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ORIGINAL ARTICLE

Predictors of Improvement in Health-Related Quality of Life after Primary Total Knee Arthroplasty

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Background To evaluate and analyze patient factors that influence the magnitude of improvement in health-related quality of life in Middle Eastern patients.

Patients and Methods Records of patients who underwent primary total knee arthroplasty (TKA) were reviewed. The Oxford knee score (OKS) and EuroQoL-5 dimensions 5 levels (EQ. 5D5L) score were filled out by patients preoperatively and at the final follow-up. Patients were divided into two groups using the median improvement in EQ. 5D5L utility as the cutoff value. Univariate and multivariate analyses were used to compare both groups to identify factors that are associated with more improvement in EQ. 5D5L utility.

Results A total of 130 patients were included, consisting of 66 high gainers and 64 low gainers. At the final follow up, patients in both groups achieved higher OKS and EQ. 5D5L utility scores compared with preoperative values. Univariate analysis showed that patients with grade 4 osteoarthritis, any degree of fixed flexion deformity and worse preoperative EQ. 5D5L utility were more likely to achieve more improvement in utility. Change in OKS did not match the change in EQ. 5D5L utility. Multivariate analysis demonstrated that preoperative utility was the only factor influencing gain in utility. The probability of high gain in EQ. 5D5L utility after TKA in patients with a preoperative utility more than 0.22 was 13% (95% confidence interval: 7.5–21.6). With a lower preoperative utility, the probability of high gain in utility increased to 93.4% (95% confidence interval: 84.6–97.4).

Conclusions Preoperative utility can guide healthcare providers to predict which patients would benefit much after TKA, and thereby prioritize patients with lower preoperative utility.
Level of evidence: IV.

Keywords EuroQoL-5 dimensions 5 levels, Health-related quality of life, Oxford knee score, Total knee arthroplasty.
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INTRODUCTION

Total knee arthroplasty (TKA) is one of the most commonly performed surgical procedures for pain relief and functional improvement in patients with advanced degenerative joint disease. In the last two decades, TKA has become increasingly popular [1]. Despite the success of TKA, up to 30% of patients are dissatisfied. This dissatisfaction has been shown to be related to the patients' quality of life, which is influenced by multiple patient-related factors [2]. Identifying these factors can help improve patient satisfaction and quality of life after TKA, which can have a positive impact on both patients and the healthcare system.

Outcomes after TKA can be assessed using either patient-reported outcome measures (PROM) such as the Forgotten Joint Score (FJS-12) [3], Western Ontario and McMaster Universities Osteoarthritis Index 9 (WOMAC) [4] and EuroQoL-5 Dimensions (EQ. 5D) [5], or clinician-reported outcome measures (knee society score and range of motion). PROM can be either generic or disease-specific. Unlike disease-specific PROMs, generic PROMs evaluate health-related functional status that is not limited to a particular disease. The benefit of including patients in the assessment of treatment outcomes has been established in the recent literature and various PROMs are available [6]. EQ. 5D is a widely used generic PROM that is preference-based [5].

Patient demand, expectations, and activity can be considerably variable depending on cultural, religious and occupational factors. Tarabichi *et al.,* [7] noted how different Middle Eastern patients are, particularly in terms of range of motion demand and expectations. However, these studies focused on clinician-reported outcomes rather than patient-reported outcomes [7,8].

The purpose of this study was to evaluate and analyze patient factors that influence the magnitude of improvement in health-related quality of life (HRQoL) in Middle Eastern patients. The hypothesis was that patients with fixed sagittal deformity, fixed coronal deformity more than 20, or worse preoperative utility would achieve higher improvement in HRQoL after TKA.

PATIENTS AND METHODS

After Institutional Review Board approval was obtained, patient records were retrospectively reviewed and analyzed. All patients with degenerative knee joint disease who underwent TKA from 2019 to 2021 with a minimum follow-up of 1 year were included. Exclusion criteria were revision arthroplasty or history of previous infection in the same knee. All surgeries were performed by experienced surgeons who are staff members of the Adult Hip and Knee Reconstruction Unit at a university teaching hospital. All procedures were performed through a regular medial para-patellar approach, with measured bony resection to restore mechanical alignment and insertion of either a posterior-stabilized (PS) or a constrained condylar knee (CCK) prosthesis.

Outcome assessment

Preoperative data were extracted from patients' records including demographics, comorbidities, and amount of fixed sagittal and/or coronal deformities. Both Oxford knee score [9] (OKS) and EuroQoL-5 dimensions 5 levels (EQ. 5D5L) [10] score were filled out by patients both preoperatively and at final follow-up. Preoperatively, patients were asked to fill out a paper form for both scores. At the final follow-up, forms were filled out either on paper during follow-up visits or by phone. EQ. 5D5L was used to estimate utilities, which are estimates of the preference for a given state of health. Utilities often range between 0 and 1, where 1 reflects a valuation of "perfect health" and 0 refers to valuation of "death." In some of these measures values below zero may be possible, representing health states perceived to be worse than death [11].

Improvement in utility was estimated by subtracting preoperative from the postoperative utility per patient. Patients who achieved improvement in EQ. 5D5L utility more than the median value of the whole cohort were considered high gainers, whereas other patients were considered low gainers. Univariate and multivariate analyses were used to compare both groups to identify demographic, clinical, and radiographic factors that are associated with more improvement in EQ. 5D5L score. In addition, OKS and EQ. 5D5L utility scores were observed and analyzed.

Statistical analysis

Categorical variables were described using numbers and percentages. Continuous data were described using mean and SD, ordinal data were described using median and interquartile range (IQR). The HRQoL was estimated from the health profiles using the Egyptian tariff [12].

In bivariate analysis, the impact of different factors on EQ. 5D5L utility was tested using logistic regression models. Multivariate analysis was conducted to predict whether the patient would achieve high improvement in EQ. 5D5L utility after TKA. Two models were proposed for multivariate analysis: the full model and the reduced model. The full model was built using multiple logistic regression and included all the predictors with statistically significant impact in the bivariate analysis. The reduced model included all the predictors with statistically significant impact in the full model. The predictive performance of the full and reduced models were compared using the receiver operating characteristic (ROC) curve analysis and cross-validated accuracy.

Receiver operating characteristic curve analysis

In the ROC curve, x-axis represents the sensitivity (probability that the model can predict high gainers correctly). The y-axis shows the 100-specificity (probability that the model can predict low gainers correctly). Each point on the ROC plot represents a sensitivity/specificity pair corresponding to a particular model value. A model with perfect discrimination has an ROC plot that passes

through the upper left corner (100% sensitivity, 100% specificity). The closer the ROC plot is to the upper left corner, the higher the overall accuracy of the model. The model with a significantly higher area under the curve (AUC) was chosen as the final model. AUC is roughly classified as follows: an AUC of 0.9–1 and 0.8–0.9 refers to excellent and good predictions, respectively. Lower AUCs refer to fair to poor predictions.

Cross-validated accuracy

Accuracy is the percentage of the cases which were predicted correctly as high or low gainers. However, accuracy of the model tends to be biased upward if estimated on the same dataset used to build the model. Thus, accuracy of the model was estimated using the cross-validation technique, where five random splits of the dataset were created five times. Every split composed of training (80% of the whole data) and validation (20% of the whole data) sets. The model was fit to the training data, and predictive accuracy was assessed using the validation data. Results were then averaged over the splits. Cross-validation was conducted using the caret R package. Statistical significance was set at *P* value less than 0.05.

RESULTS

A total of 130 patients met the inclusion criteria and were included. Using the median improvement in EQ. 5D5L utility as a cut off (0.72, IQR 0.350), the whole cohort was split into 66 high gainers and 64 low gainers. As shown in Figure (1), the median EQ. 5D5L utility improvement among high gainers (median 0.91, IQR 0.325) was 1.62 times that in low gainers (median 0.56, IQR 0.153). The mean follow-up in the whole cohort was 12.72 months. At the final follow up, patients in both groups achieved higher OKS and EQ. 5D5L utility scores compared with preoperative values. Median improvement in OKS and EQ. 5D5L utility in the whole cohort were 23.01 and 0.72, respectively. Mean EQ. 5D5L utility in the whole cohort improved from 0.15 to 0.92.

In the whole cohort, the mean age and BMI were 59 and 34, respectively. Of the included patients, 85% were females, and 86% had comorbidities. The osteoarthritis grade was grade 4 in 32% of the included patients. The degree of coronal deformity was between 10 and 20º in more than half of the included patients, whereas 20% had a fixed flexion deformity preoperatively.

High gainers had significantly higher BMI. Otherwise, there were no differences between the two groups in terms of demographics (Table 1). Patients with grade 4 osteoarthritis according to the Kellgren and Lawrence classification [13], those with any degree of fixed flexion deformity, as well as those with worse preoperative EQ. 5D5L utility were more likely to achieve greater improvement in utility (Tables 2, 3). There were no differences in terms of degree of coronal deformity, type of implant, and preoperative OKS. In addition, change in OKS did not match the change in EQ. 5D5L utility (Table 3).

Bivariate analysis revealed that there are three predictors of high gain of EQ. 5D5L utility after TKR: BMI, preoperative utility, and the degree of OA. These three variables were included in the full model. As shown in Table (4), only preoperative utility was significantly contributing to that model. Using cross-validation, the overall accuracy of the model was 86.2% (SD 6.4).

The reduced model included the only predictor that was significantly contributing to improvement in EQ. 5D5L utility in the full model, which is preoperative utility. Overall accuracy, as estimated by cross-validation, was better than that in the full model (89.6%, SD 7.2).

Figure (2) shows the ROC of the full and reduced models. The predictive performances of both were excellent [AUC= 0.964, 95% confidence interval (CI): 0.929–0.999, *P*<0.001 and AUC= 0.965, 95% CI: 0.930–1.000, *P*<0.001] respectively. There was no statistically significant difference between the predictive performance of the two models (difference in AUC= 0.004, *P*=0.113).

According to the reduced model, the probability of high gain in EQ. 5D5L utility after TKA in patients with a preoperative utility more than 0.22 is 13% (95% CI: 7.5–21.6). With a lower preoperative utility, the probability of high gain in utility increased to 93.4% (95% CI: 84.6–97.4).

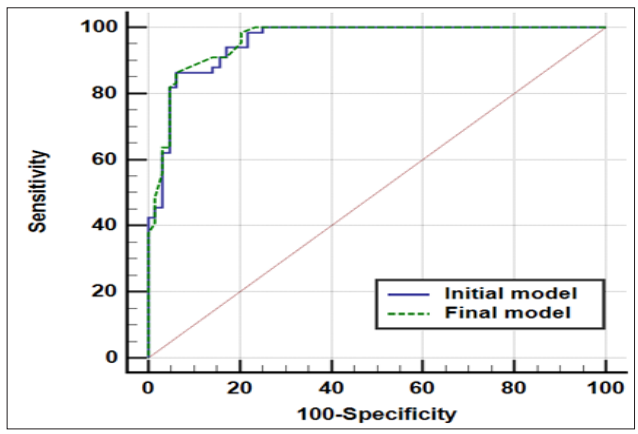

Figure 1: Evaluation of predictive performance of the initial and final models. The former includes preoperative utility, sagittal deformity, OA, and BMI. The latter includes preoperative utility only.

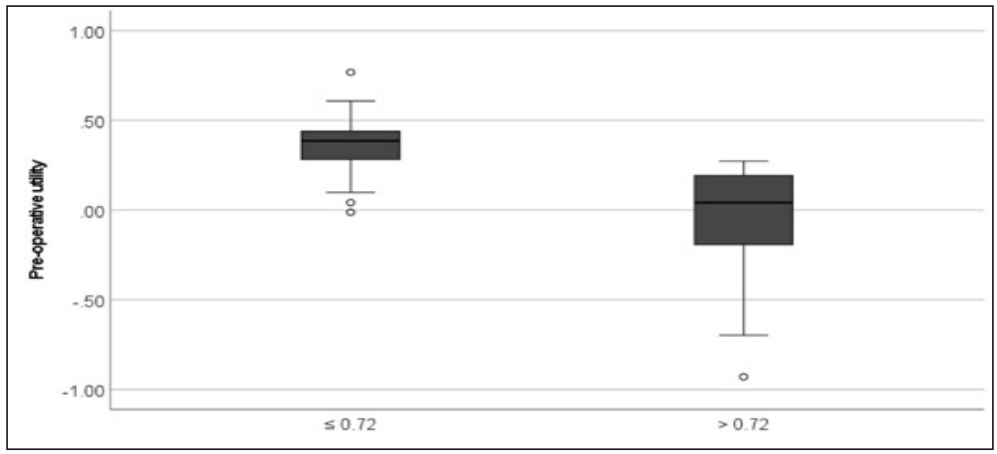

Figure 2: Improvement in health-related quality of life after TKA in terms of utility measured by EQ-5D. The median EQ. 5D5L utility improvement among high gainers (median 0.91, interquartile range 0.325) was 1.62 times that in low gainers (median 0.56, interquartile range 0.153). EQ. 5D5L, EuroQoL-5 dimensions 5 levels; TKA, total knee arthroplasty.

Table 1: Demographics:

	Improvement								
	Whole sample		Low gainers		High gainers				
	N=130		*N*=64		*N*=66		*P*	OR	95% CI
Age	59.09±8.41		58.7±7.74		59.47±9.06		0.602	1.01	0.97, 1.05
Sex									
Female	111	85%	52	47%	59	53%			
Male	19	15%	12	63%	7	37%	0.194	0.51	0.19, 1.4
Education status							0.899		
Illiterate	46	35%	21	46%	25	54%			
Read and write	25	19%	13	52%	12	48%	0.609	0.78	0.29, 2.06
High school	12	9%	6	50%	6	50%	0.788	0.84	0.24, 3
Graduated or higher	45	35%	24	53%	21	47%	0.464	0.74	0.32, 1.68
Income							0.388		
Not sufficient	63	48%	32	51%	31	49%			
Sufficient without savings	54	42%	28	52%	26	48%	0.909	0.96	0.46, 1.98
Sufficient with savings	13	10%	4	31%	9	69%	0.196	2.32	0.65, 8.33
BMI	34.45±8.27		32.79±6.08		36.05±9.72		0.029	1.05	1.01, 1.1
Any comorbidity									
No	18	14%	6	33%	12	67%			
Yes	112	86%	58	52%	54	48%	0.153	0.47	0.16, 1.33
No. of comorbidities							0.139		
0	18	14%	6	33%	12	67%			
1	78	60%	37	47%	41	53%	0.282	0.55	0.19, 1.63
2 or more	34	26%	21	62%	13	38%	0.055	0.31	0.09, 1.03

Values in the table represent number and percentage or mean±SD; CI: Confidence interval; OR: Odds ratio.

Table 2: Clinical, radiographic, and implant type data:

	Improvement								
	Whole sample		Low gainers		High gainers				
	N=130		*N*=64		*N*=66		*P*	OR	95% CI
Bilaterality									
No	115	88%	60	52%	55	48%			
Yes	15	12%	4	27%	11	73%	0.073	3.00	0.9, 9.97
OA grade									
2 or 3	88	68%	49	56%	39	44%			
4	42	32%	15	36%	27	64%	0.035	2.26	1.06, 4.83
Degree of coronal deformity							0.909		
<10	31	30%	12	39%	19	61%			
10	47	52%	22	47%	25	53%	0.662	1.14	0.64, 2.02
20	12	13%	6	50%	6	50%	1.00	1.00	0.32, 3.1
Sagittal deformity									
None	64	49%	33	52%	31	48%			
Fixed FD	26	20%	7	27%	19	73%	0.037	2.89	1.07, 7.82
Implant							0.248		
PS-TKA	78	60%	43	55%	35	45%			
PS-TKA with stem	36	28%	14	39%	22	61%	0.109	c	0.86, 4.32
CCK-TKA	16	12%	7	44%	9	56%	0.408	1.58	0.53, 4.67
Postoperative period in months	12.72 (16.98)		12.77 (17.26)		12.6 (17.17)		0.239	0.98	0.95, 1.01

Values in the table represent number and percentage or median (interquartile range); CCK-TKA: Constrained condylar knee total knee arthroplasty; CI: Confidence interval; FD: Flexion deformity; OA: Osteoarthritis; OR: Odds ratio; PS-TKA: Posterior-stabilized total knee arthroplasty.

Table 3: EuroQoL-5 dimensions 5 levels utility and Oxford knee score:

	Improvement					
	Whole sample	Low gainers	High gainers			
	N=130	*N*=64	*N*=66	*P*	OR	95% CI
Domains						
Preop MO	4 (1)	3 (1)	4 (1)	(0.095)	1.48	0.93, 2.34
Preop SC	2 (2)	2 (2)	2 (2)	(0.424)	1.13	0.84, 1.51
Preop UA	3.5 (1)	3.5 (1)	3.5 (1)	(0.178)	0.75	0.49, 1.14
Preop PD	4 (0)	4 (0)	4 (0)	(0.859)	1.05	0.62, 1.77
Preop AD	1 (1)	1 (1)	2 (1)	(0.707)	1.07	0.76, 1.49
Preop OKS	18.21±5.23	17.41±4.21	18.98±5.99	(.091)	1.06	0.99, 1.14
Postop OKS	41.22±3.46	41.06±2.74	41.36±4.04	(0.619)	1.03	0.93, 1.13
Delta OKS	23.01±5.53	23.66±4.49	22.38±6.34	(0.192)	0.96	0.9, 1.02
Preop utility	0.15±0.31	0.36±0.13	−0.05±0.3	(0.000)	0.15	0.07, 0.32
Postop utility	0.92±0.09	0.91±0.11	0.94±0.07	(0.049)	1.52	1, 2.3

Values in the table represent median (interquartile range) or mean±SD; AD: Anxiety/depression; CI: Confidence interval; MO: Mobility; OKS: Oxford knee score; OR: Odds ratio; PD: Pain/discomfort; SC: Self-care; UA: Usual activities.

Table 4: Logistic regression models to predict marked gain in EuroQoL-5 dimensions 5 levels utility after TKR:

	Coefficient	SE	Wald statistic	*P* value
Full model				
Preoperative utility	−19.244	4.068	22.375	<0.001
4th grade of OA	−0.458	0.778	0.346	0.556
BMI	−0.006	0.038	0.025	0.873
Constant	4.544	1.873	5.885	0.015
Reduced model				
Preoperative utility	−19.110	3.918	23.796	<0.001
Constant	4.224	0.969	19.010	<0.001

DISCUSSION

The main outcome of this study is a higher likelihood of better improvement in HRQoL, as measured by the gain in EQ. 5D5L utility, after TKA was associated with worse preoperative utility, making our hypothesis partially true. The main advantage of this study that distinguishes it from similar studies in the literature is that it uses health-related QoL measure as the primary outcome.

BMI

In this study, patients with a higher BMI had greater improvement in EQ. 5D5L utility scores. However, on performing multivariate analysis, BMI did not turn out to be a significant independent factor influencing gain in utility. Several studies have demonstrated that patients with a lower BMI achieve better postoperative functional quality of life outcomes after TKA [14,15]. However, a few studies disputed these results showing that postoperative functional performance and improvement in PROMs are similar irrespective of the BMI [16,17]. We are not aware of studies that show that patients with a higher BMI achieve better outcomes. Results of this study do not contradict with the previous ones as the greater improvement in patients with a higher BMI is likely secondary to lower preoperative EQ. 5D5L utility scores rather than higher postoperative EQ. 5D5L utility. This is also consistent with a recent study showing that a higher BMI is associated with lower postoperative HRQoL scores, although obese patients achieved greater improvement in EQ-5D scores [18].

Osteoarthritis grade

Improvement in EQ. 5D5L utility score was significantly greater in patients with worse radiographic grade of osteoarthritis. However, similar to BMI, osteoarthritis grade was not a significant independent factor in the multivariate analysis. The gain in PROMs has been previously shown to be highest with grade 4 osteoarthritis [19,20]. We support the clinical practice of reserving TKA for patients with grade 4 osteoarthritis and attempt all nonoperative measures for lower grades.

Coronal and sagittal deformity

In a mechanically aligned TKA, postoperative neutral coronal alignment results in longer TKA survival [21]. In the sagittal plane, preoperative fixed flexion deformity can lead to greater quadriceps energy expenditure and resultant fatigue, as well as limb length discrepancy and shortened stride length. These often result in early fatigue in standing, walking, and stair-climbing [22]. In the current study, none of the coronal or sagittal deformities had a significant independent influence on gain in HRQoL.

Utility

EQ. 5D5L utility is based on a system that describes health in terms of five dimensions: mobility, self-care, usual activities, pain/discomfort, and anxiety/depression. Each dimension has five levels: no problems, slight problems, moderate problems, severe problems, and extreme problems. It is a modification of the generic EQ. 5D3L that expands the range of responses to five instead of three for each dimension, hence improving its measurement properties and discriminatory power [23].

In this study, higher gain in HRQoL, as reported by the EQ. 5D5L utility score was associated with lower preoperative utility. However, preoperative, postoperative, and gain in OKS failed to predict the amount of gain in HRQoL. This indicates that health-related QoL does not necessarily correlate with knee-specific PROMs. In contrast, Eibich *et al.,* [24] showed that postoperative EQ. 5D utility was higher than preoperative utility for all patients with OKS less than or equal to 44. Price *et al.,* [25] demonstrated that meaningful improvement (≥7 points in OKS) is more likely to be achieved in patients with preoperative OKS less than or equal to 41, and recommended that patients with OKS more than 41 should not be referred for possible arthroplasty. Gummaraju *et al.,* [26] showed that both OKS and EQ. 5D are imperfect predictors of satisfaction as they are influenced by patient comorbidities. Results of multivariate analysis in this study negate their results as the EQ. 5D5L utility was a significant independent predictor of improvement in HRQoL.

LIMITATIONS

There are a number of limitations to this study. First, the study is retrospective in design with a relatively short follow-up period. However, PROMs have been shown to change significantly only in the first 6 months postoperatively rendering the follow-up period in this study adequate [27]. Second, the study lacks complete clinical and radiographic evaluation of patients as it was based

on data from patient registry. Finally, EQ. 5D5L utility was used in the calculation of both the primary outcome measure (gain in HRQoL) as well as some of the variables such as preoperative and postoperative utility.

CONCLUSION

The probability of high gain in HRQoL after TKA in patients with a preoperative utility more than 0.22 was 13%, whereas with lower preoperative utility, the probability of high gain in utility increased to 93.4%. This can guide healthcare providers to predict which patients would benefit much after TKA, and thereby prioritize patients with lower preoperative utility.

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CONFLICTS OF INTEREST

There are no conflicts of interest.

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