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Assessment of Residual Pain and Dissatisfaction in Total Knee Arthroplasty

Methods Matter

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Background: Residual pain after total knee arthroplasty (TKA) refers to knee pain after 3 to 6 months postoperatively. The estimates of the proportion of patients who experience residual pain after TKA vary widely. We hypothesized that the variation may stem from the range of methods used to assess residual pain. We analyzed data from 2 prospective studies to assess the proportion of subjects with residual pain as defined by several commonly used metrics and to examine the association of residual pain defined by each metric with participant dissatisfaction.

Methods: We combined participant data from 2 prospective studies of TKA outcomes from subjects recruited between 2011 and 2014. Residual pain was defined using a range of metrics based on the WOMAC (Western Ontario and McMaster Universities Osteoarthritis Index) pain score (0 to 100, in which 100 indicates worst), including the minimal clinically important difference (MCID) and patient acceptable symptom state (PASS). We also examined combinations of MCID and PASS cutoffs. Subjects self-reported dissatisfaction following TKA, and we defined dissatisfied as somewhat or very dissatisfied at 12 months. We calculated the proportion of participants with residual pain, as defined by each metric, who reported dissatisfaction. We examined the association of each metric with dissatisfaction by calculating the sensitivity, specificity, positive predictive value, and Youden index.

Results: We analyzed data from 417 subjects with a mean age (and standard deviation) of 66.3 ± 8.3 years. Twenty-six participants (6.2%) were dissatisfied. The proportion of participants defined as having residual pain according to the various metrics ranged from 5.5% to >50%. The composite metric Improvement in WOMAC pain score ≥20 points or final WOMAC pain score ≤25 had the highest positive predictive value for identifying dissatisfied subjects (0.54 [95% confidence interval, 0.35 to 0.71]). No metric had a Youden index of ≥50%.

Conclusions: Different metrics provided a wide range of estimates of residual pain following TKA. No estimate was both sensitive and specific for dissatisfaction in patients who underwent TKA, underscoring that measures of residual pain should be defined explicitly in reports of TKA outcomes.

Level of Evidence: Therapeutic Level III. See Instructions for Authors for a complete description of levels of evidence.

Primary total knee arthroplasty (TKA) is a common procedure typically performed for severe knee osteoarthritis. In 2018, 715,200 TKAs were recorded in the National Inpatient Sample in the United States[1]. In 2019, 109,540 TKAs were performed in England, Wales, and Northern Ireland[2]. Pain and pain-related functional limitations are the main clinical indications for undergoing TKA, widely considered an efficacious treatment for those with painful knee osteoarthritis who have undergone failed conservative therapy[3,4].

Although TKA is generally regarded as a successful intervention, some patients report that they are dissatisfied, do not have improvement in quality of life, or continue to experience pain[5-7]. Postoperative pain is expected following TKA, but pain persisting beyond 3 to 6 months postoperatively is referred to as residual pain[8]. Systematic reviews and registry data have suggested that the proportion of patients with residual pain several months after TKA varies widely across studies[8,9]. For example, in a systematic review of 11 prospective studies,

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Beswick et al. found that estimates of unfavorable pain outcomes after TKA ranged from 8% to 27%[9], and more recent cohort studies have reported that 16% to 33% of patients experience residual pain after TKA[10,11]. In a cross-sectional study of 250 patients undergoing TKA, 19% reported "severe" to "unbearable" pain at 3 years after primary TKA[10]. In a prospective study from an Ontario registry, 28% reported dissatisfaction with relief of pain when climbing stairs and 15% reported dissatisfaction with relief of pain when walking on flat ground 1 year after TKA[12].

The wide range of pain estimates following TKA may relate to the way in which each study defined residual pain[8,9]. Patient-reported outcome measures such as the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) are typically used to assess TKA outcomes and have been demonstrated to be valid, reliable, and responsive to change[3]. Reported estimates of residual pain are typically based on achieving either an absolute score threshold at the follow-up assessment or a specified improvement in score between baseline and follow-up, such as the minimal clinically important difference (MCID)[13,14]. In the systematic review by Beswick et al.[9], each estimate of residual pain was based on failing to meet a threshold of improvement on the WOMAC, Knee Osteoarthritis Outcome Score, Oxford Knee Score, or a visual analog scale (VAS) for pain over a 3-month to 5-year postoperative period.

We hypothesized that estimates of residual pain vary widely depending on the method used to define the threshold for residual pain. We reasoned that the most meaningful definitions of residual pain should be associated with dissatisfaction with the results of TKA. To that end, we examined the association between the various estimates of residual pain, using commonly used metrics such as the MCID, and patient-reported dissatisfaction.

Materials and Methods

Study Participants

We used the data from 2 prospective studies. The AViKA (Adding Value in Knee Arthroplasty) Navigator study was a randomized controlled trial of subjects undergoing TKA for knee osteoarthritis by 5 orthopaedic surgeons at a tertiary medical center (Brigham and Women's Hospital)[15]. Between August 2011 and November 2013, we screened 1,234 participants scheduled to undergo TKA at that center[15]. The study compared 2 management strategies over the first 6 months postoperatively: enhanced postoperative care with frequent follow-up by a care navigator, and usual postoperative care[16]. Subjects were followed for up to 60 months. The results of the trial have been reported previously[17].

Study of Total Knee Arthroplasty Responses (STARs) was a prospective cohort study of patients who underwent TKA that recruited subjects at 1 academic center (NYU Langone Medical Center) and 2 community orthopaedic centers (Orthopaedic & Spine Center of the Rockies and University of Maryland St. Joseph Medical Center). Participants were screened and enrolled between September 2012 and April 2014. All participants completed a baseline questionnaire within 6 weeks prior to the surgical procedure and were followed postoperatively for up to 60 months[18].

Both AViKA and STARs study participants were followed for at least 12 months after the TKA, the follow-up interval used in this analysis. The AViKA and STARs protocols were approved by the Partners Healthcare (now Mass General Brigham) institutional review board (protocol 2010P002597). Data were collected and managed using Research Electronic Data Capture (REDCap)[19].

Inclusion and Exclusion Criteria

AViKA and STARs participants were adults who were ≥40 years of age and underwent TKA for knee osteoarthritis. In the AViKA and STARs cohorts, participants were excluded if they had dementia, had psychological issues that precluded participation, lived in a nursing home, or had plans for bilateral TKA. To investigate the association between residual pain and dissatisfaction in this study, we further excluded participants with missing 12-month WOMAC pain scores or satisfaction scores.

Baseline Data

We assessed baseline (preoperative) demographic and clinical characteristics. We dichotomized several continuous measures to make them more interpretable. For example, we dichotomized body mass index (BMI) at ≥30 kg/m^2. We used the 5-item Mental Health Inventory (MHI-5) as a measure of anxiety and depressive feelings[20]. The scale ranges from 1 to 100 (best); we dichotomized it at 68[21], as an MHI-5 score of <68 has been validated to indicate worse mental health[22]. We dichotomized the 5-question subscale of the Pain Catastrophizing Scale, which measures catastrophic thinking related to pain on a scale measuring from 0 to 52, with higher scores corresponding to higher levels of pain catastrophizing[23]. We used a cutoff of ≥30 to represent a high degree of pain catastrophizing[24].

Dissatisfaction

We defined dissatisfaction following TKA at 12 months using 2 questions from the validated Self-Administered Patient Satisfaction (SAPS) questionnaire[25]. Participants were deemed dissatisfied if they answered "very dissatisfied" or "somewhat dissatisfied" to the questions of "How satisfied are you with the results of your knee replacement in relieving your pain?" or "Overall, how satisfied are you with the results of your knee replacement?" (possible responses: very dissatisfied, somewhat dissatisfied, somewhat satisfied, very satisfied). We chose these 2 satisfaction items because they represent the individual participant's overall assessment of the outcome following TKA and of pain relief, often the primary indication for TKA[26,27].

Residual Pain

We defined residual pain by a range of thresholds involving baseline and follow-up WOMAC pain scores. The WOMAC pain scores are a validated 5-item pain questionnaire where subjects respond to each item by checking 1 of 5 ordinal Likert responses[28]. The WOMAC pain scores are responsive to change following surgical intervention for knee osteoarthritis, with minimal floor effects[29]. The score was converted to a 0-to-100 scale, with 100

being the worst pain. Definitions of residual pain, chosen from the published literature, have been derived in samples of patients with knee osteoarthritis undergoing several different therapies including TKA, high tibial osteotomy, and drug therapies (Table I)[30-33].

We first calculated the proportion of subjects with residual pain as defined by various commonly used metrics (algorithms involving a threshold value) using the WOMAC pain scores. We present and define these metrics in Table I, along with the nomenclature that we use in this study for each metric. Kim et al. reported WOMAC pain on a 0-to-20 scale; hence, we multiplied their reported MCID by 5, as we used a WOMAC pain score of 0 to 100[34]. Escobar et al. used an anchor-based method to determine a patient acceptable symptom state (PASS) value of 75 that was based on reverse WOMAC pain scores; hence, we used a value of 25 on WOMAC pain scores as the PASS threshold[35]. In addition, we created 2 composite outcomes combining literature-based estimates of the PASS and MCID. Second, we calculated the proportion of subjects with residual pain using a series of thresholds for improvement (e.g., 5 points, 10 points, 15 points) in WOMAC pain scores.

Statistical Analysis

We determined the relationship of each estimate of residual pain with dissatisfaction using the 12-month follow-up data. We created a contingency table to determine the association between the presence of residual pain and dissatisfaction using each metric defined in Table I. We calculated the sensitivity, specificity, and positive predictive value of each measure of residual pain in relation to dissatisfaction with the results of the TKA, along with their 95% confidence intervals (CIs). For each residual pain definition, we plotted the sensitivity against 1 – specificity for dissatisfaction. We then calculated the Youden index (the percentage of sensitivity plus the percentage of specificity – 100) for each metric. The Youden index permits the selection of an optimal threshold value or cutoff between sensitivity and specificity[36]. A Youden index of ≥50% has been considered appropriate for a diagnostic test[37]. All analyses were conducted using R statistical software (version 12.0; The R Foundation).

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Results

Cohort Characteristics

There were 575 participants enrolled in the AViKA and STARs cohorts. Of these, 158 subjects (27.5%) had missing satisfaction or WOMAC pain scores at 12 months and were excluded from this study. The included and excluded participants had similar baseline demographic characteristics, although

TABLE I Metrics Employed in the Literature to Define Residual Pain After Knee Surgery Using the WOMAC Pain Score

Metric	Definition	Cutoff	Treatment	Nomenclature in This Manuscript	Interpretation	Study
Minimal clinically important difference (MCID)	The smallest difference that individuals consider important[41]	11	TKA	MCID11	WOMAC pain score change ≥ 11	Clement[30]
		25	High tibial osteotomy	MCID25	WOMAC pain score change ≥ 25	Kim[34]
Minimally important change (MIC)	The change in the WOMAC score, relative to the baseline score, for individuals who report a little improvement in their quality of life[30]	21	TKA	MIC21	WOMAC pain score change ≥ 21	Clement[30]
Minimal clinically important change (MCIC)	The smallest difference in score, in the domain of interest, that individuals perceive as beneficial[42]	31.25	TKA	MCIC31.25	WOMAC pain score change ≥ 31.25	Maratt[42]
Minimally important difference (MID)	The smallest change in an outcome that individuals identify as important[43]	7.5	TKA	MID7.5	WOMAC pain score change ≥ 7.5	Holtz[31]
Meaningful within-person change (MWPC)	The smallest change at which individuals experience a meaningful clinical benefit[33]	30% improvement	Oral medical therapy	MWPC30%	WOMAC pain score change ≥ 30% of baseline	Conaghan[33]
PASS	The highest level of symptoms at which individuals consider themselves well[44]	25	TKA	PASS25	Final WOMAC pain scale score ≤ 25	Escobar[35]

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TABLE II Dissatisfied Participants with Residual Pain Following TKA According to Commonly Employed Metrics

Metric	Proportion Not Meeting Threshold*	WOMAC Pain Improvement	Dissatisfied†		Confusion Matrix Derivations			
			Yes	No	Sensitivity‡	Specificity‡	Positive Predictive Value‡	Youden Index (%)
MCID11	56 (13.4%)	<11	12	44	0.46 (0.27 to 0.67)	0.89 (0.85 to 0.92)	0.21 (0.14 to 0.3)	35
		≥11	14	347	—	—	—	—
MIC21	128 (31%)	<21	19	109	0.73 (0.52 to 0.88)	0.72 (0.67 to 0.76)	0.14 (0.11 to 0.18)	45
		≥21	7	282	—	—	—	—
MWPC30%	38 (9.1%)	<30%	11	27	0.42 (0.23 to 0.63)	0.93 (0.9 to 0.95)	0.28 (0.18 to 0.41)	35
		≥30%	15	364	—	—	—	—
MCIC31.25	217 (52%)	<31.25	23	194	0.88 (0.7 to 0.98)	0.5 (0.45 to 0.55)	0.1 (0.09 to 0.11)	38
		≥31.25	3	197	—	—	—	—
MID7.5	40 (9.6%)	<7.5	9	31	0.35 (0.17 to 0.56)	0.92 (0.89 to 0.95)	0.22 (0.13 to 0.34)	27
		≥7.5	17	360	—	—	—	—
MCID25	129 (31%)	<25	19	110	0.73 (0.52 to 0.88)	0.72 (0.67 to 0.76)	0.14 (0.11 to 0.18)	45
		≥25	7	281	—	—	—	—
PASS25	29 (7%)	Follow-up score ≤25	12	17	0.46 (0.27 to 0.66)	0.96 (0.93 to 0.97)	0.4 (0.27 to 0.56)	42
		Follow-up score >25	14	374	—	—	—	—

*The values are given as the number of patients, with the percentage of the 417 patients in parentheses. †The values are given as the number of patients. ‡The values are given as the estimate, with the 95% CI in parentheses.

those excluded were slightly more likely to be female (68% compared with 60%) and baseline WOMAC pain scores were also slightly worse in those excluded (48 compared with 40).

Of the 417 subjects who met the study inclusion criteria, 244 (58.5%) were enrolled in in the AViKA study and 173 (41.5%) were enrolled in the STARs study. Overall, the included

TABLE III Dissatisfied Participants with Residual Pain Following TKA According to Composite WOMAC Pain Score Outcomes

Composite Outcome	Proportion Not Meeting Threshold*	WOMAC Pain Score	Dissatisfied†		Confusion Matrix Derivations			
			Yes	No	Sensitivity‡	Specificity‡	Positive Predictive Value‡	Youden Index (%)
MCID25 and PASS25	135 (32%)	Improvement ≤25 and final score ≥25	19	116	0.73 (0.52 to 0.88)	0.7 (0.65 to 0.74)	0.14 (0.11 to 0.17)	43
		Improvement ≥25 and final score ≤25	7	275	—	—	—	—
MCID25 or PASS25	23 (5.5%)	Improvement ≤25 or final score ≥25	12	11	0.46 (0.27 to 0.67)	0.97 (0.95 to 0.98)	0.5 (0.3 to 0.68)	43
		Improvement ≥25 or final score ≤25	14	380	—	—	—	—
WOMAC=20 or PASS25	22 (5%)	Improvement ≤20 or final score ≥25	12	10	0.46 (0.27 to 0.67)	0.97 (0.95 to 0.99)	0.54 (0.35 to 0.71)	43
		Improvement >20 or final score ≤25	14	381	—	—	—	—
WOMAC=20 and PASS25	103 (24.7%)	Improvement ≤20 and final score ≥25	18	85	0.69 (0.48 to 86)	0.78 (0.74 to 0.82)	0.17 (0.12 to 0.22)	47
		Improvement ≥20 and final score ≤25	8	306	—	—	—	—

*The values are given as the number of patients, with the percentage of the 417 patients in parentheses. †The values are given as the number of patients. ‡The values are given as the percentage, with the 95% CI in parentheses.

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cohort was middle-aged (mean age [and standard deviation] of 66.3 ± 8.3 years) and predominantly female (60.0%), White (93%), and overweight (mean BMI, 30.6 ± 6.3 kg/m^2), with 205 (49%) of 417 participants classified as obese (BMI ≥30 kg/m^2). The mean WOMAC pain score was 40.0 ± 17.1 points. Nineteen participants (4.6%) answered "somewhat dissatisfied" or "very dissatisfied" to "How satisfied are you with the TKA in relieving pain?" Twenty-six participants (6.2%) were deemed dissatisfied, having answered "very dissatisfied" or "somewhat dissatisfied" to "How satisfied are you with the results of your knee replacement in relieving your pain?" or "Overall, how satisfied are you with the results of your knee replacement?" The mean baseline WOMAC pain score was 40.2 ± 15.7 points for dissatisfied participants and 39.6 ± 17.3 points for satisfied participants. The mean 12-month WOMAC pain score was 30.4 ± 22.3 points for the 26 dissatisfied participants and 7.2 ± 10.6 points for the satisfied participants. Five percent of the participants had baseline Pain Catastrophizing Scale scores of >30 points, and 24.7% had an MHI-5 of <68.

Relationship Between Metrics and Youden Index

Table II highlights the proportion of participants who met each criterion for residual pain and those who were dissatisfied. The estimates of residual pain varied widely from 5.5% to >50.0% according to the metric employed. The composite metric MCID25 or PASS25 was defined as having a WOMAC pain improvement of at least 25 points or meeting the PASS threshold score of 25. The composite metric MCID25 or PASS25 had the highest positive predictive value (0.54 [95% CI, 0.35 to 0.71]), meaning that 54.0% of subjects who met this definition of residual pain were dissatisfied with the results of the TKA. The MCIC31.25 (a WOMAC pain score improvement exceeding a minimal clinically important change [MCIC] of 31.25) had the highest sensitivity (0.88 [95% CI, 0.7 to 0.98]); 88% of dissatisfied participants did not improve by >31.25 points. The highest specificity was found for the composite metric MCID25 or PASS25 (0.97 [95% CI, 0.95 to 0.98]) and WOMAC=20 or PASS25 (0.97 [95% CI, 0.95 to 0.99]) (Table III). The MIC21 (a WOMAC pain score improvement exceeding a minimally important change [MIC]

TABLE IV Dissatisfied Participants with Residual Pain Following TKA According to WOMAC Pain Score Improvements

Improvement in WOMAC Pain Score	Proportion Not Meeting Threshold*		Dissatisfied†		Confusion Matrix Derivations			
		Improvement	Yes	No	Sensitivity†	Specificity†	Positive Predictive Value†	Youden Index (%)
5	29 (7%)	<5	8	21	0.31 (0.14 to 0.52)	0.95 (0.92 to 0.97)	0.27 (0.15 to 0.43)	26
		≥5	18	370	—	—	—	—
10	40 (9.6%)	<10	9	31	0.35 (0.17 to 0.56)	0.92 (0.89 to 0.95)	0.22 (0.13 to 0.34)	27
		≥10	17	360	—	—	—	—
15	57 (13.7%)	<15	12	45	0.46 (0.29 to 0.67)	0.88 (0.85 to 0.91)	0.2 (0.13 to 0.3)	34
		≥15	14	346	—	—	—	—
20	96 (23%)	<20	18	78	0.69 (0.48 to 0.86)	0.8 (0.76 to 0.84)	0.18 (0.14 to 0.23)	49
		≥20	8	313	—	—	—	—
25	129 (31%)	<25	19	110	0.73 (0.55 to 0.88)	0.72 (0.67 to 0.76)	0.14 (0.1 to 0.18)	45
		≥25	7	281	—	—	—	—
30	181 (43%)	<30	21	160	0.81 (0.6 to 0.93)	0.59 (0.54 to 0.64)	0.11 (0.1 to 0.14)	40
		≥30	5	231	—	—	—	—
35	219 (53%)	<35	24	195	0.92 (0.75 to 0.99)	0.5 (0.45 to 0.55)	0.11 (0.1 to 0.12)	42
		≥35	2	196	—	—	—	—
40	254 (61%)	<40	24	230	0.92 (0.75 to 0.99)	0.4 (0.36 to 0.46)	0.09 (0.08 to 0.1)	32
		≥40	2	161	—	—	—	—
45	298 (71%)	<45	25	273	0.96 (0.83 to 1)	0.3 (0.25 to 0.35)	0.08 (0.07 to 0.09)	26
		≥45	1	118	—	—	—	—
50	333 (80%)	<50	26	307	1 (0.87 to 1)	0.2 (0.18 to 0.26)	0.07 (0.06 to 0.08)	20
		≥50	0	84	—	—	—	—
60	394 (94%)	<60	26	368	1 (0.86 to 1)	0.06 (0.04 to 0.09)	0.06 (0.05 to 0.07)	6
		≥60	0	23	—	—	—	—

*The values are given as the number of patients, with the percentage of the 417 patients in parentheses. †The values are given as the number of patients. ‡The values are given as the percentage, with the 95% CI in parentheses.

of 21.0) and MCID25 (a WOMAC pain score improvement exceeding an MCID of 25.0) both had a Youden index of 45%. The composite metric WOMAC Pain >20 and PASS25 had a Youden index of 47% (Table III).

Relationship Between Metrics and the WOMAC Pain Score

The various thresholds for the improvement in the WOMAC pain score yielded a wide range of estimates of residual pain (7.0% to >50.0% of participants) (Table IV). Generally, the sensitivity of the residual pain cutoff for dissatisfaction increased as the required improvement in the WOMAC pain score increased (Table IV). An improvement in the WOMAC pain score of <5 had the lowest sensitivity (0.31 [95% CI, 0.14 to 0.52]) for detecting dissatisfied subjects. A WOMAC pain score improvement of 20 had the highest Youden index of 49%. The composite outcome change in WOMAC=20.0 or PASS25 had the highest specificity (0.97 [95% CI, 0.95 to 0.99]) for detecting dissatisfaction as well as the highest positive predictive value (0.54 [95% CI, 0.35 to 0.71]) (Table III).

Figure 1 plots sensitivity versus 1 − specificity for the ability of incremental WOMAC pain improvement cutoffs and the metric cutoffs for residual pain to predict participants who were dissatisfied. The thresholds with a Youden index close to 50% were the MIC21 (WOMAC pain improvement of >21.0) and MCID25 (WOMAC pain improvement of >25.0). Other metrics with a Youden index approaching the acceptable level were WOMAC pain score improvements of 20.0, which had a Youden index of 49%, and 25.0, which had a Youden index of 45%. The composite measurement combining WOMAC pain change of 20.0 and PASS25 score (where participants had to improve in the WOMAC pain score by 20.0 and have a score of at least the PASS value of 25.0) had a Youden index of 47% (Table III). The Youden index was 35% for the MCID11, 35% for a 30% percentage improvement in the WOMAC pain score of exceeding a meaningful within-person change (MWPC30%), and 38% for the MCIC31.25. The MID7.5 (an improvement exceeding a minimally important difference [MID] of 7.5) had a low Youden index of 27%. The Youden index for the incremental WOMAC pain score improvements ranged from 6% to 49% (Table IV).

Discussion

In this study, we determined the proportion of participants with residual pain at 1 year following TKA using various definitions of residual pain based on commonly used metrics.

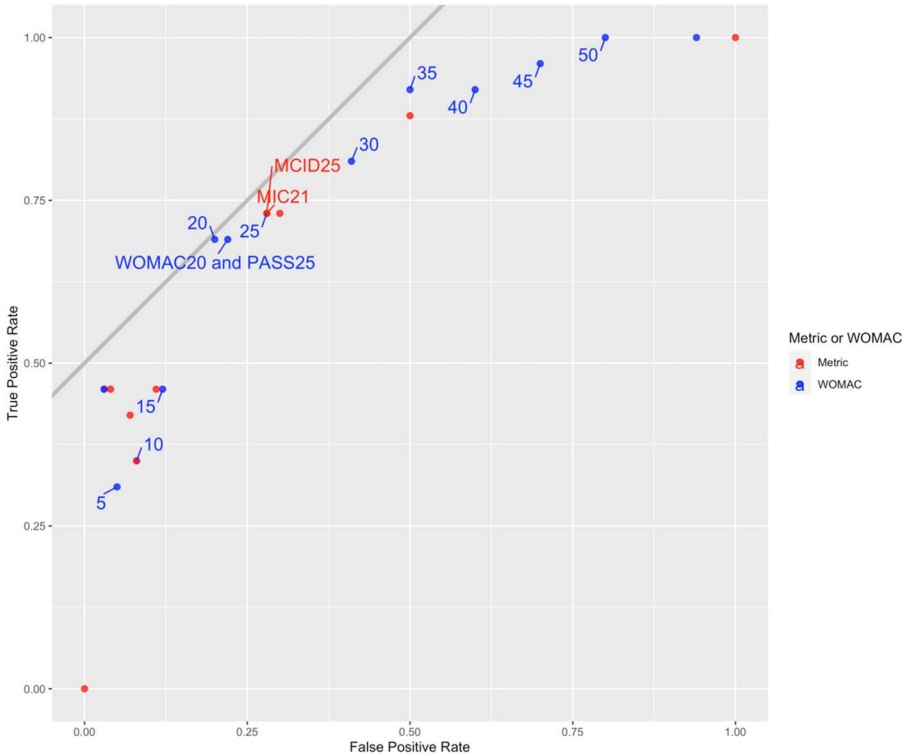

Fig. 1

Scatterplot showing the true-positive rate (sensitivity) and false-positive rate (1 − specificity) for various definitions of residual pain and dissatisfaction with TKA. The false-positive rate is plotted against the true-positive rate for each metric and each WOMAC pain improvement cutoff. The gray line represents a threshold with a Youden index of 50%. The points labeled MIC21, MCID25, and WOMAC 20 and PASS25 and WOMAC pain improvements of 20 and 25 have a Youden index close to 50%. WOMAC pain improvements of ≥5 are also labeled to show that increasing changes in the WOMAC pain score have increasing sensitivity and decreasing specificity for dissatisfaction. The red dots represent the metrics and metric composite thresholds as outlined in Tables II and III. The blue dots represent the incremental WOMAC pain score improvements and WOMAC composite thresholds as outlined in Tables III and IV.

We found that the resulting prevalence of residual pain after TKA varied from 5.5% to >50.0%, depending on the definition. The dissatisfaction rate of 6.2% was lower than the 20.0% value that has been reported in the literature[12,38]. No measure of residual pain that we considered was both highly sensitive and highly specific for dissatisfaction, suggesting that residual pain and dissatisfaction are related but distinct domains of the patient experience after TKA. A WOMAC pain score improvement of <20.0 appeared to provide the best balance between sensitivity and specificity with respect to predicting participant dissatisfaction, with a Youden index of 49%.

Our study complements findings by Beswick et al.[9], who found a wide range (8% to 27%) of residual pain reporting in subjects assessed with various metrics in 11 distinct study populations across many countries. In a study of 53 participants undergoing viscosupplementation for knee osteoarthritis, Conrozier et al. reported that 90% of participants were satisfied if they met the PASS criterion of <40 for the WOMAC pain rating scale[39]. They concluded that the PASS value more closely aligns with patient satisfaction than an absolute change in the WOMAC pain score[39]. We found that 40% of participants who did not meet the PASS25 threshold were dissatisfied (positive predictive value, 0.4 [95% CI, 0.27 to 0.56]). Our study corroborates the findings by Beswick et al.[9] that there is a wide variation in residual pain estimates and also suggests that the variation in residual pain estimates is due not solely to heterogenous cohorts but also to the variation in the methods employed.

By using incremental cutoffs for WOMAC pain, we showed that a reasonable compromise between sensitivity and specificity of residual pain metrics in estimating dissatisfaction appears to be an improvement in the WOMAC pain score in the range of 15 to 25 points (Table IV). For all commonly used metrics (e.g., the MCID), incremental improvements in WOMAC pain scores, and composite outcomes, the sensitivity was low, with wide 95% CIs (Tables II, III, and IV).

A limitation of the analysis was the loss to follow-up of 27% of the participants, as those who did not respond at 1 year did have a slightly worse baseline WOMAC pain score (48 compared with 40). We also determined satisfaction using only 2 satisfaction questions, and we acknowledge that a number of participants may be satisfied in other respects. We acknowledge that there may be a proportion of patients who are dissatisfied because of mechanical or biological implantation problems. Furthermore, our study only examined participants with residual pain. Residual pain can be used as a proxy for failure, but an individual's definition of dissatisfaction may be based on other variables, such as insufficient improvement in range of movement or stiffness. A strength of our study, compared with others assessing residual pain, was that we assessed residual pain using a range of metrics in the same study sample, enabling us to disentangle heterogeneity due to the outcome metrics from that due to differences in the study samples[9,40].

In conclusion, the prevalence of residual pain is sensitive to the definition of residual pain. The heterogeneity of reported residual pain rates and in the outcome metrics on which they are based suggests a need for a more standardized method for using patient-reported outcome measures as measures of residual pain following TKA. In addition, a more robust measure of residual pain that better reflects patient satisfaction following TKA may be beneficial. Given that pain relief is the primary goal of participants who undergo TKA, an ideal residual pain metric would minimize the number of subjects with residual pain who report that they are satisfied and minimize the number of subjects without residual pain who are dissatisfied. Our data also support complementing residual pain metrics with other dimensions of well-being, such as satisfaction, in overall assessments of TKA outcomes. ■

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