From Generic to Personalized: How PROMs Phenotypes May Redefine Meaningful Improvement Thresholds in Total Knee Arthroplasty

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INTRODUCTION:
Patient-reported outcome measures (PROMs) have gained increasing importance in assessing the effectiveness of total knee arthroplasty (TKA) from the patient's perspective. The Centers for Medicare & Medicaid Services (CMS) has recently finalized a landmark policy mandating the collection and reporting of PROMs for TKA by 2027, underscoring the value of incorporating patient perspectives into quality measurement and value-based care initiatives. To interpret PROMs and define clinically meaningful improvements, various concepts have been developed, including the minimal clinically important difference (MCID), patient acceptable symptom state (PASS), and substantial clinical benefit (SCB). However, there is significant variability in these thresholds across different patient populations and study methodologies. This study aimed to 1) categorize THA patients into phenotypes and calculate MCID, PASS, and SCB thresholds for each phenotype and 2) determine the percentage of patients in each phenotype that achieve or exceed the MCID, PASS, and SCB thresholds calculated specifically for their phenotype group.
METHODS: A prospective cohort of 10,988 patients who underwent primary TKA between January 2016 and December 2022 was retrospectively analyzed. Demographic data, comorbidities, and preoperative and one-year postoperative Knee Disability and Osteoarthritis Outcome Score (KOOS) pain, physical function short form (PS), and joint replacement (JR) scores were collected. Patients were stratified into eight phenotypes based on their preoperative KOOS pain, PS, and Veterans RAND 12-Item Health Survey Mental Component Score (VR-12 MCS) scores, with each PROM classified as above (+) or below (-) the median score. MCID values were determined using a distribution-based approach (half standard deviation of change scores), while PASS values were established using an anchor-based method based on patient satisfaction at one year. SCB was evaluated using an anchor question comparing current physical health to the previous year.
RESULTS:
MCID, PASS, and SCB thresholds demonstrated substantial variability across PROM phenotypes (Table 1-3). MCID values ranged from 2.76 to 5.37 for KOOS pain, 2.80 to 7.08 for KOOS PS, and 2.44 to 5.52 for KOOS JR. The proportion of patients achieving MCID varied from 90% to 98% for KOOS pain, 84% to 97% for KOOS PS, and 89% to 97% for KOOS JR. SCB thresholds spanned from 19.45 to 47.22 for KOOS pain, 12.3 to 33.0 for KOOS PS, and 18.502 to 34.051 for KOOS JR. The percentage of patients attaining SCB ranged from 52% to 72% for KOOS pain, 33% to 63% for KOOS PS, and 35% to 62% for KOOS JR. PASS thresholds extended from 71.88 to 83.33 for KOOS pain, 66.4 to 75.1 for KOOS PS, and 65.994 to 76.332 for KOOS JR. The proportion of patients reaching PASS varied from 64% to 75% for KOOS pain, 55% to 70% for KOOS PS, and 50% to 68% for KOOS JR.
DISCUSSION AND CONCLUSION: Significant variability exists in MCID, PASS, and SCB thresholds across different preoperative PROM phenotypes for TKA patients, with up to 2.5-fold differences between groups. Patients with worse baseline function paradoxically require higher improvement thresholds to achieve satisfaction. Universal thresholds systematically may misclassify outcomes and undermine patient-centered care. With CMS mandating PROM collection by 2027, adopting phenotype-specific thresholds may be essential for accurate outcome assessment, realistic patient expectations, and optimized value-based care in total knee arthroplasty.

Table 1. Calculated MCID thresholds for KOOS Pain, PS, JR

Variable	MCID	Pct_MCID
Pain P+PS+MCS+	5.22	92
Pain P+PS+MCS-	4.89	92
Pain P+PS-MCS+	2.76	96
Pain P+PS-MCS-	2.81	90
Pain P-PS+MCS+	3.17	98
Pain P-PS+MCS-	3.37	96
Pain P-PS-MCS+	4.87	97
Pain P-PS-MCS-	5.37	97
PS P+PS+MCS+	4.12	85
PS P+PS+MCS-	3.61	84
PS P+PS-MCS+	3.78	97
PS P+PS-MCS-	3.55	94
PS P-PS+MCS+	2.80	93
PS P-PS+MCS-	2.97	85
PS P-PS-MCS+	5.96	96
PS P-PS-MCS-	7.08	94
JR P+PS+MCS+	3.97	91
JR P+PS+MCS-	3.62	89
JR P+PS-MCS+	2.58	97
JR P+PS-MCS-	2.44	94
JR P-PS+MCS+	2.84	97
JR P-PS+MCS-	2.85	93
JR P-PS-MCS+	4.75	97
JR P-PS-MCS-	5.52	95
Variable	MCID	Pct_MCID
Pain P+PS+MCS+	5.22	92
Pain P+PS+MCS-	4.89	92
Pain P+PS-MCS+	2.76	96
Pain P+PS-MCS-	2.81	90
Pain P-PS+MCS+	3.17	98
Pain P-PS+MCS-	3.37	96
Pain P-PS-MCS+	4.87	97
Pain P-PS-MCS-	5.37	97
PS P+PS+MCS+	4.12	85
PS P+PS+MCS-	3.61	84
PS P+PS-MCS+	3.78	97
PS P+PS-MCS-	3.55	94

Variable	MCID	Pct_MCID
PS P-PS+MCS+	2.80	93
PS P-PS+MCS-	2.97	85
PS P-PS-MCS+	5.96	96
PS P-PS-MCS-	7.08	94
JR P+PS+MCS+	3.97	91
JR P+PS+MCS-	3.62	89
JR P+PS-MCS+	2.58	97
JR P+PS-MCS-	2.44	94
JR P-PS+MCS+	2.84	97
JR P-PS+MCS-	2.85	93
JR P-PS-MCS+	4.75	97
JR P-PS-MCS-	5.52	95

Table 3. Calculated PASS thresholds for KOOS Pain, PS, JR

Pain PASS

subgroup	optimal_cutpoint	youden	sensitivity	specificity	AUC	prevalence	Percentage
P+PS+MCS+	81.25	0.6501029	0.8116883	0.8384146	0.8813444	0.8756634	0.73
P+PS+MCS-	80.56	0.6381751	0.8033924	0.8347826	0.8741628	0.8493779	0.70
P+PS-MCS+	83.33	0.5230759	0.7679739	0.7551020	0.8137255	0.8619718	0.68
P+PS-MCS-	77.78	0.6285641	0.7992958	0.8292683	0.8740982	0.7759563	0.64
P-PS+MCS+	77.78	0.6929428	0.8300395	0.8629032	0.8918197	0.8595696	0.73

subgroup	optimal_cutpoint	youden	sensitivity	specificity	AUC	prevalence	Percentage
P-PS+MCS-	75.00	0.6295378	0.7838235	0.8457143	0.8903193	0.7953216	0.64
P-PS-MCS+	71.88	0.6829346	0.8789346	0.8040000	0.9036610	0.8321021	0.75
P-PS-MCS-	71.88	0.6167131	0.7860825	0.8306306	0.8844205	0.7775551	0.64

PS PASS

subgroup	optimal_cutpoint	youden	sensitivity	specificity	AUC	prevalence	Percentage
P+PS+MCS+	75.1	0.5751392	0.7517953	0.8233438	0.8585397	0.8754420	0.65
P+PS+MCS-	70.3	0.5535015	0.8023904	0.7511111	0.8449845	0.8479730	0.68
P+PS-MCS+	70.3	0.5322390	0.7278912	0.8043478	0.8381026	0.8647059	0.62
P+PS-MCS-	68.2	0.5323436	0.7095588	0.8227848	0.8404924	0.7749288	0.55
P-PS+MCS+	70.3	0.6157341	0.8206522	0.7950820	0.8538456	0.8578089	0.70
P-PS+MCS-	66.4	0.5988599	0.8414634	0.7573964	0.8701472	0.7951515	0.68
P-PS-MCS+	66.4	0.6044673	0.8345928	0.7698745	0.8671539	0.8328671	0.69
P-PS-MCS-	66.4	0.5745103	0.7317073	0.8428030	0.8632632	0.7774968	0.56

JR PASS

subgroup	optimal_cutpoint	youden	sensitivity	specificity	AUC	prevalence	Percentage
P+PS+MCS+	76.332	0.6238556	0.7515152	0.8723404	0.8688275	0.8753316	0.57
P+PS+MCS-	70.704	0.5945056	0.8091398	0.7853659	0.8725894	0.8448145	0.61
P+PS-MCS+	73.342	0.5673077	0.6923077	0.8750000	0.8404808	0.8666667	0.51
P+PS-MCS-	70.704	0.5389766	0.7154472	0.8235294	0.8421808	0.7834395	0.50
P-PS+MCS+	68.284	0.6240073	0.8717949	0.7522124	0.8744110	0.8543814	0.68
P-PS+MCS-	68.284	0.6459393	0.8030822	0.8428571	0.8836656	0.8066298	0.56

Table 2. Calculated SCB thresholds for KOOS Pain, PS, JR

SCB pain

subgroup	optimal_cutpoint	youden	sensitivity	specificity	AUC	prevalence	Percentage
P+PS+MCS+	27.78	0.3457676	0.7671614	0.5786062	0.7310705	0.6359882	0.63
P+PS+MCS-	30.55	0.2876095	0.6932039	0.5944056	0.6918370	0.5455508	0.55
P+PS-MCS+	30.56	0.3448304	0.8613139	0.4835165	0.7326141	0.6008772	0.70
P+PS-MCS-	19.45	0.4139640	0.9639640	0.4500000	0.7234610	0.4805195	0.72
P-PS+MCS+	47.22	0.3869399	0.7750678	0.6118721	0.7433270	0.6275510	0.62
P-PS+MCS-	44.45	0.3816671	0.7218310	0.6598361	0.7520203	0.5378788	0.52
P-PS-MCS+	41.67	0.3887781	0.8903654	0.4984127	0.7418631	0.6564885	0.73
P-PS-MCS-	41.67	0.4409601	0.8734336	0.5675266	0.7742583	0.5477008	0.66

SCB PS

subgroup	optimal_cutpoint	youden	sensitivity	specificity	AUC	prevalence	Percentage
P+PS+MCS+	15.0	0.3315763	0.7254174	0.6061588	0.7098617	0.6359882	0.58
P+PS+MCS-	14.8	0.3078009	0.7203883	0.5874126	0.6788173	0.5455508	0.54
P+PS-MCS+	30.2	0.4041068	0.6788321	0.7252747	0.7051416	0.6008772	0.48
P+PS-MCS-	33.0	0.3592342	0.5675676	0.7916667	0.7352102	0.4805195	0.33
P-PS+MCS+	21.2	0.4150796	0.7073171	0.7077626	0.7551138	0.6275510	0.51
P-PS+MCS-	12.3	0.3837451	0.8591549	0.5245902	0.7262901	0.5378788	0.63
P-PS-MCS+	29.5	0.3447398	0.7923588	0.5523810	0.7081712	0.6564885	0.61
P-PS-MCS-	28.4	0.3624045	0.8070175	0.5553869	0.7285342	0.5477008	0.59

SCB JR

subgroup	optimal_cutpoint	youden	sensitivity	specificity	AUC	prevalence	Percentage
P+PS+MCS+	19.192	0.3550790	0.7762172	0.5788618	0.7303508	0.6345811	0.54
P+PS+MCS-	20.824	0.2912296	0.6875000	0.6037296	0.6927038	0.5441020	0.46
P+PS-MCS+	34.051	0.4080372	0.6058394	0.8021978	0.7434427	0.6008772	0.35
P+PS-MCS-	18.502	0.4286036	0.9369369	0.4916667	0.7135135	0.4805195	0.60
P-PS+MCS+	23.867	0.3745059	0.8699187	0.5045872	0.7416337	0.6286201	0.62
P-PS+MCS-	23.017	0.3812910	0.8586572	0.5226337	0.7304599	0.5380228	0.56
P-PS-MCS+	34.051	0.3760365	0.7927032	0.5833333	0.7422769	0.6590164	0.53
P-PS-MCS-	29.063	0.3928619	0.8508772	0.5419847	0.7561939	0.5492085	0.56