

Evaluation of the American Academy of Orthopaedic Surgeons Appropriate Use Criteria for the Nonarthroplasty Treatment of Knee Osteoarthritis in Veterans

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While patients without knee instability use more nonarthroplasty treatments over a longer period prior to total knee arthroplasty, patients with less severe knee osteoarthritis are at risk of receiving interventions judged to be rarely appropriate.

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Knee osteoarthritis (OA) affects almost 9.3 million adults in the US and accounts for \$27 billion in annual health care expenses.^{1,2} Due to the increasing cost of health care and an aging population, there has been renewed interest in establishing criteria for nonarthroplasty treatment of knee OA.

In 2013, using the RAND/UCLA Appropriateness method, the American Academy of Orthopaedic Surgeons (AAOS) developed an appropriate use criteria (AUC) for nonarthroplasty management of primary OA of the knee, based on orthopaedic literature and expert opinion.³ Interventions such as activity modification, weight loss, prescribed physical therapy, nonsteroidal anti-inflammatory drugs, tramadol, prescribed oral or transcutaneous opioids, acetaminophen, intra-articular corticosteroids, hinged or unloading knee braces, arthroscopic partial meniscectomy or loose body removal, and realignment osteotomy were assessed. An algorithm was developed for 576 patients scenarios that incorporated patient-specific, prognostic/predictor variables to assign designations of “appropriate,” “may be appropriate,” or “rarely appropriate,” to treatment interventions.^{4,5} An online version of the algorithm (orthoguidelines.org) is available for physicians and surgeons to judge appropriateness of nonarthroplasty treatments; however, it is not intended to mandate candidacy for treatment or intervention.

Clinical evaluation of the AAOS AUC

is necessary to determine how treatment recommendations correlate with current practice. A recent examination of the AAOS Appropriateness System for Surgical Management of Knee OA found that prognostic/predictor variables, such as patient age, OA severity, and pattern of knee OA involvement were more heavily weighted when determining arthroplasty appropriateness than was pain severity or functional loss.⁶ Furthermore, non-AAOS AUC prognostic/predictor variables, such as race and gender, have been linked to disparities in utilization of knee OA interventions.⁷⁻⁹ Such disparities can be costly not just from a patient perspective, but also employer and societal perspectives.¹⁰

The Department of Veterans Affairs (VA) health care system represents a model of equal-access-to care system in the US that is ideal for examination of issues about health care utilization and any disparities within the AAOS AUC model and has previously been used to assess utilization of total knee arthroplasty.⁹ The aim of this study was to characterize utilization of the AAOS AUC for nonarthroplasty treatment of knee OA in a VA patient population. We asked the following questions: (1) What variables are predictive of receiving a greater number of AAOS AUC evaluated nonarthroplasty treatments? (2) What variables are predictive of receiving “rarely appropriate” AAOS AUC evaluated nonarthroplasty treatment? (3) What factors are predictive of duration of nonarthroplasty care until total knee arthroplasty (TKA)?

METHODS

The institutional review board at the Louis Stokes Cleveland VA Medical Center in Ohio approved a retrospective chart review of nonarthroplasty treatments utilized by patients presenting to its orthopaedic section who subsequently underwent knee arthroplasty between 2013 and 2016. Eligibility criteria included patients aged ≥ 30 years with a diagnosis of unilateral or bilateral primary knee OA. Patients with posttraumatic OA, inflammatory arthritis, and a history of infectious arthritis or Charcot arthropathy of the knee were excluded. Patients with a body mass index (BMI) > 40 or a hemoglobin $A_{1c} > 8.0$ at presentation were excluded as nonarthroplasty care was the recommended course of treatment above these thresholds.

Data collected included race, gender, duration of nonarthroplasty treatment, BMI, and Kellgren-Lawrence classification of knee OA at time of presentation for symptomatic knee OA.¹¹ All AAOS AUC-evaluated nonarthroplasty treatments utilized prior to arthroplasty intervention also were recorded (Table 1). Indications and classifications for each subject were entered into the AAOS AUC online algorithm, and every AAOS AUC evaluated treatment utilized was assigned a rating of appropriate, may be appropriate, or rarely appropriate, based on the algorithm results for that clinical scenario (Table 2). Information regarding anti-inflammatory, analgesic, and prescribed oral or transcutaneous opioid use for chronic knee pain during the period of nonoperative management of knee OA prior to TKA was obtained by review of medication lists and reconciliation with orthopaedic consultation notes in the electronic health record. Peri-operative anti-inflammatory, analgesic, and prescribed oral or transcutaneous opioid use did not constitute an AUC intervention.

STATISTICAL ANALYSIS

Statistical analysis was completed with GraphPad Software Prism 7.0a (La Jolla, CA) and Mathworks MatLab R2016b software (Natick, MA). Univariate analysis with Student *t* tests with Welch corrections in the setting of unequal variance, Mann-Whitney nonparametric tests, and Fisher exact test were generated in the appropriate

TABLE 1 Patient Indications and Classifications^a

Patient Indication	Classification
Function-limiting pain	a. Function-limiting pain at moderate to long distances b. Function-limiting pain at short distances (limiting activity to 2 city blocks, the equivalent to walking the length of a shopping mall) c. Pain at rest
Range of motion	a. Full range of extension/flexion b. Lack of full extension ($> 5^\circ$ flexion contracture) and/or flexion $< 110^\circ$
Ligamentous instability	a. No ligamentous instability b. Ligamentous instability
Pattern of arthritis involvement	a. Predominantly 1 compartment b. > 1 compartments
Imaging	a. Mild-to-moderate joint space narrowing (without complete loss of joint space) b. Severe (complete loss of joint space)
Limb alignment	a. Normal alignment b. Varus/valgus and/or patellofemoral malalignment
Mechanical symptoms	a. Yes b. No
Age (y)	a. Young (30-49) b. Middle (50-69) c. Old (> 70)

^aClassification descriptors of the patient indications used in the American Academy of Orthopaedic Surgeons appropriate use criteria algorithm for nonarthroplasty treatment of knee osteoarthritis.

setting. Multivariable analyses also were conducted. For continuous outcomes, stepwise multiple linear regression was used to generate predictive models; for binary outcomes, binomial logistic regression was used.

Factors analyzed in regression modeling for the total number of AAOS AUC evaluated nonarthroplasty treatments utilized and the likelihood of receiving a rarely appropriate treatment included gender, race, function-limiting pain, range of motion (ROM), ligamentous instability, arthritis pattern, limb alignment, mechanical symptoms, BMI, age, and Kellgren-Lawrence grade. Factors analyzed in timing of TKA included the above variables plus the total number of AUC interventions, whether the patient received an inappropriate intervention, and average appropriateness of the interventions received. Residual analysis with Cook's distance was used to identify outliers in regression. Observations with Cook's distance > 3 times the

TABLE 2 American Academy of Orthopaedic Surgeons Appropriate Use Criteria RAND/UCLA Appropriateness Scale

Scale	Rating	Description
Rarely appropriate	1 to 3	Median panel rating between 1 and 3 with no disagreement
May be appropriate	4 to 6	Median panel rating between 4 and 6 or median panel rating between 1 and 9 with disagreement
Appropriate	7 to 9	Median panel rating between 7 and 9 with no disagreement

TABLE 3 Patient Demographics

Demographics	Study Participants
Sex, No. (%)	
Male	89 (97.8)
Female	2 (2.2)
Race, No. (%)	
White	64 (70.3)
African American	23 (25.3)
Other	4 (4.4)
Laterality, No. (%)	
Right	47 (52.0)
Left	44 (48.0)
Age at presentation, y	
Mean (SD)	62.8 (8.8)
Median	62

mean Cook's distance were identified as potential outliers, and models were adjusted accordingly. All statistical analyses were 2-tailed. Statistical significance was set to $P \leq .05$ for all outputs.

RESULTS

In the study, 97.8% of participants identified as male, and the mean age was 62.8 years (Table 3). The study group was predominantly white (70.3%). All participants had a diagnosis of primary OA. The majority of patients were aged 51 to 70 years (68.1%) and presented with pain occurring following short-distance ambulation (79.1%) but without mechanical symptoms (80.2%). On examination, the majority of patients were found to have full knee ROM (53.8%), no ligamentous instability (97.8%), and normal limb alignment (60.4%). Radiographically, patients most often had multicompartamental disease (69.2%) with evidence of severe joint-space

narrowing (63.7%), resulting in a plurality of patients having a Kellgren-Lawrence arthritis grade of 3 (46.2%) (Table 4).

Appropriate Use Criteria Interventions

Patients received a mean of 5.2 AAOS AUC evaluated interventions before undergoing arthroplasty management at a mean of 32.3 months (range 2-181 months) from initial presentation. The majority of these interventions were classified as either appropriate or may be appropriate, according to the AUC definitions (95.1%). Self-management and physical therapy programs were widely utilized (100% and 90.1%, respectively), with all use of these interventions classified as appropriate.

Hinged or unloader knee braces were utilized in about half the study patients; this intervention was classified as rarely appropriate in 4.4% of these patients. Medical therapy was also widely used, with all use of NSAIDs, acetaminophen, and tramadol classified as appropriate or may be appropriate. Oral or transcutaneous opioid medications were prescribed in 14.3% of patients, with 92.3% of this use classified as rarely appropriate. Although the opioid medication prescribing provider was not specifically evaluated, there were no instances in which the orthopaedic service provided an oral or transcutaneous opioid prescriptions. Procedural interventions, with the exception of corticosteroid injections, were uncommon; no patient received realignment osteotomy, and only 12.1% of patients underwent arthroscopy. The use of arthroscopy was deemed rarely appropriate in 72.7% of these cases.

Factors Associated With AAOS AUC Intervention Use

There was no difference in the number of AAOS AUC evaluated interventions received based on BMI (mean [SD] BMI < 35, 5.2 [1.0] vs BMI ≥ 35, 5.3 [1.1], $P = .49$), age (mean [SD] aged < 60 years, 5.4 [1.0] vs aged ≥ 60 years, 5.1 [1.2], $P = .23$), or Kellgren-Lawrence arthritic grade (mean [SD] grade ≤ 2, 5.5 [1.0] vs grade > 2, 5.1 [1.1], $P = .06$). These variables also were not associated with receiving a rarely appropriate intervention (mean [SD] BMI < 35, 0.27 [0.5] vs BMI > 35, 0.2 [0.4], $P = .81$; aged > 60 years, 0.3 [0.5] vs aged < 60 years, 0.2 [0.4], $P = .26$;

Kellgren-Lawrence grade < 2, 0.4 [0.6] vs grade > 2, 0.2 [0.4], $P = .1$).

Regression modeling to predict total number of AAOS AUC evaluated interventions received produced a significant model ($R^2 = 0.111$, $P = .006$). The presence of ligamentous instability (β coefficient, -1.61) and the absence of mechanical symptoms (β coefficient, -0.67) were negative predictors of number of AUC interventions received. Variance inflation factors were 1.014 and 1.012, respectively. Likewise, regression modeling to identify factors predictive of receiving a rarely appropriate intervention also produced a significant model (pseudo $R^2 = 0.06$, $P = .025$), with lower Kellgren-Lawrence grade the only significant predictor of receiving a rarely appropriate intervention (odds ratio [OR] 0.54; 95% CI, 0.42 -0.72, per unit increase).

Timing from presentation to arthroplasty intervention was also evaluated. Age was a negative predictor (β coefficient -1.61), while positive predictors were reduced ROM (β coefficient 15.72) and having more AUC interventions (β coefficient 7.31) (model $R^2 = 0.29$, $P = < .001$). Age was the most significant predictor. Variance inflation factors were 1.02, 1.01, and 1.03, respectively. Receiving a rarely appropriate intervention was not associated with TKA timing.

DISCUSSION

This single-center retrospective study examined the utilization of AAOS AUC-evaluated nonarthroplasty interventions for symptomatic knee OA prior to TKA. The aims of this study were to validate the AAOS AUC in a clinical setting and identify predictors of AAOS AUC utilization. In particular, this study focused on the number of interventions utilized prior to knee arthroplasty, whether interventions receiving a designation of rarely appropriate were used, and the duration of nonarthroplasty treatment.

Patients with knee instability used fewer total AAOS AUC evaluated interventions prior to TKA. Subjective instability has been reported as high as 27% in patients with OA and has been associated with fear of falling, poor balance confidence, activity limitations, and lower Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) physical function scores.¹²

TABLE 4 AAOS AUC Indications in Study Population

Indications	No. (%)
Function-limiting pain	
Long distance	10 (11.0)
Short distance	72 (79.1)
Pain at night	9 (9.9)
Range of motion	
Full	49 (53.8)
> 5° flexion contraction	42 (46.2)
Ligamentous instability	
No	89 (97.8)
Yes	2 (2.2)
Pattern of arthritic involvement	
Single compartment	28 (30.8)
Multiple compartments	63 (69.2)
Joint space narrowing	
Mild-to-moderate	33 (36.3)
Severe	58 (63.7)
Limb alignment	
Normal	55 (60.4)
Varus/valgus/patellofemoral malalignment	36 (39.6)
Mechanical symptoms	
Absent	73 (80.2)
Present	18 (19.8)
Age group, y	
30-50	11 (12.1)
51-70	62 (68.1)
> 70	18 (19.8)
Kellgren-Lawrence arthritis grade	
0	0
1	12 (13.2)
2	20 (22.0)
3	42 (46.2)
4	17 (18.7)

Abbreviations: AAOS, American Academy of Orthopaedic Surgeons; AUC, appropriate use criteria.

However, it has not been found to correlate with knee laxity.¹³ Nevertheless, significant functional impairment with the risk of falling may reduce the number of nonarthroplasty interventions attempted. On the other hand, the presence of mechanical symptoms resulted in greater utilization of nonarthroplasty interventions. This is likely due to the greater utilization of arthroscopic partial meniscectomy or loose body removal in this group of patients. Despite its inclusion as an AAOS AUC evaluated intervention, arthroscopy remains a contentious treatment for symptomatic knee pain in the setting of OA.^{14,15}

For every unit decrease in Kellgren-Lawrence OA grade, patients were 54% more likely to receive a rarely appropriate intervention prior to knee arthroplasty. This is supported by the recent literature examining the AAOS AUC for surgical management of knee OA. Riddle and colleagues developed a classification tree to determine the contributions of various prognostic variables in final classifications of the 864 clinical vignettes used to develop the appropriateness algorithm and found that OA severity was strongly favored, with only 4 of the 432 vignettes with severe knee OA judged as rarely appropriate for surgical intervention.⁶

Our findings, too, may be explained by an AAOS AUC system that too heavily weighs radiographic severity of knee OA, resulting in more frequent rarely appropriate interventions in patients with less severe arthritis, including nonarthroplasty treatments. It is likely that rarely appropriate interventions were attempted in this subset of our study cohort based on patient's subjective symptoms and functional status, both of which have been shown to be discordant with radiographic severity of knee OA.¹⁶

Oral or transcutaneous prescribed opioid medications were the most frequent intervention that received a rarely appropriate designation. Patients with preoperative opioid use undergoing TKA have been shown to have a greater risk for postoperative complications and longer hospital stay, particularly those patients aged < 75 years. Younger age, use of more interventions, and decreased knee ROM at presentation were predictive of longer duration of nonarthroplasty treatment. The use of more AAOS AUC evaluated interventions in these patients suggests that the AAOS AUC model may effectively be used to manage symptomatic OA, increasing the time from presentation to knee arthroplasty.

Interestingly, the use of rarely appropriate interventions did not affect TKA timing, as would be expected in a clinically effective nonarthroplasty treatment model. The reasons for rarely appropriate nonsurgical interventions are complex and require further investigation. One possible explanation is that decreased ROM was a marker for mechanical symptoms that necessitated additional intervention in the form of knee arthroscopy, delaying time to TKA.

Limitations

There are several limitations of this study. First, the small sample size (N = 90) requires acknowledgment; however, this limitation reflects the difficulty in following patients for years prior to an operative intervention. Second, the study population consists of veterans using the VA system and may not be reflective of the general population, differing with respect to gender, racial, and socioeconomic factors. Nevertheless, studies examining TKA utilization found, aside from racial and ethnic variability, patient gender and age do not affect arthroplasty utilization rate in the VA system.¹⁷

Additional limitations stem from the retrospective nature of this study. While the Computerized Patient Record System and centralized care of the VA system allows for review of all physical therapy consultations, orthotic consultations, and medications within the VA system, any treatments and intervention delivered by non-VA providers were not captured. Furthermore, the ability to assess for confounding variables limiting the prescription of certain medications, such as chronic kidney disease with NSAIDs or liver disease with acetaminophen, was limited by our study design.

Although our study suffers from selection bias with respect to examination of nonarthroplasty treatment in patients who have ultimately undergone TKA, we feel that this subset of patients with symptomatic knee OA represents the majority of patients evaluated for knee OA by orthopaedic surgeons in the clinic setting. It should be noted that although realignment osteotomies were sometimes indicated as appropriate by AAOS AUC model in our study population, this intervention was never performed due to patient and surgeon preference. Additionally, although it is not an AAOS AUC evaluated intervention, viscosupplementation was sporadically used during the study period; however, it is now off formulary at the investigation institution.

CONCLUSION

Our study suggests that patients without knee instability use more nonarthroplasty treatments over a longer period before TKA, and those patients with less severe knee OA are at risk of receiving an intervention judged to be rarely appropriate

by the AAOS AUC. Such interventions do not affect timing of TKA. Nonarthroplasty care should be individualized to patients' needs, and the decision to proceed with arthroplasty should be considered only after exhausting appropriate conservative measures. We recommend that providers use the AAOS AUC, especially when treating younger patients with less severe knee OA, particularly if considering opiate therapy or knee arthroscopy.

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Author disclosures

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Disclaimer

The opinions expressed herein are those of the authors and do not necessarily reflect those of *Federal Practitioner*, Frontline Medical Communications Inc., the US Government, or any of its agencies.

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