated Femoral Nerve Block (Chan 2012, Sahin 2014, Hinarejos 2016, Ortiz-Gomez 2017, Dimaculangan 2019, Wyatt 2015), Adductor Nerve Block (Leung 2018, Rousseau-Saines 2018, Ortiz-Gomez 2017), Sciatic Block (Liu 2014, Hinarejos 2016), and Lumbar Plexus Block (Liu 2014).

Four high quality studies (Chan 2012, Liu 2014, Hinarejos 2016, Rousseau-Saines 2018) demonstrated significantly lower VAS pain scores, and three high quality studies (Biswas 2018, Rousseau-Saines 2018, Dimaculangan 2019) demonstrated significantly lower opioid requirements during the postoperative period when peripheral nerve blockade was utilized compared to parenteral opioids alone.

Three high quality (Sahin 2014, Biswas 2018, Rousseau-Saines 2018) studies demonstrated no difference in adverse effects (nausea, vomiting, pruritis, urinary retention) between peripheral nerve blockade and no block.

Two high quality (Leung 2018, Dimaculangan 2019) studies and one low quality (Wyatt 2015) study showed no significant difference in early postoperative range of motion compared to no block. However, one high quality study (Chan 2012) demonstrated significantly better overall range-of-motion and a reduction in opioid-related side effects with the use of peripheral nerve blockade when compared to no peripheral nerve block use. Another high quality study (Liu 2014) demonstrated that peripheral nerve block use improved the Quality of Recovery (e.g., Emotive, Nociceptive and Cognitive domains) during the immediate postoperative period.

Benefits/ Harms of Implementation

The risks associated with peripheral nerve blockade may include bleeding, infection, and associated neural injury. Although rare, these potential risks need to be balanced with the documented benefits of peripheral nerve blockade. Depending upon clinical circumstances, peripheral nerve blockade may also be associated with postoperative motor weakness. Under these conditions, care must be taken to minimize the risk of patient falls or delayed mobilization during the hospitalization.

Future Research

Additional prospective studies may be needed to evaluate the long-term (>24-hour) analgesic benefits of peripheral nerve blockade, as well as their impact on functional outcomes. In addition, higher quality studies are also needed to compare specific peripheral nerve block techniques and to compare other modalities of perioperative analgesia (e.g., periarticular injection, neuraxial anesthesia). Future studies comparing the effectiveness of a single perioperative peripheral nerve block versus continuous infusion should be performed for standard outcomes. The scope of this guideline does not include the combination of. Future guidelines should investigate the combination of PNB and Periarticular Local Infiltration (PAI) / Periarticular Block (PAB), as it was not included in the scope of this guideline.

PERIARTICULAR LOCAL INFILTRATION

Periarticular injections used in total knee arthroplasty lead to decreased postoperative pain and opioid requirements.

Strength of Evidence: Strong

Strength of Recommendation: Strong ★★★★

Evidence from two or more "High" quality studies with consistent findings for recommending for or against the intervention.

Rationale

We reviewed eight randomized clinical trials that represented the best available evidence. All studies were randomized clinical trials of high quality. These articles assess the ability of a periarticular block (PAB) to reduce postoperative pain after a TKA. One study (Affas 2011) looked at PAB and a femoral block. Three studies (Busch 2006, Fitz 2021, Ikeuchi 2013) looked at PAB compared to control. One study (Chia 2013) looked at adding varying amounts of corticosteroids to the PAB. One study (Kulkarni 2019) looked at PAB and adductor canal block. Two studies (Ukai 2020 and Tsukada 2014) looked at PAB and epidurals. Compared with epidural analgesia, periarticular injection offers better postoperative pain relief, earlier recovery of knee flexion angle, and lower incidence of nausea. PAI achieves better pain control as compared to ACB in patients undergoing unilateral TKA. Overall pain scores were low in the study involving local infiltration catheters and PAB (Fitz 2020). An intraarticular pain catheter in conjunction with a multimodal approach with intra-operative PAB after TKA does not improve 48-hour pain scores or opioid consumption compared with PAI alone in this randomized controlled trial. The study involving varying levels of corticosteroids assessed two different doses of triamcinolone acetate (N = 42 in each group) added to local anesthetic in TKA for osteoarthritis (Chia 2013). There were no significant differences in pain scores or ROM between the control and corticosteroid groups. Differences in secondary outcomes were also non-significant. Peri-articular corticosteroids do not appear to be of benefit in TKA. In a study involving periarticular injection versus no injection (Busch 2006), the patients who had received the injection used significantly less patient-controlled analgesia over the first twenty-four hours after the surgery. These patients also had favorable patient satisfaction and pain during activity scores in the post-anesthetic-care unit and four hours post operatively. Affas (2011) showed periarticular infiltration led to slightly lower average pain at rest compared to continuous femoral block. Both LIA and femoral block provide good analgesia after TKA. LIA may be considered superior to femoral block since it is cheaper and easier to perform.

Benefits/ Harms of Implementation

There is significant benefit with pain control with the use of PAB.

Outcome Importance

The outcome of PAB versus no PAB, as well as other forms of anesthesia, is better.

Cost Effectiveness / Resource Utilization

Several high quality studies show cost effectiveness and ease of performing with PAB compared with other forms of anesthesia such as femoral nerve block.

Acceptability

The recommendation comes with high acceptability. There is a low risk to benefit ratio. There are several high quality studies showing the benefit and cost effectiveness of PABs.

Feasibility
The feasibility with this recommendation is high. PAB has been shown to be easier to perform compared to other forms of analgesia.

Future Research
Future research would include comparing different types of PABs. Future guidelines should investigate the combination of Peripheral Nerve Block (PNB) and Periarticular Local Infiltration (PAI) / Periarticular Block (PAB), as it was not included in the scope of this guideline.

TRANEXAMIC ACID

In patients with no known contraindications, tranexamic acid (TXA) should be used because its use decreases postoperative blood loss, postoperative drain collection, and reduces the necessity of postoperative transfusions following total knee arthroplasty (TKA).

Strength of Evidence: Strong

Strength of Recommendation: Strong ★★★★

Evidence from two or more "High" quality studies with consistent findings for recommending for or against the intervention.

Rationale

Intravenous administration of tranexamic acid significantly reduces blood loss, drainage collection, and transfusion requirement postoperatively. Ten high quality studies (Sahin 2019, Lacko 2017, Sun 2017, Tzatzairis 2016, Drosos 2016, Aguilera 2015, Ye 2019, Keyhani 2016, Seo 2013, Molloy 2007) have demonstrated reduced blood loss postoperatively.

Intra-articular injection of tranexamic acid reduces blood loss postoperatively. Ten high quality studies (Lei 2020, Sahin 2019, Wong 2015, Yang 2015, Li 2018, Seo 2013, Sa Ngasoongsong 2013, Sarzaeem, 2014, Antinolfi, 2013, Gautam, 2011) demonstrated reduced blood loss postoperatively after intra-articular injection of tranexamic acid. Three high quality studies (Digas 2015, Oztas 2015, Sa-Ngasoongsong 2011) demonstrated reduced post-operative drainage in addition to reduced blood loss. Studies published by Seo (2013), Digas (2015) and Lacko (2017) demonstrated reduced blood transfusion.

Five high quality studies have reported reduced blood loss after topical use of Tranexamic acid. However, the term Intra-articular versus topical was used interchangeably. Drosos (2016) and Georgiadis (2013) used a topical administration technique in which the drug was poured into the joint. Tzatzairis (2016), Aguilera (2015) and Keyhani (2016) described their use as topical, but the drug was injected into the joint space.

Benefits/ Harms of Implementation

Reduction in blood loss and blood transfusion will improve patient outcome. However, there are statistically non-significant reports of complication of deep vein thrombosis by three high quality studies (Yang 2015, Oztas 2015, Seo 2013). Yang (2015) and Seo (2013) also reported increased pulmonary embolism. There were reports of wound healing (Wang 2015) and would hematoma (Yang 2015). All the reports of complications were either statistically insignificant high-quality studies or low-quality studies. Therefore, the benefit of TXA administration outweighs the risk.

Outcome Importance

Reduction in blood loss and blood transfusion is a significant benefit directly to patients. In addition, health care settings will benefit from the savings and efficiency of avoiding additional care.

Cost Effectiveness / Resource Utilization

While the cost of different administration routes of TXA (oral versus IV versus topical or IA) differ, TXA is economical and has low resource utilization in in-patient and outpatient settings.

Acceptability

TXA use, with the resulting reduction in blood loss and blood transfusion, is desirable and acceptable.

Feasibility
TXA has been used extensively and is deemed feasible.

Future Research
Contraindication for tranexamic acid in TKA has not yet been very well defined and should be the subject of future research. Tranexamic acid is still an FDA "off label" that can be used in arthroplasty. FDA contraindications for TXA's approved usages include patients with acquired defective color vision, patients with subarachnoid hemorrhage, patients with active intravascular clotting, and in patients with hypersensitivity to tranexamic acid (accessdata.fda.gov). Most of the studies have used thromboembolic disorders, cerebrovascular conditions, and cardiovascular disorder as an exclusion criterion.

SURGICAL NAVIGATION

There is no difference in outcomes, function, or pain between navigation and conventional techniques.

Strength of Evidence: Strong

Strength of Recommendation: Moderate ★★★☆ (downgraded)

Evidence from two or more "Moderate" quality studies with consistent findings, or evidence from a single "High" quality study for recommending for or against the intervention. Also, higher strength evidence can be downgraded to limited due to major concerns addressed in the EtD Framework.

Rationale

This recommendation has been downgraded due to unique patient populations and associated costs. The advantages of surgical navigation remain unclear with a majority of studies for outcomes, function, and pain showing no difference when compared to conventional TKA. Seven high quality studies for KSS (Yu 2020, Kim 2018, Kim 2017, Todesca 2017, Blyth 2015, Yan 2015, Tsuda 2021), six high quality studies for WOMAC (Hsu 2019, Kim 2018, Kim 2017, Todesca 2017, Cip 2014, Seon 2009), three high quality studies for OKS (Yu 2020, Yan 2015, Tsuda 2021), eight high quality studies for KSS Function (Selvanayagam 2019, Kim 2018, Kim 2017, Todesca 2017, Blyth 2015, Yan 2015, Tsuda 2021, Thiengwittayaporn 2013), six high quality studies for range of motion (Kim 2018, Kim 2017, Blyth 2015, Yan 2015, Cip 2014, Seon 2009), and four high quality studies for pain (Blyth 2015, Kim 2018, Kim 2017, Hsu 2019) showed no difference between surgical navigation and conventional TKA.

The studies comparing blood loss were heterogenous and reporting methods varied, or details were not given. Two high quality studies (Hsu 2019, Ikawa 2017) were in favor of surgical navigation and two high quality studies (Thiengwittayaporn 2013, Kim 2007) showed no difference for blood loss. There were limited studies regarding complications with two high quality studies (Thiengwittayaporn 2013, Blakeney 2011) showing no difference. Lastly, there was one high quality study (Kim 2018) with a 15-year follow up that showed no difference in radiographic parameters, aseptic loosening, or survivorship between surgical navigation and conventional TKA.

As far as operative time, the majority of studies were in favor of conventional TKA. Four high quality studies (Tsuda 2021, Lutzner 2008, Chin 2005, Blakeney 2011) showed longer operative times and one high quality study (Ikawa 2017) showed longer femoral resection time with surgical navigation.

*KSS = Knee Society Score, WOMAC = Western Ontario and McMaster University osteoarthritis Index, OKS = Oxford Knee Score

Benefits/ Harms of Implementation

Potential benefits for surgical navigation are for specific cases of deformity correction due to trauma or previous retained hardware where conventional instruments cannot be used. Although navigation may result in fewer outliers, increased operative times may lead to increased costs. Furthermore, reliance on computer technology increases the potential to having to abort in the presence of a malfunction.

Outcome Importance

The outcomes between surgical navigation and conventional instruments showed no difference.

Cost Effectiveness / Resource Utilization

Current studies show increased cost to use surgical navigation. However, newer, more cost-effective techniques have been developed and newer studies may change their cost effectiveness and utilization.

Acceptability
The recommendation comes with varying acceptability. Some surgeons may prefer to use surgical navigation even though the outcomes are no different from conventional instruments.

Feasibility
Since there are a number of studies that report no difference in outcomes between surgical navigation and conventional instruments, it may be more feasible to work the downsides of using the technology. Specifically, work on improving efficiency to decrease operating room times and using more cost-effective technology.

Future Research
Since there are multiple studies showing no difference in patient outcomes, the desired benefit would be to show if better alignment reduces loosening and improves survivorship long term with large, randomized studies.

RISK FACTORS: BODY MASS INDEX (BMI)

There is no difference in postoperative functional scores between patients with a BMI < 30 and obese patients (BMI 30-39.9); however, there may be increased risk of complications in morbidly obese patients (≥40), in particular, surgical site infections.

Strength of Evidence: Strong

Strength of Recommendation: Strong ★★★★

Evidence from two or more "High" quality studies with consistent findings for recommending for or against the intervention.

Rationale

Several high-quality studies were reviewed which investigated the relationship between BMI and patient outcomes after surgical management of knee osteoarthritis. The average pre-operative objective knee society score was 55.88 (range-34 to 74) which improved to 71.84 (range-51 to 89) at six weeks and to 92.79 (range-71 to 100) at six months. Following this improvement, the scores remained steady at the last follow up with mean score being 93.01 (range-72 to 100) (Agarwala 2020, Benjamin 2001).

The functional knee scores before surgery averaged 52.91(range-30 to 75). The score at six weeks were 62.33 (range-35 to 85) which improved significantly at six months to 80.63 (range- 45 to100). The scores at the last follow up remained the same as the 12 months follow up (Agarwala 2020). During follow-up, 2.1% patients had SSI (Ahmed 2016). No significant difference between the obese and non-obese groups (Amin 2006).

Regarding the Oxford Knee Score, wound complications were significantly higher ($p < 0.001$) at a rate of 17% patient with a BMI of 40 and greater compared with 9% in patients with a BMI of less than 40. (Baker 2012). As BMI increased, knee flexion degree, KOOS and Lysholm scores also decreased significantly (Basdelioglu 2020). At baseline, gait velocity and knee ROM were significantly lower in obese patients compared with those in the nonobese group, and obese patients were more symptomatic than nonobese patients, and their improvement was significantly higher (WOMAC scores) (Bonneyfoy 2017).

While readmission rates were higher in obese patients (Sloan 2020, Basdelioglu 2020), there was no difference in outcomes in obese patients undergoing bilateral total knee arthroplasty (Ogur 2020).

There was also an increase in complications such as infections and bleeding (Shih 2004).

Benefits/ Harms of Implementation

While there is a significant benefit of pain improvement and function in obese patients who undergo TKA, there is increased risk of SSIs. Regarding implant-specific considerations, the practitioner should consult implant manufacturers' guidelines before surgery, as they may caution against the use of particular implants in patients with high BMI.

Outcome Importance

The outcome of TKA in non-morbidly obese patients is comparable to non-obese patients with excellent post-operative objective and functional scores. However, the risk of SSIs may increase in obese patients after TKA.

Cost Effectiveness / Resource Utilization

Several high-quality studies show that there is an increased risk of SSIs in obese patients after TKA. Several studies also highlighted increased length of stay and use of resources such as antibiotics and the need for consulting services which may increase the cost.

Acceptability

The recommendation comes with varying acceptability. Some surgeons may feel some loss of autonomy with clinical decision making when deciding who is indicated for surgery.

Feasibility

There have been a number of high-quality studies showing comparable postoperative functional outcomes between non-obese and obese patients. As such, it may be more feasible for surgeons to consider the overall health of the patient. If the patient has several risk factors that may contribute to a poor outcome, then it may be more reasonable to better optimize this patient before surgery. If the patient has only one risk factor such as obesity, delaying surgery may cause further functional issues and poor quality of life.

Future Research

Future research should include more studies on functional outcomes in obese patients.

RISK FACTORS: DIABETES/HYPERGLYCEMIA

Optimization of perioperative glucose control (<126mg/dl) after total knee arthroplasty should be attempted in diabetic patients and non-diabetic patients with hyperglycemia, as it can lead to less favorable postoperative outcomes and higher complication rates.

Strength of Evidence: Strong

Strength of Recommendation: Strong ★★★★

Evidence from two or more "High" quality studies with consistent findings for recommending for or against the intervention.

Rationale

There is one high quality study (Reategui 2017) concluding that postoperative hyperglycemia control reduces the postoperative complications in patients who have undergone TKA. Patients were classified as non-diabetic patients (group 1), diabetic patients (group 2) and patients with stress hyperglycemia (group 3). The last two groups were recommended assessments by a primary care physician (PCP). After one year follow up the groups were compared with respect to incidence of postoperative complications. The groups were also compared regarding the decrease or increase of HbA1c levels with the incidence of complications. Patients that consulted their PCP presented lower medical complication rates than those who did not. Surgical site infection and mechanical complication were increased. A decrease of HbA1c value was related to less medical systemic complications. There are two high quality studies (Ojemolon 2020, Teo 2018) and one low quality study (Zhang 2021) assessing patients with diabetes and outcomes after TKA. Zhang (2021) shows patients with uncontrolled diabetes HGB A1C >8 having a lower KSS and WOMAC score, however, there is no difference between their mental component scores and patient satisfaction. Additionally, they also reported lower ROM and SF-36 scores. In Teo (2018), patients with diabetes have a lower Oxford, KSS, and SF-36 score. There was no difference in range of motion, length of hospitalization stay, infection risk, and patient satisfaction. Diabetic patients also had a 50% reduction in body mass index after TKA compared to 36% in nondiabetic patients. Ojemolon (2018) reviewed NSQIP data of diabetic patients and non-diabetic patients which showed lower complication rates in diabetic patients in areas such as infection, DVT, PE, sepsis, pneumonia, and MI.

Benefits/ Harms of Implementation

The risks associated with performing total knee arthroplasty on patients with poorly controlled diabetes may include higher surgical complications such as SSIs and mechanical complications. These patients also tend to have lower functional scores. These increased complications may require further financial resources to treat them.

Outcome Importance

Patients with uncontrolled diabetes may have a higher rate of complications after total knee arthroplasty.

Cost Effectiveness / Resource Utilization

Several high-quality studies show that there is an increased risk of SSIs in patients with uncontrolled diabetes after TKA. Several studies also highlighted increased use of resources such as antibiotics and the need for consulting services which may increase the cost.

Acceptability

The recommendation comes with varying acceptability.

Feasibility
Since there have been a number of studies showing increase complications in patients with uncontrolled diabetes, it is reasonable to better optimize this patient before surgery to decrease risk.

Future Research
Additional prospective studies are needed to evaluate functional outcomes in patients with controlled and uncontrolled diabetes.

View background materials via the SMOAK2 CPG eAppendix 1
View data summaries via the SMOAK2 CPG eAppendix 2

TOURNIQUETS

Evidence reports that there is no difference in outcomes, function, pain, or blood transfusions between the use of tourniquets and nonuse of tourniquets.

Strength of Evidence: Strong

Strength of Recommendation: Strong ★★★★

Evidence from two or more "High" quality studies with consistent findings for recommending for or against the intervention.

Rationale

There were multiple studies evaluating pain and tourniquet use with six high quality studies (Ozkunt 2018, Liu 2017, Yi 2021, Hamawandi 2021, Liu 2014, Ledin 2012) showing increased pain in the immediate postoperative period. Additionally, there is moderate evidence to support avoidance of using a tourniquet in order to decrease opioid consumption (Hamawandi 2021, Kheir 2018, Nicolaiciuc 2019).

Studies regarding outcomes were heterogenous and inconclusive. Two high quality studies (Ozkunt 2018, Hamawandi 2021) did not favor using a tourniquet and two high quality studies (Ayik 2019, Liu 2017) showed no significant difference for KSS. Four high quality studies showed no significant difference in motion, including total ROM (Ayik 2019, Liu 2017), flexion (Goel 2019, Alexandersson 2019), or extension (Alexandersson 2019).

Five high quality studies (Ledin 2012, Harsten 2015, Mori 2016, Goel 2019, Hamawandi 2021) were in favor of using a tourniquet to reduce blood loss. However, there were different methods of blood loss calculation, and two studies (Ledin 2012, Mori 2016) did not use tranexamic acid (TXA). Three high quality studies (Goel 2019, Liu 2017, Hamawandi 2021) showed no difference for deep vein thrombosis, moderate evidence (Alexandersson 2019, Yi 2021, Hamawandi 2021) showed no difference for length of stay, and there were not enough high quality studies to show a difference for quadricep strength, wound complications, or operating time.

*KSS = Knee Society Score, ROM = range of motion

Benefits/ Harms of Implementation

Surgeons should take care to balance the advantages and disadvantages of using a tourniquet. Reported advantages of using a tourniquet include dry field, shorter operative time, better visibility, reduced blood loss, dry bone surfaces for better cement interdigitation and implant survivorship. Adverse effects include ischemia, quadricep muscle damage, increased swelling and stiffness, nerve compression, injury to calcified vessels, and potential for deep venous thrombosis (DVT). If a tourniquet is used, it is recommended to keep the surgical time down to decrease the risk for DVT.

Outcome Importance

The outcomes for TKA with tourniquet versus no tourniquet were equivalent. While there are limited studies in young patient populations, this recommendation may be used with caution in surgeon practices with younger patient populations as the use of tourniquet may cause increased quadricep pain and weakness.

Cost Effectiveness / Resource Utilization

This recommendation likely does not affect cost-effectiveness or resource utilization for a majority of surgeons. However, surgeons who desire to improve their efficiency may consider using it to decrease operating room time.

Acceptability
Surgeons will likely find the cumulative study results and recommendation acceptable.

Feasibility
There are a number of studies showing comparable outcomes with or without tourniquet use. It would be feasible for surgeons to consider the patient's history when making a decision about using a tourniquet. Specific considerations would include a history of DVT, lower extremity vascular stents, and poor bone quality if cementing implants.

Future Research
There is a gap in the literature regarding the long term effect of tourniquet use and quadricep strength in younger patients. As the operative age continues to decrease and activity and expectations after total knee arthroplasty continue to increase, future studies should focus on this group of patients.

View background materials via the SMOAK2 CPG eAppendix 1
View data summaries via the SMOAK2 CPG eAppendix 2

PATELLAR RESURFACING

Evidence reports that there is no difference between patellar resurfacing or non-patellar resurfacing in total knee arthroplasty.

Strength of Evidence: Strong

Strength of Recommendation: Strong ★★★★

Evidence from two or more "High" quality studies with consistent findings for recommending for or against the intervention.

Rationale

Several high quality studies with contradictory results conclude that patellar resurfacing and non-patellar resurfacings are both viable options. Nine high quality studies reported equivalent functional outcomes with resurfaced versus non-resurfaced patellae using the KSS function (Raaij 2020, Aunan 2016, Dong 2018, Kaseb 2018, Roberts 2015), range of motion (Kaseb, 2018, Roberts 2015, Thiengwittayaporn 2019), stiffness (Aunan 2016), KOOS-ADL (Raaij 2020, Dong 2018, Aunan 2016, Ali 2016), KOOS Symptoms (Aunan 2016, Ali 2016, Kang 2019), KSS stairs (Roberts 2015), and Feller patellofemoral scores (Koh 2019). Such equivalence was furthered by one additional moderate quality study (Kaseb 2019) and three low quality studies (Albrecht 2016, Hsu 2006, Chun 2017). Only three high quality studies suggested improvement in certain function metrics among patients with patellar resurfacing, including the KSS function score (Ha 2019), active range of motion (Roberts 2015), and total patellar score (Thiengwittayaporn 2019).

Five high quality analyses reported no difference in pain metrics including VAS pain (Kaseb 2018, Ali 2016, Koh 2019), Kujala anterior knee pain scale (Kaseb 2018), anterior knee pain as a symptom (Dong 2018, Thiengwittayaporn 2019), continued pain (Koh 2019), and the feller patellofemoral score for anterior knee pain (Koh 2019) among patients with and without patellar resurfacing after TKA. Similarly, one low quality study supported equivalent pain metrics among patients with resurfaced versus non-resurfaced patellae after TKA (Chun 2017). KOOS-Pain with resurfaced versus non-resurfaced patellae was analyzed in two high quality studies with contradictory findings (Raaij 2020, Aunan 2016). One high-quality study suggested better anterior pain at rest and while walking in the non-resurfaced cohort (Roberts 2015). Finally, two high quality studies (Raaij 2020, Ali 2016) reported similar KOOS-QoL and KOOS-Sports scores regardless of patellar management while one study (Aunan 2016) reported superior KOOS-QoL and -Sport scores among patellar resurfacing patients.

Composite knee scores demonstrated a similar pattern of conflicting findings, with the majority of studies describing equivalent outcomes according to WOMAC (Kaseb 2018, Chun 2017), HSS (Kaseb 2018, Chun 2017), KOOS total (Kaseb 2018, Kaseb 2019), and the Feller patellofemoral scores (Dong 2018, Koh 2019). In contrast, the KSS total score was found to be higher among patients who underwent patellar resurfacing according to three (Dong 2018, Aunan 2016, Ha 2019) of seven high quality studies, while the remaining studies reported no difference based on patellar management (Raaij 2020, Kaseb 2018, Roberts 2015, Thiengwittayaporn 2019).

Four high-quality studies highlighted that adverse event rates were similar regardless of patellar management, including total revisions (Dong 2018), infection (Aunan 2016), crepitus (Dong 2018, Thiengwittayaporn 2019, Koh 2019), patellar fracture, and quadricep tendon rupture (Aunan 2016).

Benefits/ Harms of Implementation

Patellar resurfacing may be associated with improvement in certain patient-reported outcome scores such as KOOS-Pain, QoL, and Sports. However, such improvement is inconsistent and remains substantially disputed. In contrast, despite their relatively low incidence, potential complications of patellar resurfacing include but are not limited to loss of bone stock, increased future revision complexity, patellar fracture, avascular necrosis, and extensor mechanism violation, which may be catastrophic in the setting of primary elective TKA.

Outcome Importance
Reoperation, long term anterior knee pain, and patient satisfaction.

Cost Effectiveness / Resource Utilization
Unsurfaced patella poses the benefits of a faster surgery, avoiding potential complications of patellar resurfacing, and decreased cost compared to resurfacing. However, such potential benefits need to be balanced against the potential risk of requiring resurfacing at a later date, and revision rates.

Acceptability
Literature is conflicted regarding patellar management after primary elective TKA. As such, provider-preference based patellar management should be acceptable to medical providers. It is important to emphasize that this recommendation applies to primary knee arthroplasty. Physicians should exercise caution based on anatomic and bone-stock variability among patients as well as the patient-specific activity level, age and risk of future revision.

Feasibility
There are no significant barriers to implementation of recommendation. Elimination of patellar resurfacing may reduce operative time, blood loss and additional expenses.

Future Research
Large multicenter prospective RCT or cohort studies to assess indications for selective patellar resurfacing.

Additional References:
Kang H, Zheng R, Dong C, Fu K, Wang F. No influence of patellar fixation technique on clinical outcomes of double-bundle medial patellofemoral ligament reconstruction: a systematic review. Arch Orthop Trauma Surg Germany, 2019;139(1):79–90.

CRUCIATE RETAINING ARTHROPLASTY

Cruciate retaining (CR) and posterior stabilized (PS) total knee arthroplasty (TKA) designs have similarly efficacious/favorable postoperative outcomes.

Strength of Evidence: Strong

Strength of Recommendation: Strong ★★★★

Evidence from two or more "High" quality studies with consistent findings for recommending for or against the intervention.

Rationale

Use of CR designs has increased annually since 2016 with lower revision rates compared to PS, but there are multiple strong studies to support no difference in ROM, function, or outcomes. Vertullo (2017) noted higher risk of revision after PS in comparison to CR. Three high quality studies for total ROM (van den Boom 2020, Kawakami 2015, Tanzer 2002), four high quality studies for flexion (van den Boom 2020, Kawakami 2015, Chaudhary 2008, Tanzer 2002), and two high quality studies for extension (Kawakami 2015, Chaudhary 2008) showed no difference between CR and PS. With respect to function, four high quality studies showed no difference in WOMAC Function (van den Boom 2020, Dowsey 2020, Beaupre 2016, Chaudhary 2008) and two high quality studies showed no difference in WOMAC stiffness (Dowsey 2020, Beaupre 2016) between CR and PS.

Two high quality studies showed no difference in KSS and WOMAC scores (van den Boom 2020, Dowsey 2020) and SF-36 General Health (van den Boom 2020, Beaupre 2016). However, one high quality study favored PS for KSS (Ozturk 2016). Four high quality studies showed no difference in WOMAC Pain scores (van den Boom 2020, Dowsey 2020, Beaupre 2016, Chaudhary 2008) and one high quality study showed no difference in VAS (Ozturk 2016).

*ROM = range of motion, KSS = Knee Society Score, WOMAC = Western Ontario and McMaster University osteoarthritis Index, OKS = Oxford Knee Score, VAS = visual analogue score

Benefits/ Harms of Implementation

There are no known harms with this recommendation. Surgeons should be aware of the advantages and disadvantages of particular types of femoral implant designs. For example, difference in removal of bone and risk of intraoperative fracture during component insertion due to box size for PS versus CR.

Outcome Importance

The studies show CR and PS are comparable with excellent ROM, function, and outcomes.

Cost Effectiveness / Resource Utilization

There are no reported cost differences or resource utilization for CR versus PS.

Acceptability

This recommendation will likely be acceptable for surgeons as the decision to use CR or PS is up to them and they will have similar outcomes with either choice.

Feasibility

It is feasible that surgeons will continue to make the decision to use CR or PS in their practice based on similar outcomes between the two types of femoral implants.

Future Research

There have been a multitude of studies on CR versus PS femoral implants, but future research may focus on amount of bone loss and difficulty of revision TKA after CR versus PS. Additionally, emerging techniques outside the CR or PS classifications should be investigated through high-quality study designs.

PATIENT SPECIFIC TECHNOLOGY

The practitioner should not use patient specific technology (e.g., guides, cutting blocks) because there is no significant difference in patient outcomes, function, or pain as compared to conventional total knee arthroplasty (TKA). Additionally, it does not reduce operating time, blood loss, length of stay, and/or complications.

Strength of Evidence: Strong

Strength of Recommendation: Strong ★★★★

Evidence from two or more "High" quality studies with consistent findings for recommending for or against the intervention.

Rationale

*Note: patient specific implants (femoral and tibial components) were not addressed in this review of the literature.

There are inconsistencies in high quality studies with respect to patient outcomes with the majority of studies showing no difference between patient specific and standard instrumentation. Six high quality studies for the KSS (Yan 2015, Schotanus 2019, Abane 2015, Boonen 2016, Stolarczyk 2018, Kosse 2018), six high quality studies for the OKS (Yan 2015, Turgeon 2019, Abane 2018, Abane 2015, Huijbregts 2016, Boonen 2016), four high quality studies for EG-5D VAS (Schotanus 2019, Teeter 2019, Van Leeuwen 2017, Boonen 2016), two high quality studies for EG-5D (Schotanus 2019, Boonen 2016), and three high quality studies showed no difference in VAS Satisfaction (Turgeon 2019, Kosse 2018, Kotela 2015). The study with the longest follow up of 5 years showed no significant differences in survival or patient outcomes between patient specific and standard instrumentation (Schotanus 2019).

With respect to patient function and pain, there were multiple high quality studies that also showed no difference between patient specific and standard instrumentation. Seven high quality studies for KSS Function (Yan 2015, Teeter 2019, Abane 2018, Abane 2015, Maus 2018, Stolarczyk 2018, Kosse 2018), three high quality studies for UCLA activity score (Turgeon 2019, Teeter 2019, Kosse 2018), two high quality studies for SF-12 Physical (Teeter 2019, Huijbregts 2016), and two high quality studies for KOOS ADL and KOOS Symptoms (Van Leeuwen 2017, Kosse 2018), and there was also no difference in ROM (Yan 2015, Sun 2020, Van Leeuwen 2017). Multiple high-quality studies did not support the use of patient specific instrumentation to improve pain with six high quality studies for VAS (Schotanus 2019, Turgeon 2019, Boonen 2016, Stolarczyk 2018, Kosse 2018, Kotela 2015) showing no difference compared to standard instrumentation.

There were multiple inconsistencies in the studies that analyzed operative time comparing patient specific to standard instrumentation. Six high quality studies showed no difference (Yan 2015, Turgeon 2019, Van Leeuwen 2017, Huijbregts 2016, Silva 2020, Maus 2018), four high quality studies favored standard instrumentation (Teeter 2019, Sun 2020, Stolarczyk 2018, Roh 2013), and three high quality studies favored patient specific instrumentation (Boonen 2013, Pfitzner 2014, Vide 2017).

The reporting and results for blood loss were heterogenous and inconsistent with studies using blood transfusion, hemoglobin, and blood loss. One high quality study (Vide 2017) was in favor of patient specific technology and two high quality studies showed no difference (Silva 2020, Kotela 2015) for blood transfusion. Two high quality studies showed no difference (Van Leeuwen 2017, Vide 2017) and one high quality study was in favor of standard technology (Silva 2020) for hemoglobin levels. Two high quality studies showed no difference (Stolarczyk 2018, Kotela 2015) and one high quality study was in favor of patient specific technology (Sun 2020) for blood loss.

There is strong evidence to support patient specific instrumentation does not affect length of stay or complications. Five high quality studies showed no difference compared to conventional instrumentation (Turgeon 2019, Van Leeuwen 2017, Silva 2020, Maus 2018, Kotela 2015). There is strong evidence to support no difference in total revisions, infection, and manipulation under anesthesia (MUA) for patient specific versus standard instrumentation; two high quality studies for total revisions (Schotanus 2019, Boonen 2016), three high quality studies for infection (Huijbregts 2016, Silva 2020, Boonen 2016), and two high quality studies for MUA (Huijbregts 2016, Boonen 2016).

*KSS = Knee Society Score, OKS = Oxford Knee Score, WOMAC = Western Ontario and McMaster University osteoarthritis Index, EG-5D = EuroQol, VAS = visual analogue score, UCLA = University of California and Los Angeles, KOOS = Knee injury and Osteoarthritis Outcome Score, ROM = range of motion

Benefits/ Harms of Implementation
Proposed benefits of patient specific instrumentation lie in improved accuracy of alignment which could benefit long-term outcomes as malalignment of components is a known major cause of failure and revision. Patient specific instrumentation is useful for rare circumstances when intramedullary instrumentation cannot be utilized. Radiation from CT scan is a potential harm with using patient specific instrumentation.

Outcome Importance
The use of patient specific instrumentation does not improve outcomes, but anecdotally outcomes may be better for surgeons who use it routinely instead of standard instrumentation.

Cost Effectiveness / Resource Utilization
Patient specific instrumentation requires increased cost for hardware/software and advanced imaging (MRI or CT). Seldomly, the MRI may not pass the manufacturer's protocol rendering the study unusable. Template planning and fabrication takes extra time for the patient specific instrumentation that may decrease its usefulness. Conversely, potential cost savings could exist if its use reduces instruments and sterilization costs, reduced processing, and reduction in hospital storage of implants.

Acceptability
A small number of surgeons continue to use patient specific instrumentation. Those who are accustomed to using them, may find these results unacceptable and will continue to use them.

Feasibility
It is feasible to abandon patient specific instrumentation technology, however some surgeons who still use it in their workflow may find it difficult to return to standard instrumentation.

Future Research
Future research should focus on reduction of outliers in alignment and the long-term effects of patient specific versus conventional instrumentation. Additionally, large studies comparing patient specific to conventional off-the-shelf implants would be beneficial.

KINEMATIC VS. MECHANICAL ALIGNMENT

There is no difference in composite/functional outcomes or complications between kinematic or mechanical alignment principles in total knee arthroplasty.

Strength of Evidence: Strong

Strength of Recommendation: Strong ★★★★

Evidence from two or more "High" quality studies with consistent findings for recommending for or against the intervention.

Rationale

Six high quality studies (Young 2020, MacDessi 2020, Matsumoto 2017, Yeo 2019, McEwen 2020, Sarzaeem 2021) included to see if there is any difference between kinematic versus mechanical principle of total knee arthroplasty. Composite scores like WOMAC Total, HSS Total, KOOS Total, Oxford Knee Score, Forgotten Joint Score, SF-36, and other scores were evaluated. Patient functional scores like KSS Function, Range of Motion, WOMAC function, WOMAC Stiffness, Flexion and Extension, KOOS ADL, SF 36 and many other scores were compared.

Among composite scores, two high quality studies (MacDessi 2020, McEwen 2020) show equivalent KOOS total scores, two high quality studies (Young 2020, McEwen 2020) show equivalent Oxford knee scores, three high quality studies (Young 2020, MacDessi 2020, McEwen 2020) demonstrate equivalent forgotten joint scores.

Functional scores show similar results to composite scores. Two high quality studies (Young 2020, Yeo 2019) show equivalent KSS function. Two high quality studies (MacDessi 2020, McEwen 2020) show equivalent extension, KOOS ADL, KOOS symptoms scores, KOOS QoL, KOOS Sports and KOOS Pain scores between two groups.

Benefits/ Harms of Implementation

There is no significant benefit of kinematic principle which often utilizes more resources than the mechanical alignment knee.

Outcome Importance

Composite and functional scores are equivalent in both groups.

Cost Effectiveness / Resource Utilization

Kinematic knee could be performed without specialized navigation or convinced computer-assisted programs. However, five out of six high quality studies included in the discussion utilized navigation, robotic, or computer assistance programs which add to the cost of care. There does not appear to be any benefit of extra cost in this scenario.

Acceptability

The acceptability of this recommendation is high. There are several high-quality studies showing equivalent outcome scores.

Feasibility

The feasibility of this recommendation is high. Some institutions may not have access to resources such as computer assistance or navigation. Since several high-quality studies show no difference in outcomes, the increased use of resources is of no benefit.

Future Research

Future research should include the use of kinematic and mechanical alignment and its limitations with varying degrees of deformity.

PRE-OPERATIVE OPIOID USE

Cessation of preoperative opioids should be attempted for total knee arthroplasty (TKA), as preoperative opioid use demonstrates decreased postoperative functional scores and increased pain scores and complications.

Strength of Evidence: Low

Strength of Recommendation: Moderate ★★★☆ (Upgraded)

Evidence from one or more "Low" quality studies with consistent findings or evidence from a single "Moderate" quality study recommending for or against the intervention. Also, lower strength evidence can be upgraded to moderate due to concerns addressed in the EtD Framework.

Rationale

This recommendation has been upgraded due to increased risk of opioid overdose postoperatively. We reviewed various prospective and retrospective studies that represented the best available evidence. All articles provided low-quality evidence. These articles assess use of preoperative opioid use in patients and the outcomes after TKA. Two studies looked at tramadol use preop (Driesman 2019, Wilson 2021). When comparing patients who took tramadol preoperatively to patients who were opiate naïve, patients that used tramadol trended toward significantly less improvement in functional outcomes in terms of the Knee Disability Osteoarthritis Outcome Score (Driesman 2019). While tramadol-only use has lower risk than traditional opioids, tramadol-only use preceding TKA is associated with increased rates of readmission, wound complication, and revision surgery (Wilson 2021). Several studies looked at opioid use preop compared to patients that were opioid naïve. Patients on opioids preop had lower WOMAC, VAS scores and physical function scores at 1 year compared to opioid naïve patients (Goplen 2021). One study looked at revision total knee arthroplasty (Ingall 2021). Patients who are actively taking opioids at the time of revision TKA report significantly lower preoperative and postoperative outcome scores, PROMIS and KOOS scores. Kim (2019) found that after adjusting for baseline risk profiles, including comorbidities and frailty, continuous opioid users had a higher risk of revision operations and opioid overdose at 30 days post-TKA but not of in-hospital or 30-day mortality. A retrospective study done in approximately 30,000 patients showed that the use of preop opioids was a predictor of revision total knee arthroplasty (Starr 2018). There is consistent evidence to show poorer outcomes in patients that are on preop opioids compared to opioid naïve patients.

Benefits/ Harms of Implementation

There is significant benefit with limiting use of opioids preop. One study (Kim 2019) showed an increase in opioid overdose at 30 days post TKA.

Outcome Importance

The outcome of patients that are on preop opioids prior to TKA tend to be poorer than opioid naïve patients undergoing TKA.

Cost Effectiveness / Resource Utilization

Studies show increase in revision TKA, and longer hospital stays in patients on preop opioids which would not be cost effective.

Acceptability

The acceptability of this recommendation is high. There are several studies that show the benefits of limiting opioid use preoperatively.

Feasibility

The feasibility of this recommendation varies. It may be difficult for some surgeons to control opioid use in patients preoperatively if they are not the primary prescribers and if patients have pain sources other than their knee.

Future Research

Future research should include collaborative studies or efforts with pain management providers and/or primary care physicians. There is consistent evidence to show poorer outcomes in patients that are on preop opioids compared to opioid naïve patients. However, there is the need for more higher quality level one studies. Ethical considerations regarding level one studies must be considered as it would require patients to be blinded and randomized to narcotic use preoperatively and carries the risk of long-term addiction.

OPTIONS

Low quality evidence, no evidence, or conflicting supporting evidence have resulted in the following statements for patient interventions to be listed as options for the specified condition. Future research may eventually cause these statements to be upgraded to strong or moderate recommendations for treatment.

CEMENTLESS FIXATION: ALL CEMENTLESS COMPONENTS VS. HYBRID FIXATION (CEMENTLESS TIBIAL COMPONENT)

All cementless components or hybrid fixation (cementless femur) in total knee arthroplasty show similar functional outcomes and rates of complications and reoperations.

Strength of Evidence: Moderate

Strength of Option: Limited ★★☆☆ (downgraded)

Evidence from two or more "Moderate" quality studies with consistent findings, or evidence from a single "High" quality study for recommending for or against the intervention. Also, higher strength evidence can be downgraded to limited due to major concerns addressed in the EtD Framework.

Rationale

In general, the body of evidence was notable for heterogeneity in study design, comparative study groups (including cementless, hybrid, and cemented fixation), and confounding results. As such, the recommendation has been downgraded.

There were twelve high quality studies (Demey 2011, Fernandez-Fairen 2013, Kim 2014, Lizaur-Utrilla 2014, Kendrick 2015, Pulido 2015, Van Hamersveld 2017, Nam 2019, Batailler 2020, Hampton 2020, Kim 2020, Murylev 2020) and seventeen low quality (Khaw 2002, Carlsson 2005, Baker 2007, Park 2011, Pandit 2013, Bagsby 2016, Kerens 2017, Boyle 2018, Nugent 2019, Manoli 2019, Deroche 2020, Irmola 2020, Lizaur-Utrilla 2020, Mohammad 2020, Gifstad 2021, Silverstein 2021, Quispel 2021) studies evaluating the use of various combinations of cemented versus cementless fixation of components (tibia, femur, patella) in total knee arthroplasty.

Three low quality studies (Nugent 2019, Irmola 2020, Quispel 2021) compared cementless and hybrid fixation. Irmola (2020) and Nugent (2019) showed significantly lower total revision rates in the hybrid group, but no difference in specific indications. Nugent (2019) showed statistically significantly better Oxford knee scores at 6 months postoperative in the hybrid fixation group, but no difference at 5 and 10 years.

Only one study (Irmola 2020) compared hybrid fixation to inverse hybrid (cemented femoral component and uncemented tibial component), finding no difference in revisions at 5 years.

Future Research

Continued long-term comparative studies between modern cemented and cementless component fixation options in knee arthroplasty will help to further define the utility of these component types, durability of fixation, and effect of evolving component designs (e.g., modular and monolithic) on patient-reported outcomes. Certainly, newer fixation materials (e.g., porous metals) should be evaluated in long-term follow-up. Identifying patient-specific factors that may inform the decision to utilize a particular fixation technique, or to avoid complications associated with particular fixation strategies, is important. Registry data and long-term studies (greater than ten years clinical follow up) should inform durability of particular components and may serve to analyze implant-specific complications and revision risk. Given some variability in the reported patient-reported outcome measures between treatment groups in particular high-quality studies, more clinical data may discern subtle differences in clinical outcomes based on the use of cemented or cementless component fixation. Issues of cost and cost-effectiveness should also be incorporated into future clinical studies.

UNICOMPARTMENTAL KNEE ARTHROPLASTY VS. HIGH/PROXIMAL TIBIAL OSTEOTOMY

The practitioner could use unicompartmental knee arthroplasty or tibial osteotomy for the treatment of knee osteoarthritis.

Strength of Evidence: Moderate

Strength of Option: Limited ★★☆☆ (downgraded)

Evidence from two or more "Moderate" quality studies with consistent findings, or evidence from a single "High" quality study for recommending for or against the intervention. Also, higher strength evidence can be downgraded to limited due to major concerns addressed in the EtD Framework.

Rationale

This statement was downgraded due to the quality of evidence in support of UKA. There is limited high quality evidence to support the use of UKA versus HTO in early, unicompartmental OA. All included literature examined these procedures for the treatment of medial unicompartmental knee osteoarthritis. One high quality study (Stukenborg-Colsman 2001) of patients with predominantly medial compartment osteoarthritis demonstrated equivalent postoperative complication rates, implant survivorship, and knee society scores among UKA versus HTO recipients. Such equivalence in postoperative adverse event rates was supported by four additional low quality studies (Watanabe 2021, Rodkey 2021, Tuncay 2015, Petersen 2016) which found similar rates of total revision, infection, deep venous thrombosis, hematoma formation, implant loosening (but not aseptic loosening), mechanical symptoms and arthritis progression. Conversely, one moderate quality study (Shaofei 2017) and four low quality studies (Petersen 2016, Ziqi 2020, Kim 2019, Jeon 2017) reported superior early pain, physical function, and/or quality of life metrics with UKA compared to HTO.

Overall, there is considerable overlap in indications for UKA and HTO, based on patient's age range, levels of activity demands/expectations, and clinical presentation of unicompartmental osteoarthritis. Furthermore, TKA represents the revision option for both treatments and yields satisfactory functional outcomes and survivorship. A recent meta-analysis (Cao 2018) reported that UKA patients have lower revision rates, mitigated minor and major complications, and less postoperative pain compared to their HTO counterparts. However, such results are ascertained from the compilation and pooled analysis of relatively low-quality evidence. In contrast, HTO patients attain a greater range of motion; nevertheless, this advantage may not be of clinical significance given the satisfactory ROM attained using UKA. Both modalities offer a similar postoperative knee function score, walking velocity, and mid-term revision rates. It is critical to highlight those outcomes and survivorship of both surgical modalities are heavily modified by surgeon experience and technique, in addition to implant design for UKA. Advances such as robotic UKA may offer a venue for further improvement in survivorship.

Benefits/ Harms of Implementation

Performing UKA in an appropriately selected population affords the advantages of lower revision rates, mitigated minor and major complications, and less postoperative pain compared to their HTO counterparts. However, such advantages are contingent upon surgeon experience and implant design; thereby rendering the potential for failure (i.e., higher revision and lower mid-to long term survivorship) among less experienced substantially higher. Nevertheless, the introduction of robotic UKA may mitigate, in part, the inter-surgeon variability.

Cost Effectiveness / Resource Utilization

Owing to the lower costs and near-comparability of outcomes, HTO affords higher cost-effectiveness compared to UKA especially in 50 to 60-year-old patient with medial unicompartmental knee osteoarthritis (Kamaruzaman 2017). Specifically, Markov model using a probabilistic willingness-to-pay (WTP) threshold sensitivity analysis demonstrated that a $50,000 per QALY, HTO was cost effective in

57% of the time compared to 19% in UKA. At a WTP threshold of $100,000/QALY, HTO was cost-effective 43% of time versus 26% for UKA. HTO and UKA are associated with 14.62, and 14.63, estimated discounted QALYs, respectively. Conversely, discounted total direct medical costs were $20,436 for HTO versus $24,637 for UKA (in 2012 U.S.D). The incremental cost-effectiveness ratio (ICER) was $420,100 per QALY for unicompartmental knee arthroplasty.

Acceptability and Feasibility
Overall, UKA has fair acceptability and feasibility among surgeons and patients. AJRR data indicates diminishing rates reaching 2.7% of all primary knee arthroplasties reported to AJRR for 2017. However, such rates rebounded with numbers increasing to 4.2% in 2020 (American Joint Replacement Registry 2020 Annual Report).

Future Research
Further research into long-term cost-effectiveness using both surgical modalities is required, especially in delineating indications and patient selection. Such investigational venues should account for costs and outcomes of conversion TKA after each modality; specifically, the incidence of infection, early failure, and patient reported outcomes after the conversion surgery. This is critical given that TKA is the final common pathway after either procedure which may be considered less invasive “temporizing measures” in a substantial subset of the young osteoarthritis patient population until TKA is eventually performed. Further research is also warranted into the comparative utilization rates of each procedure over the last decade and their respective projected volumes.

BILATERAL SIMULTANEOUS TOTAL KNEE ARTHROPLASTY VS. STAGED

In the absence of reliable evidence, it is the opinion of the workgroup that simultaneous bilateral total knee arthroplasty (TKA) could be performed vs. staged (>90 days) bilateral TKA in appropriately selected patients but should be performed with caution and should be avoided with patients who are at high risk of cardiopulmonary complications.

Strength of Evidence: Low
Strength of Option: Consensus ★☆☆☆ (downgraded)
Description: Evidence there is no supporting evidence, or limited level evidence was downgraded due to major concerns addressed in the EtD framework. In the absence of reliable evidence, the guideline work group is making a recommendation based on their clinical opinion.

Rationale
This recommendation has been downgraded due to the potential harms to the patient. In the limited evidence available, no difference in overall complication rates for patients who underwent bilateral simultaneous TKA versus stage TKA is found. Several studies demonstrate lower hemoglobin (Feng 2019) in simultaneous TKA group, but there are mixed findings regarding increased blood transfusion (Feng 2019, Wan 2021, Bohm 2016). Some studies found increased risk of PE with bilateral simultaneous TKA (Hadley 2017, Bohm 2016) though others found no difference in the compared groups (Goyal 2020, Arslan 2018, Zhao 2015). When specifically comparing bilateral simultaneous versus staged (excluding unilateral TKA), no mortality difference has been reported (Yoon 2010).

In the limited evidence available, findings are consistent that there are no functional outcome differences between simultaneous and staged bilateral TKA (Goyal 2020, Feng 2019).

Advantages to simultaneous bilateral TKA include cost savings (Wan 2021), decreased overall length of stay (Feng, 2020, Wan 2021, Kahlenberg 2021, Siedlecki 2018).

Benefits/ Harms of Implementation
Bilateral simultaneous TKA may be preferred for some patients with bilateral advanced knee osteoarthritis. While bilateral simultaneous TKA has shown to have increased risks when compared to unilateral TKA in recent literature (Warren 2021), multiple low-quality studies (Poultisides 2015, Seol 2016, Bohm 2016) have found adverse effects, including total adverse effects, in favor bilateral simultaneous TKA in comparison to bilateral staged TKA.

Cost Effectiveness / Resource Utilization
Limited evidence suggests bilateral simultaneous total knee arthroplasty is cost saving.

Future Research
This recommendation is based on limited evidence from retrospective studies and limited power prospective series, and analyses thereof. Well-designed large prospective or randomized trials will further the understanding of specific criteria for patients choosing between either staged or simultaneous bilateral total knee arthroplasty.

RISK FACTORS: SMOKING

Smoking cessation should be attempted before total knee arthroplasty, as a history of smoking may result in higher complications, lower functional scores, higher pain scores, and SSIs.

Strength of Evidence: Low
Strength of Option: Consensus ★☆☆☆ (downgraded)
Description: Evidence there is no supporting evidence, or limited level evidence was downgraded due to major concerns addressed in the EtD framework. In the absence of reliable evidence, the guideline work group is making a recommendation based on their clinical opinion.

Rationale
This recommendation has been downgraded for imprecision. There is one low quality study (An, 2021) assessing female patients who are heavy smokers compared to no smoking and mild smokers and their outcomes after total knee arthroplasty. The study reports lower HSS, ROM and SF-Physical. The study also demonstrated higher SSIs and higher pain scores in the heavy smoking group. Even though, our total knee arthroplasty specific inclusion criteria led to limited evidence, it is a widely accepted in the total knee arthroplasty literature that smoking is an independent risk factor.

Benefits/ Harms of Implementation
The risks associated with performing total knee arthroplasty on patients with heavy smoking history may include lower functional scores and higher SSIs which may increase the financial resources needed to manage some of these issues.

Outcome Importance
Patients who smoke have higher rates of complications after total knee arthroplasty.

Cost Effectiveness / Resource Utilization
Smoking has been shown to increase complications such as SSIs which would increase use of resources such as antibiotics and the need for consulting services which may increase the cost.

Acceptability
The recommendation comes with high acceptability.

Feasibility
Since smoking may increase complications in patients after total knee arthroplasty, it is reasonable to achieve smoking cessation before surgery.

Future Research
Additional prospective studies are needed to evaluate functional outcomes and surgical complications long term. Further studies in smoking cessation preoperatively and its effects on outcomes should also be undertaken.

DISCHARGE FACILITIES / DISPOSITION

Discharge to home, with or without home services, is associated with fewer adverse events compared to discharge to acute rehabilitation facility or skilled nursing facility.

Strength of Evidence: Low

Strength of Option: Limited ★★☆☆

Description: Evidence from one or more "Low" quality studies with consistent findings or evidence from a single "Moderate" quality study recommending for or against the intervention.

Rationale

There were no high quality and three low quality studies (Naylor 2017, McLawhorn 2017, Padgett 2018) evaluating whether discharge to an acute rehabilitation facility or skilled nursing facility improve outcomes and/ or decrease complications compared with discharge to home, with or without home services.

McLawhorn (2017) showed fewer adverse events and readmissions with home discharge. Padgett (2018) demonstrated a higher length of stay with home discharge, but no difference in adverse events. Naylor (2017) showed significantly better functional scores with home discharge. In the absence of reliable, comparative studies a consensus recommendation was made by the workgroup.

It is worth noting that literature comparing costs associated with discharge disposition was not included for analysis.

Benefits/ Harms of Implementation

There are no known harms associated with implementing this recommendation. The decision to discharge a patient to home versus post-acute care facility should be made with consideration of patient's medical complexity and postoperative function. The practitioner should be aware of the advantages and disadvantages of specific discharge disposition.

Future Research

Higher-quality studies are needed to compare outcomes associated with discharge disposition following total knee arthroplasty.

Of note, Christensen (2020) showed significantly better VAS Pain, strength, and functional testing at one-month post-op with immediate outpatient physical therapy as compared to immediate home physical therapy followed by outpatient therapy. While this was not included in the recommendation, this may be another opportunity for further research.

ROBOTICS IN TOTAL KNEE ARTHROPLASTY

Evidence suggests no significant difference in function, outcomes, or complications in the short term between robotic assisted and conventional total knee arthroplasty (TKA).

Strength of Evidence: High
Strength of Option: Limited ★★☆☆ (downgraded)
Description: Evidence there is no supporting evidence, or limited level evidence was downgraded due to major concerns addressed in the EtD framework. In the absence of reliable evidence, the guideline work group is making a recommendation based on their clinical opinion.

Rationale

This statement was downgraded due to the varying treatments (robots used) between studies. One high quality study (Kim, 2020) evaluating robotic assisted total knee arthroplasty (TKA) with conventional technique found no clinical benefits to robotic surgery, but another higher quality study (Cho, 2019) demonstrates improved accuracy and fewer outliers with robotics.

However, numerous low-quality studies demonstrate improved outcomes with robotic assisted TKA. King (2020) favored MAKO robotic assisted TKA to conventional jig technique for MUA. Jeon (2019) favored ROBODOC to conventional technique for periprosthetic fracture at 9 years with decreased outliers. Shaw (2021) favors robotic technique for 90-day revisions. Kayani (2018) finds robotic assisted TKA had benefits over conventional technology in early post op VAS pain and improved early functional recovery and discharge. Bollars (2020) image free robot decreased outliers. Hamilton (2021) robotic group had earlier discharge and more likely to go home. King (2020) showed MAKO robotic assisted TKA lead to shorter length of stay and reduction in pain. However, average procedure time was nine minutes longer in this group. While Liow (2014, 2017) showed that ROBODOC lead to similar short term clinical outcomes, the robotic assisted group showed better restore joint line and mechanical axis. Two-year outcomes showed subtle improvements with robotic assisted TKA. Marchand (2021) showed MAKO robotic assisted TKA improved two-year functional scores and lower aseptic revision rates. Marchand (2017) showed MAKO robotic assisted TKA improved short term pain, physical function, and total satisfaction. In Mitchell's (2021) retrospective review, robotics demonstrated significant early clinical benefits with reduced length of stay, opioids, and re-admission. Park (2007) showed that ROBODOC improved accuracy, despite the risk of higher complications with inexperienced practitioners. Song's (2013) ROBODOC procedure reduced outliers and lead to better balancing. Yang (2017) showed that ROBODOC reduced outliers and radiolucency. Bendich (2021) showed lower re-admission rate with robotic assisted TKA.

Benefits/ Harms of Implementation

Robotic assisted surgery may require preoperative imagery exposing the patient to radiation and its potential harm.

Outcome Importance

Practitioners should carefully examine the presented evidence during decision making, especially in the presence of robotic assisted surgery's growing popularity for TKA.

Cost Effectiveness / Resource Utilization

Robotic assisted surgery, although more expensive, may cut cost by improving pain, decreased LOS, and readmissions. Long term outcomes may reduce revision burden.

Feasibility

This recommendation faces no feasibility challenge.

View background materials via the SMOAK2 CPG eAppendix 1
View data summaries via the SMOAK2 CPG eAppendix 2

Future Research

Recent studies of this new and constantly improving and evolving technology show improved early short-term outcomes and pain scores. Novel robotic technologies will need to conduct long term randomized controlled trials to demonstrate clinical advantage (i.e., safety and efficacy) over conventional surgical techniques.

ROBOTICS IN UNICOMPARTMENTAL KNEE ARTHROPLASTY

Evidence suggests no significant difference in function, outcomes, or complications in the short term between robotic assisted and conventional unicompartmental knee arthroplasty.

Strength of Evidence: High

Strength of Option: Limited ★★☆☆ (downgraded)

Description: Evidence there is no supporting evidence, or limited level evidence was downgraded due to major concerns addressed in the EtD framework. In the absence of reliable evidence, the guideline work group is making a recommendation based on their clinical opinion.

Rationale

This statement was downgraded due to the varying treatments (robots used) between studies. Robotic technology is a significantly broad term. They can be broadly divided into haptic versus non-haptic robot. Haptic robot like MAKO assist surgeons in preparation of bone while others are an alignment guide.

Blyth (2017) demonstrated improved early functional score in robotic group. However, the study included Mako fixed bearing in robotic group and the Oxford mobile bearing knee in manual group. Pain score was significant up to eight weeks. It's unclear if they used a tourniquet in one or both groups which may account for the difference in pain score. Few other low-quality studies (Clement 2020, Crizer 2021, Kayani 2019) demonstrated improvement in early functional score.

Zhang (2016) showed significantly better component alignment and no difference in functional score between robotic and traditional groups. In this study, coronal mechanical axis (CMA) was significantly better in robotic UKA than traditional UKA group. At 24-month follow-up, rate of outliers of 3° varus or valgus were 50% less in robotic group. Two low-quality studies (Batailler 2019, Park 2019) has shown improve the alignment in robotic group.

A moderate quality study by Gilmour (2018), there is no difference between two groups. Two other low-quality study (Hansen 2014, Wong 2019) demonstrated no difference in outcome or alignment.

Improvement in alignment and functional outcome is predominantly reported in low-quality studies. It is possible that these improvements will be demonstrated by high-quality studies in future. High quality long-term studies are needed to see if haptic technology results in better outcome.

View background materials via the SMOAK2 CPG eAppendix 1
View data summaries via the SMOAK2 CPG eAppendix 2

APPENDICES

Appendix I: References

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Appendix II: PICO Questions and Inclusion Criteria Used to Define Literature Search

1. In adult patients with osteoarthritis undergoing TKA who have a drain put in at the time of surgery, is there a reduction in complications or an improvement in outcomes compared with patients who do not have a drain placed?
2. In adult patients with osteoarthritis undergoing KA (vs TKA?), does the use of bone cement fixation for one or more of the knee arthroplasty components improve outcomes or reduce complications when compared with use of bony ingrowth components (no use of bone cement).
3. In adult patients with osteoarthritis undergoing unicompartmental KA for predominantly unicompartmental OA, are outcomes and/or implant survivorship improved compared to those patients undergoing osteotomy (distal femoral for lateral compartment involvement, proximal tibial for medial compartment involvement, and tibial tubercle for patellofemoral involvement) or TKA?
4. In adult patients with osteoarthritis undergoing KA and with no known contraindications to specific anesthesia, does neuraxial anesthesia reduce complications or improve outcomes compared to general anesthesia?
5. In adult patients with osteoarthritis undergoing KA and with no known contraindications to specific anesthesia, does peri-operative peripheral nerve block for pain control reduce complications or improve outcomes compared to using no peripheral nerve block?
6. In adult patients with osteoarthritis undergoing KA and with no known contraindications to the use of tranexamic acid, does the use of topical, nasal, oral or intravenous tranexamic acid reduce complications and / or improve outcomes compared to not using tranexamic acid?
7. In adult patients with bilateral osteoarthritis undergoing TKA and with no known contraindications, does bilateral simultaneous KA (both knee surgeries during the same anesthetic) have improved outcomes or reduced complications compared with the combined complications of both individual KA (two knee surgeries, with two separate anesthetics) either within 90 days or within 6 months?
8. In adult patients with osteoarthritis undergoing KA and with no known contraindications to surgical navigation, does intraoperative surgical navigation improve outcomes or decrease complications compared with not using surgical navigation?
9. Are obese adult patients (using the WHO definition of BMI ≥ 30) with osteoarthritis undergoing TKA at higher risk for worse outcomes and/or increased complications as compared to non-obese patients (i.e. BMI < 30) undergoing TKA?
10. In obese (WHO definition, BMI ≥ 30) adult patients with osteoarthritis undergoing KA, are outcomes diminished (?) or complications increased compared with non-obese patients (WHO definition, BMI < 30) undergoing KA?
11. Smoking: In adult currently tobacco-smoking patients with osteoarthritis undergoing KA, are outcomes diminished or complications increased compared with non-currently tobacco-smoking patients undergoing KA?
12. In depressed adult patients with osteoarthritis undergoing KA, are outcomes diminished or complications increased compared with non-depressed patients undergoing KA?
13. In diabetic adult patients with osteoarthritis undergoing KA, are outcomes diminished or complications increased compared with non-diabetic patients undergoing KA?
14. In adult patients with osteoarthritis undergoing TKA and with no known contraindications, does using a tourniquet during surgery improve outcomes or decrease complications compared with not using a tourniquet?
15. In adult patients with osteoarthritis undergoing TKA, does patellar resurfacing improve outcomes or decrease complications when compared to patients without patellar resurfacing?
16. In adult patients with osteoarthritis undergoing TKA, does the use of cruciate retaining arthroplasty design improve outcomes or decrease complications when compared to patients with posterior stabilized arthroplasty design?

17. In adult patients with osteoarthritis undergoing KA, does the use of patient specific technology improve outcomes and / or decrease complications when compared to standard knee replacement technique?
18. In adult patients with osteoarthritis undergoing KA and with no known contraindications to specific medications used, does peri-articular local infiltration (anesthetic and/or anti-inflammatory and/or analgesic) reduce complications or improve outcomes compared to not injecting this mixture?
19. In adult patients with osteoarthritis undergoing KA, does use of an all-polyethylene tibial component increase complications or diminish outcomes compared to a modular (metal and polyethylene) tibial component?
20. In adult patients with osteoarthritis undergoing KA, does discharge to an acute rehabilitation facility or skilled nursing facility improve outcomes and / or decrease complications compared with discharge to home, with or without home services?
21. In adult patients with osteoarthritis undergoing KA, does robotic-assistance technology improve outcomes and / or decrease complications?
22. In adult patients with osteoarthritis undergoing medial unicompartmental KA, does robotic-assistance technology improve outcomes and / or decrease complications?
23. In adult patients with osteoarthritis undergoing KA, does kinematic alignment improve outcomes and / or decrease complications?
24. In adult patients with osteoarthritis undergoing KA, does pre-operative opioid consumption leads to poor patient outcomes?

STUDY INCLUSION CRITERIA

Criteria to be Customized by Work Group (by PICO question or stage of care, if necessary)

1. Study must be of an osteoarthritis-related injury or prevention thereof
2. Study must be published in or after 1966 for surgical treatment, rehabilitation, bracing, prevention
3. Study must be published in or after 1966 for all others non specified
4. Study should have 10 or more patients per group (Work group may further define sample size)
5. For surgical treatment a minimum of N days/months/year (refer to PICO questions for detailed follow up duration) For non-operative treatment a minimum of N days/months/year (refer to PICO questions for detailed follow up duration)
6. For *prevention* studies a minimum of N days/months/year (refer to PICO questions for detailed follow up duration)

NEW 2020 Criteria to be Customized by Work Group (by PICO question or stage of care, if necessary)- approved

1. Study must be of an osteoarthritis-related injury or prevention thereof
2. Study must be published in or after 1995 for surgical treatment, rehabilitation, bracing, prevention
3. Study must be published in or after 1995 for all others non specified
4. Study should have 20 or more patients per group (Work group may further define sample size)
5. For surgical treatment a minimum of collect all follow up times (refer to PICO questions for detailed follow up duration)
6. For *prevention* studies a minimum of N days/months/year (refer to PICO questions for detailed follow up duration)

Standard Criteria for all CPGs

Article must be a full article report of a clinical study.
Retrospective non-comparative case series, medical records review, meeting abstracts, historical articles, editorials, letters, and commentaries are ***excluded***.
Confounded studies (i.e., studies that give patients the treatment of interest AND another treatment) are ***excluded***.
Case series studies that have non-consecutive enrollment of patients are ***excluded***.
Controlled trials in which patients were not stochastically assigned to groups AND in which there was either a difference in patient characteristics or outcomes at baseline AND where the authors did not statistically adjust for these differences when analyzing the results are ***excluded***.
All studies of "Very Weak" strength of evidence are ***excluded***. All studies evaluated as Level V will be ***excluded.***
Composite measures or outcomes are ***excluded*** even if they are patient-oriented.
Study must appear in a peer-reviewed publication
For any included study that uses "paper-and-pencil" outcome measures (e.g., SF-36), only those outcome measures that have been validated will be included
For any given follow-up time point in any included study, there must be ≥ 50% patient follow-up (if the follow-up is >50% but <80%, the study quality will be downgraded by one Level)
Study must be of humans
Study must be published in English
Study results must be quantitatively presented Study must not be an in vitro study
Study must not be a biomechanical study
Study must not have been performed on cadavers

We will only evaluate surrogate outcomes when no patient oriented outcomes are available.

Best Available Evidence

When examining primary studies, we will analyze the best available evidence regardless of study design. We will first consider randomized controlled trials identified by the search strategy. In the absence of two or more RCTs, we will sequentially search for prospective controlled trials, prospective comparative studies, retrospective comparative studies, and prospective case-series studies. Only studies of the highest level of available evidence are included, assuming that there were 2 or more

studies of that higher level. For example, if there are two Level II studies that address the recommendation, Level III and IV studies are not included.
We will only evaluate surrogate outcomes when no patient-oriented outcomes are available.
We did not include systematic reviews or meta-analyses compiled by others or guidelines developed by other organizations. These documents are developed using different inclusion criteria than those specified by the AAOS work group. Therefore, they may include studies that do not meet our inclusion criteria. We recalled these documents, if the abstract suggested they might provide an answer to one of our recommendations, and searched their bibliographies for additional studies to supplement our systematic review
*2020 literature search for all PICOs will be performed from last search date of 2015 CPG

Study Inclusion Criteria
Appendix III: Literature Search Strategy

Database:	MEDLINE
Interface:	Ovid MEDLINE® and Epub Ahead of Print, In-Process & Other Non-Indexed Citations, Daily and Versions ® 1946 to December 3, 2020
Date of Initial Search:	12/4/2020
Search	SMOAK 2020
Line	**Search Strategy**
1	exp Osteoarthritis-Knee/ OR (gonitis OR gonarthritis OR gonarthros*).ti,ab,kf.
2	exp Knee-Joint/ OR Knee/ OR (knee OR knees).ti,ab,kf.
3	Osteoarthritis/ OR Arthritis/ OR (osteoarthriti* OR osteoarthros* OR OA OR arthriti* OR arthrosis OR ((non-inflamm* OR noninflamm* OR degenerat* OR hypertropic) AND (joint? OR disease?))).ti,ab,kf.
4	(exp Animals/ NOT Humans/) OR exp Cadaver/ OR (animal? OR dog OR dogs OR canine OR cats OR feline OR horse? OR equine OR mouse OR mice OR rat OR rats OR rabbit? OR sheep OR porcine OR pig OR pigs OR rodent? OR monkey?).ti. OR (cadaver* OR in vitro).ti,ab. OR ((comment OR editorial OR letter OR historical article) NOT clinical trial).pt. OR address.pt. OR news.pt. OR newspaper article.pt. OR pmcbook.af. OR case reports.pt. OR (case report? OR abstracts OR editorial OR reply OR comment? OR commentary OR letter OR biomechanic*).ti.
5	(exp Infant/ OR exp Child/ OR exp Adolescent/ OR (p?ediatric* OR child OR children OR childhood OR adolescen* OR juvenile?).ti.) NOT (exp Adult/ OR adult*.ti.)
6	((1 OR (2 AND 3)) NOT (4 OR 5)) AND English.lg.
7	Arthroplasty-Replacement-Knee/ OR (arthroplast* OR replacement? OR TKA OR TKR).ti,ab,kf.
8	6 AND 7
9	exp Drainage/ OR drain*.ti,ab,kf.
10	Bone-Cements/ OR (cement* OR uncement* OR press-fit* OR (hybrid ADJ (arthroplast* OR replacement? OR TKA)) OR PMMA OR polymethylmethacrylate).ti,ab,kf.
11	(unicompartment* OR compartment* OR unicondylar OR (partial ADJ5 (arthroplast* OR replacement? OR TKA))).mp.

12	Anesthesia-Conduction/ OR exp Anesthesia-Epidural/ OR Anesthesia-Spinal/ OR exp Injections-Spinal/ OR ((neuraxial OR spinal OR epidural OR regional).ti,ab,kf. AND (exp Anesthetics/ OR exp Analgesics/ OR (an?esthesia OR an?esthetic? OR analgesi*).ti,ab,kf.))
13	Anesthesia-Local/ OR Anesthetics-Local/ OR exp Nerve-Block/ OR exp Injections-Intra-Articular/ OR ((nerve OR local OR peripheral OR periarticular OR intraarticular OR articular).ti,ab,kf. AND (exp Analgesics/ OR exp Adrenal-Cortex-Hormones/ OR (an?esthesia OR an?esthetic? OR analgesi* OR block* OR inject* OR corticosteroid* OR cortisone OR prednisolone OR methylprednisolone OR triamcinolone OR glucocorticoid* OR steroid* OR anti-inflammat*).ti,ab,kf.))
14	Tranexamic-Acid/ OR tranexamic.ti,ab,kf.
15	(bilateral AND (simultaneous* OR sequential* OR ((one OR single) ADJ (stage? OR an?esthe*)))).ti,ab,kf.
16	Surgery-Computer-Assisted/ OR exp Computer-Aided-Design/ OR ((computer ADJ (assist* OR aid*)) OR patient-specific OR patient-matched OR PSI).ti,ab,kf.
17	(kinematic* AND mechanical* AND align*).mp.
18	Risk-Factors/ OR Risk-Assessment/ OR exp Comorbidity/ OR exp Overweight/ OR Body-Mass-Index/ OR exp Diabetes-Mellitus/ OR exp Nervous-System-Diseases/ OR (obes* OR body-mass OR BMI OR comorbidit* OR co-morbidit* OR depressi* OR diabet* OR smok* OR hepatitis OR renal-insufficiency OR HIV OR Parkinson* OR neuropath* OR prognos* OR (predict* AND (outcome? OR factor?))).mp.
19	tourniquet?.mp.
20	(patell* AND (resurfac* OR re-surfac*)).mp.
21	((cruciate OR bicruciate OR condylar) ADJ5 (retain* OR retention OR preserv* OR spar* OR stabili*)).mp.
22	(polyethylene? OR poly).mp.
23	(postdischarg* OR discharg*).mp.
24	robo*.mp.

25	exp Narcotics/ OR (narcotic? OR opioid? OR opiate? OR oxycodone OR morphine OR Duramorph OR fentanyl OR meperidine OR tramadol).ti,ab,kf.
26	8 AND (9 OR 16 OR 22)
27	8 AND (10 OR 11 OR 12 OR 15 OR 18 OR 19 OR 21 OR 23)
28	8 AND (13 OR 14 OR 17 OR 24 OR 25)
29	randomized-controlled-trial.pt. OR exp Randomized-Controlled-Trials-as-Topic/ OR random-allocation/ OR random*.ti,ab.
30	(MEDLINE OR (systematic* AND review*) OR meta-analys*).ti,ab. OR (meta-analysis OR systematic-review).pt.
31	29 OR 30
32	31 OR registr*.mp.
33	26 AND 31
34	8 AND 20 AND 32
35	limit 33 to yr="2015-Current"
36	limit 34 to yr="2015-Current"
37	limit 27 to yr="2015-Current"
38	28 OR 35 OR 36 OR 37
39	limit 38 to ez=20201204-20210924

Database:	Embase
Interface:	Elsevier
Date:	12/4/2020
Search	SMOAK 2020
Line	**Search Strategy**
1	knee-osteoarthritis/exp OR (gonitis OR gonarthritis OR gonarthros*):ti,ab,kw
2	knee/exp OR (knee OR knees):ti,ab,kw
3	osteoarthritis/de OR arthritis/de OR (osteoarthriti* OR osteoarthros* OR OA OR arthriti* OR arthrosis OR ((non-inflamm* OR noninflamm* OR degenerat* OR hypertropic) AND (joint$ OR disease$))):ti,ab,kw
4	abstract-report/de OR book/de OR editorial/de OR editorial:it OR note/de OR note:it OR letter/de OR letter:it OR case-study/de OR case-report/de OR chapter:it OR conference-paper/exp OR conference-paper:it OR conference-abstract:it OR conference-review:it OR (abstracts OR editorial OR reply OR comment$ OR commentary OR letter OR biomechanic*):ti OR cadaver/de OR in-vitro-study/exp OR (cadaver* OR in-vitro):ti,ab OR animal-experiment/exp OR (animal$ OR dog OR dogs OR canine OR cats OR feline OR horse$ OR equine OR mouse OR mice OR rat OR rats OR rabbit$ OR sheep OR porcine OR pig OR pigs OR rodent$ OR monkey$):ti
5	(Juvenile/exp OR (p$ediatric* OR child OR children OR adolescen* OR juvenile$):ti) NOT (adult/exp OR adult*:ti)
6	(#1 OR (#2 AND #3)) NOT (#4 OR #5) AND [english]/lim
7	knee-arthroplasty/exp OR (arthroplast* OR replacement$ OR TKA OR TKR):ti,ab,kw
8	#6 AND #7
9	surgical-drainage/exp OR drain/exp OR drain*:ti,ab,kw
10	bone-cement/exp OR (cement* OR uncement* OR press-fit* OR (hybrid NEXT/1 (arthroplast* OR replacement$ OR TKA)) OR PMMA OR polymethylmethacrylate):ti,ab,kw
11	unicompartmental-knee-prosthesis/de OR (unicompartment* OR compartment* OR unicondylar OR (partial NEAR/5 (arthroplast* OR replacement$ OR TKA))):ti,ab,kw
12	spinal-anesthesia/de OR epidural-anesthesia/exp OR epidural-analgesia/de OR regional-anesthesia/de OR ((neuraxial OR spinal OR epidural OR regional):ti,ab,kw AND (anesthetic-agent/exp OR analgesic-agent/exp OR (an$esthesia OR an$esthetic? OR analgesi*):ti,ab,kw))
13	local-anesthesia/exp OR local-anesthetic-agent/exp OR nerve-block/exp OR periarticular-drug-administration/exp OR intraarticular-drug-administration/exp OR ((nerve OR local OR peripheral OR periarticular OR intraarticular OR articular):ti,ab,kw AND (analgesic-agent/exp OR (an$esthesia OR an$esthetic$ OR analgesi* OR block* OR inject* OR corticosteroid* OR cortisone OR prednisolone OR methylprednisolone OR triamcinolone OR glucocorticoid* OR steroid* OR anti-inflammat*):ti,ab,kw))
14	tranexamic-acid/de OR tranexamic:ti,ab,kw
15	(bilateral AND (simultaneous* OR sequential* OR ((one OR single) NEXT/1 (stage$ OR an$esthe*)))):ti,ab,kw
16	computer-assisted-surgery/de OR computer-aided-design/exp OR ((computer NEXT/1 (assist* OR aid*)) OR patient-specific OR patient-matched OR PSI):ti,ab,kw
17	(kinematic* AND mechanical* AND align*):ti,ab,kw

18	risk-factor/de OR risk-assessment/de OR comorbidity/de OR comorbidity-assessment/exp OR overweight/exp OR body-mass/de OR diabetes-mellitus/exp OR neurologic-disease/exp OR depression/exp OR (obes* OR body-mass OR BMI OR comorbidit* OR co-morbidit* OR depressi* OR diabet* OR smok* OR hepatitis OR renal-insufficiency OR HIV OR Parkinson* OR neuropath* OR prognos* OR (predict* AND (outcome$ OR factor$))):ti,ab,kw
19	tourniquet/exp OR tourniquet$:ti,ab,kw
20	(patell* AND (resurfac* OR re-surfac*)):ti,ab,kw
21	((cruciate OR bicruciate OR condylar) NEAR/5 (retain* OR retention OR preserv* OR spar* OR stabili*)):ti,ab,kw
22	polyethylene/de OR (polyethylene$ OR poly):ti,ab,kw
23	hospital-discharge/de OR (postdischarg* OR discharg*):ti,ab,kw
24	robot-assisted-surgery/exp OR robotics/exp OR robo*:ti,ab,kw
25	narcotic-agent/exp OR narcotic-analgesic-agent/exp OR (narcotic$ OR opioid$ OR opiate$ OR oxycodone OR morphine OR Duramorph OR fentanyl OR meperidine OR tramadol):ti,ab,kw
26	#8 AND (#9 OR #16 OR #22)
27	#8 AND (#10 OR #11 OR #12 OR #15 OR #18 OR #19 OR #21 OR #23)
28	#8 AND (#13 OR #14 OR #17 OR #24 OR #25)
29	randomized-controlled-trial/exp OR randomized-controlled-trial-topic/exp OR randomization/de OR random*:ti,ab,kw
30	systematic-review/exp OR meta-analysis/exp OR ((systematic* NEAR/2 review*):ti,ab,kw) OR meta-analys*:ti,ab,kw
31	#29 OR #30
32	#31 OR (register/de OR registr*:ti,ab,kw)
33	#26 AND #31
34	#8 AND #20 AND #32
35	#33 AND [2015-3000]/py
36	#34 AND [2015-3000]/py
37	#27 AND [2015-3000]/py
38	#28 OR #35 OR #36 OR #37
39	(#28 OR #35 OR #36 OR #37) AND [4-12-2020]/sd NOT [25-9-2021]/sd

Database:	Cochrane Central Register of Controlled Trials (CENTRAL)
Interface:	Wiley (https://www.cochranelibrary.com/central)
Date:	12/4/2020
Search	SMOAK 2020
Line	**Search Strategy**
1	[mh "Osteoarthritis, Knee"] OR (gonitis OR gonarthritis OR gonarthros*):ti,ab,kw
2	[mh "Knee Joint"] OR [mh Knee] OR (knee OR knees):ti,ab,kw
3	[mh ^Osteoarthritis] OR [mh ^Arthritis] OR (osteoarthriti* OR osteoarthros* OR OA OR arthriti* OR arthrosis OR (("non inflamm*" OR noninflamm* OR degenerat* OR hypertropic) AND (joint? OR disease?))):ti,ab,kw
4	"conference abstract":pt OR (abstracts OR editorial OR reply OR comment? OR commentary OR letter OR biomechanic*):ti OR (cadaver* OR "in vitro"):ti,ab OR (animal? OR dog OR dogs OR canine OR cats OR feline OR horse? OR equine OR mouse OR mice OR rat OR rats OR rabbit? OR sheep OR porcine OR pig OR pigs OR rodent? OR monkey?):ti
5	([mh Infant] OR [mh Child] OR [mh Adolescent] OR (pediatric* OR paediatric* OR child OR children OR childhood OR adolescen* OR juvenile?):ti) NOT ([mh Adult] OR adult*:ti)
6	(#1 OR (#2 AND #3)) NOT (#4 OR #5)
7	[mh "Arthroplasty, Replacement, Knee"] OR (arthroplast* OR replacement? OR TKA OR TKR):ti,ab,kw
8	#6 AND #7
9	[mh Drainage] OR drain*:ti,ab,kw
10	[mh "Bone Cements"] OR (cement* OR uncement* OR "press fit*" OR (hybrid NEXT/1 (arthroplast* OR replacement? OR TKA)) OR PMMA OR polymethylmethacrylate):ti,ab,kw
11	(unicompartment* OR compartment* OR unicondylar OR (partial NEAR/5 (arthroplast* OR replacement? OR TKA))):ti,ab,kw
12	[mh ^"Anesthesia, Conduction"] OR [mh "Anesthesia, Epidural"] OR [mh "Anesthesia, Spinal"] OR [mh "Injections, Spinal"] OR ((neuraxial OR spinal OR epidural OR regional):ti,ab,kw AND ([mh Anesthetics] OR [mh Analgesics] OR (an?esthesia OR an?esthetic? OR analgesi*):ti,ab,kw))
13	[mh "Anesthesia, Local"] OR [mh "Anesthetics, Local"] OR [mh "Nerve Block"] OR [mh "Injections, Intra-Articular"] OR ((nerve OR local OR peripheral OR periarticular OR intraarticular OR articular):ti,ab,kw AND ([mh Analgesics] OR (an?esthesia OR an?esthetic? OR analgesi* OR block* OR inject* OR corticosteroid* OR cortisone OR prednisolone OR methylprednisolone OR triamcinolone OR glucocorticoid* OR steroid* OR "anti inflammat*"):ti,ab,kw))
14	[mh "Tranexamic Acid"] OR tranexamic:ti,ab,kw
15	(bilateral AND (simultaneous* OR sequential* OR ((one OR single) NEXT/1 (stage? OR an?esthe*)))):ti,ab,kw
16	[mh ^"Surgery, Computer-Assisted"] OR [mh "Computer-Aided Design"] OR ((computer NEXT/1 (assist* OR aid*)) OR "patient specific" OR "patient matched" OR PSI):ti,ab,kw
17	(kinematic* AND mechanical* AND align*):ti,ab,kw

18	[mh "Risk Factors"] OR [mh ^"Risk Assessment"] OR [mh Comorbidity] OR [mh Overweight] OR [mh "Body Mass Index"] OR [mh "Diabetes Mellitus"] OR [mh "Nervous System Diseases"] OR (obes* OR "body mass" OR BMI OR comorbidit* OR "co morbidit*" OR depressi* OR diabet* OR smok* OR hepatitis OR "renal insufficiency" OR HIV OR Parkinson* OR neuropath* OR prognos* OR (predict* AND (outcome? OR factor?))):ti,ab,kw
19	tourniquet?:ti,ab,kw
20	(patell* AND (resurfac* OR "re surfac*")):ti,ab,kw
21	((cruciate OR bicruciate OR condylar) NEAR/5 (retain* OR retention OR preserv* OR spar* OR stabili*)):ti,ab,kw
22	(polyethylene? OR poly):ti,ab,kw
23	(postdischarg* OR discharg*):ti,ab,kw
24	robo*:ti,ab,kw
25	[mh Narcotics] OR (narcotic? OR opioid? OR opiate? OR oxycodone OR morphine OR Duramorph OR fentanyl OR meperidine OR tramadol):ti,ab,kw
26	#8 AND (#9 OR #16 OR #20 OR #22) *with Publication Year from 2015 to 2020, in Trials [with Cochrane Library publication date from Dec 2020 to Sep 2021, in Trials]* --> ***this last part is on update only***
27	#8 AND (#10 OR #11 OR #12 OR #15 OR #18 OR #19 OR #21 OR #23) *with Publication Year from 2015 to 2020, in Trials [with Cochrane Library publication date from Dec 2020 to Sep 2021, in Trials]* --> ***this last part is on update only***
28	#8 AND (#13 OR #14 OR #17 OR #24 OR #25) *[with Cochrane Library publication date from Dec 2020 to Sep 2021, in Trials]* --> ***this last part is on update only***
29	#26 OR #27 OR #28

Appendix IV: Guideline Development Group Disclosures

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Submitted on: 03/20/2020
American Shoulder and Elbow Surgeons: Board or committee member ($0) Committee Member (Self)
Arthroscopy Association of North America: Board or committee member ($0)
Bioventus: Paid consultant ($3,500) N/A(Self)
Mitek: Paid consultant ($0)
Nice Recovery Systems: Stock or stock Options Number of Shares: 5,000 N/A(Self)
Smith & Nephew: Paid consultant ($10,000) N/A(Self)

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Michigan Arthroplasty Registry Collaborative Quality Initiative (MARCQI): Board or committee member ($0)

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Submitted on: 03/20/2020
ISCT: Board or committee member ($0) Musculoskeletal committee (Self)
Journal of Hip Surgery: Editorial or governing board ($0) Associate Editor (Self)
Orthopaedic Research Society: Board or committee member ($0) Clinical Research Committee (Self)
RegenLab: Research support ($150,000) Prospective RCT(Self)
Zimmer: Research support ($75,000) Postmarket analysis – Perfusr (Self)

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Submitted on: 03/20/2020
OREF: Research support ($50,000) Goldberg Arthritis Grant (Self)
Stryker: Research support ($0)

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(This individual reported nothing to disclose); Submitted on: 03/20/2020