BVOT – QALY Analysis

Introduction

Total hip and knee arthroplasty are critical interventions for patients suffering from debilitating joint conditions, significantly enhancing their quality of life. This study aims to assess the effectiveness of these surgical procedures by examining patient-reported outcome measures (PROMs) gathered through the data collection tool MoveUP. By analyzing data from patients who underwent primary total hip or knee arthroplasty at Belgian hospitals, we aim to provide a comprehensive evaluation of changes in health-related quality of life (HRQoL) over a two-year period post-surgery. This analysis will contribute valuable insights into the long-term benefits of hip and knee arthroplasty, supporting evidence-based practices in orthopedic surgery and patient care.

Methodology

Study Population

The study encompasses patients who underwent total hip or knee arthroplasty at a Belgian hospital between November 2017 and July 2022. Patient-reported outcome measures (PROMs) were collected via the digital tool MoveUP. A total of 482 hip arthroplasty patients and 392 knee arthroplasty patients were included, based on the availability of baseline (pre-operative) and 2-year post-operative EQ-5D scores.

Eligibility criteria included:

- Undergoing primary total hip or knee replacement surgery within the specified period.
- Availability of pre-operative EQ-5D score.
- Availability of 2-year post-operative EQ-5D score.

For comparative analysis, if the study had considered 6-month post-operative results instead of the 2-year outcomes (as referenced in Acta Orthopaedica Belgica) (1), the eligible population would expand to 1255 total hip replacement patients and 1040 total knee replacement patients. This adjustment in the follow-up period significantly increases the sample size and potentially enhances the statistical power of the study.

Figure 1 and Table 1 illustrate the utility of the MoveUP database, encompassing data from both hip and knee arthroplasty patients in a unified analysis. Figure 1 presents a boxplot depicting the evolution of the EQ-5D index over time, providing a visual representation of how health-related quality of life changes from pre-operative to post-operative periods. Table 1 details the total number of entries available per period within the MoveUP database, offering insights into the comprehensive data collection effort and the scope of the study population included in the analysis.

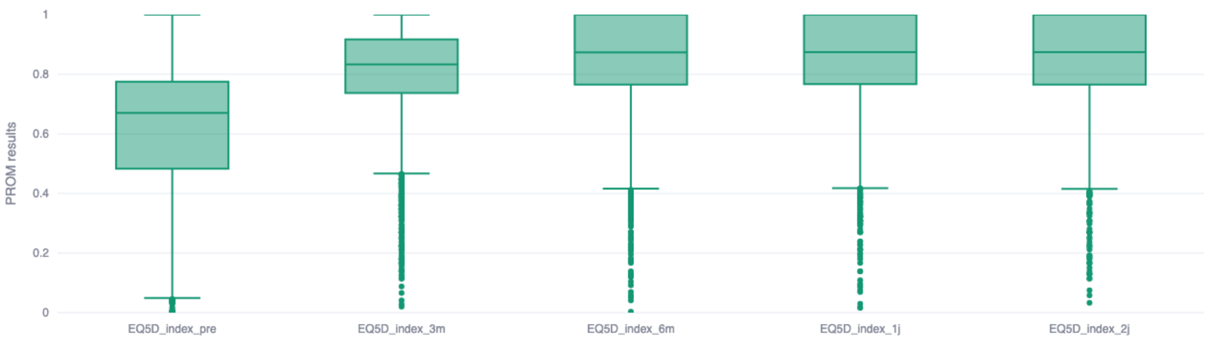

Figure 1: Insights in MoveUP tools, EQ-5D index from pre-operative phase till 2 years post-operative

Period	Total count (Hip + Knee)
Pre-operative	6733
3 months	3880
6 months	3231
1 year	2966
2 years	1600

Table 1: Data potential of MoveUP database regarding the EQ-5D score for patients operated in Belgium

Measurement Tools

The EQ-5D questionnaire was utilized as the primary PROM for QALY calculation. This instrument evaluates five dimensions of health: mobility, self-care, usual activities, pain/discomfort, and anxiety/depression. Each dimension is assessed on a five-level scale, ranging from no problems to extreme problems.

To calculate the final EQ-5D utility values, we employed the Belgian EQ-5D-5L value set published in 2022. This value set provides country-specific weights that accurately reflect the relative importance of different health states based on the preferences of the Belgian population (2).

QALY Gain Calculation

A Quality-Adjusted Life Year (QALY) is a measure that combines the quantity and quality of life to assess the value of medical interventions. QALY calculations were performed following the methodologies outlined in “Calculating QALYs, comparing QALY and DALY calculations” (3).

$$QALYs\ lived\ in\ one\ year\ =\ 1 \times HRQoL$$

The Health-Related Quality of Life, denoted as HRQoL is a measure of how well individuals perceive their physical, mental, and social health over time. It reflects the patient's subjective experience of health and disease. HRQoL values range from -1 (worse than death) to 1 (perfect health). For this study, we used the EQ-5D value set for Belgium to determine the HRQoL. From the QALYs lived in one year, we can define the Quality-Adjusted Life Expectancy (QALE), which represents the expected remaining years of life adjusted for the quality of those years.

$$QALE\ =\ \sum_{t=a}^{a+L} HRQoL_t$$

With *a* being the current age of the patient. and *L* the resulting years to live. Over time, the quality of health generally declines at a certain rate. While this rate is not fixed, we assume an annual discount rate of 3.5% as recommended by the NICE guidelines (4). Next to the general annual discount rate of the quality of health, the patient also has a certain chance for revision of the prothesis.

$$Discounted\ QALE = \sum_{t=a}^{a+L} \frac{HRQoL_t}{(1+r)^{t-a}}$$

With *r* being the discount rate and $P_{revision,\ t}$ representing the probability of requiring a revision surgery, the annual revision rates are defined as follows: for knee arthroplasty, the rate is 1% per year, while for hip arthroplasty, it is 0.5% per year.

In 2022, the average life expectancy in Belgium was 79.6 years for men and 83.8 years for women (5). In our dataset, the maximum age for men is 84.9 years and for women, it is 82.0 years. Given that some patients in the dataset are near or beyond the average life expectancy, we adjusted our calculations accordingly. The sum formula for QALE incorporates the maximum age in the life expectancy tables of Belgium for 2022, which is 105 years. We also include a probability factor indicating the likelihood of being alive at each age, $P_{alive,t}$. The probability of being alive at the time of surgery (t=a) is 1, as the patient is alive at the moment of surgery. Beyond that, national mortality rates per age are used to refine the calculation (6).

$$Final\ QALE = \sum_{t=a}^{105} \frac{HRQoL_t}{(1+r)^{t-a}} \times P_{no\ revision,t} \times P_{alive,t}$$

Finally, the gained QALYs from arthroplasty are calculated as the difference between the *Final QALE'* after intervention and the *Final QALE* without intervention.

$$QALYs\ gained = \sum_{t=a}^{105} \frac{HRQoL'_t}{(1+r)^{t-a}} \times P_{no\ revision,t} \times P_{alive,t} - \sum_{t=a}^{105} \frac{HRQoL_t}{(1+r)^{t-a}} \times P_{alive,t}$$

ICER calculation

The Incremental Cost-Effectiveness Ratio (ICER) is a metric used in health economics to evaluate the cost-effectiveness of a health intervention compared to an alternative (typically the standard of care). ICER is calculated by dividing the difference in costs between the two interventions by the difference in their effectiveness. Mathematically, it is expressed as:

$$ICER = \frac{Cost\ intervention}{QALYs\ gained}$$

where *Cost intervention* represents the total cost related to the intervention. The total cost encompasses the surgery, hospital stay and other related expenses. The QALYs gained represent the effectiveness of the intervention. The resulting ICER value indicates the additional cost per additional unit of effectiveness gained by using the intervention instead of doing nothing. An intervention is typically considered cost-effective if its ICER is below a certain threshold, which varies by healthcare system and context. In this context we consider the threshold being €40000.

Results

Demographics

For the hip arthroplasty group, the mean age at the time of surgery was 62.2 years, with a standard deviation (SD) of 9.2 years. The gender distribution in this group comprised 53.3% men and 46.7% women, indicating a slightly higher prevalence of male patients undergoing hip replacement. In the knee arthroplasty group, the mean age at surgery was slightly higher, at 63.1 years, with an SD of 8.6 years. This group showed a different gender distribution compared to the hip arthroplasty group, with 39.3% men and 60.7% women. This indicates a higher proportion of female patients undergoing knee replacement surgery.

Table 2 lists the number of patients who underwent hip and knee surgeries across different age groups, highlighting the distribution of surgeries among the specified age ranges.

These demographic details underscore the typical patient profiles for hip and knee arthroplasty within our study, reflecting slight variations in age and a notable difference in gender distribution between the two types of arthroplasty procedures. To conclude, the demographics of this study provide an acceptable representation of patients undergoing TKA and THA in Belgium (7).

Age Group	Hip (count)	Knee (count)
-50	46	23
50-55	52	52
55-60	78	75
60-65	113	78
65-70	93	63
70-75	75	73
75+	25	28

Table 2: Number of Patients Undergoing Hip and Knee Surgeries by Age Group.

EQ-5D Results

First, we will analyze the EQ-5D results to evaluate the changes in health status before and after the intervention. The EQ-5D scores, both pre-operative and post-operative (at two years), provide a quantifiable measure of the patients' health-related quality of life (HRQoL). These results are detailed in Table 3: Mean EQ-5D scores for both hip and population before and after intervention, which summarizes the mean EQ-5D scores along with their standard deviations for both hip and knee arthroplasty patients.

	Hip		Knee	
EQ-5D score	**Mean (SD)**	**p-value, Shapiro**	**Mean (SD)**	**p-value, Shapiro**
Pre-operative	0.60 (0.25)	*1e-17*	0.58 (0.26)	*7e-14*
2 years post-operative	0.90 (0.15)	*6e-29*	0.85 (0.19)	*5e-23*
p-value, Wilcoxon	*4e-69*		*2e-50*	

Table 3: Mean EQ-5D scores for both hip and population before and after intervention. Statistics for normality (Shapiro-Wilk Test) and sample comparison (Wilcoxon signed-rank Test) are included.

To quantify the increase in HRQoL resulting from the intervention, we compared the EQ-5D scores before the intervention with the EQ-5D scores two years after the intervention. This methodology is similar to that employed by Konopka et al. (8).

The results are presented in the form of histograms showing the change (Delta) in EQ-5D scores. Figures 2 and 3 illustrate these histograms for hip and knee patients, respectively. In these histograms, blue bars represent an improvement in health status, while red bars indicate a decrease. Additionally, the mean EQ-5D improvement is marked on each graph. For hip arthroplasty patients, the mean improvement in EQ-5D score is 0.30, whereas for knee arthroplasty patients, it is 0.27.

These visual representations help to clearly convey the extent of health status changes post-intervention, highlighting the overall positive impact of the surgeries on patients' HRQoL.

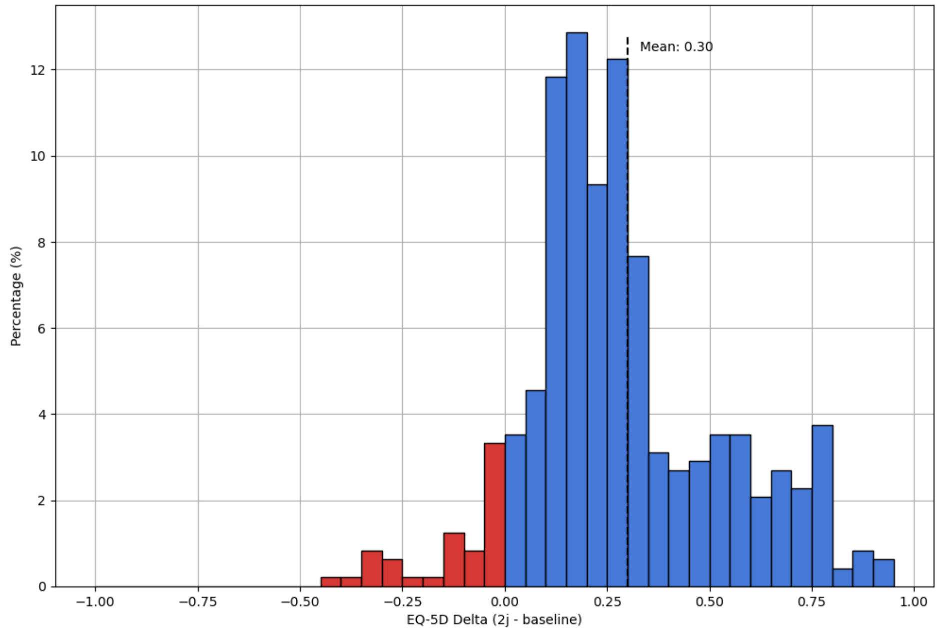

Figure 2: Histogram of the pre- to post-operative shift of the EQ-5D index for the hip population

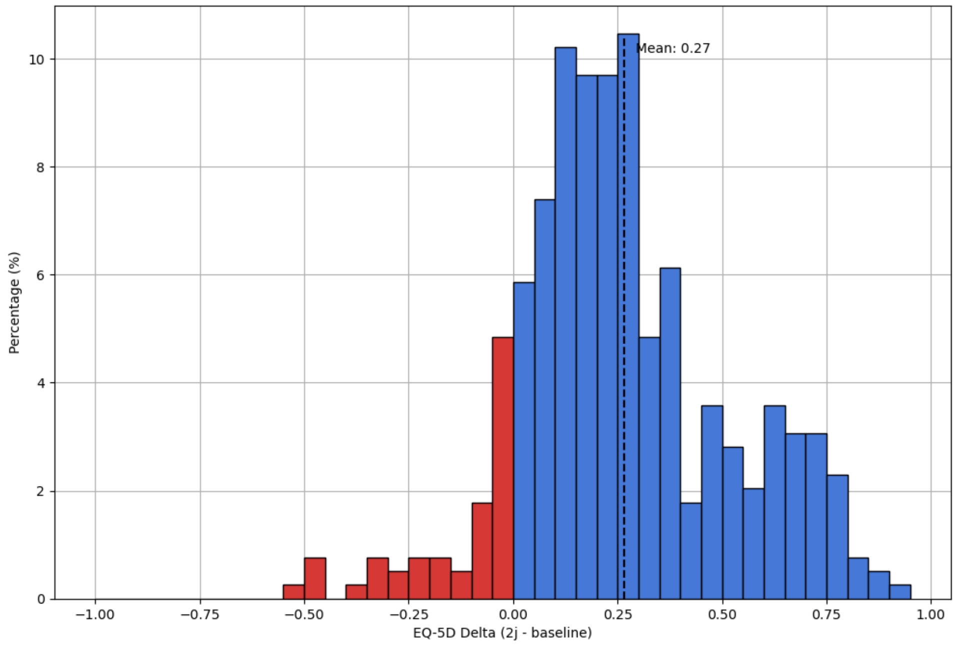

Figure 3: Histogram of the pre- to post-operative shift of the EQ-5D index for the knee population

A statistical analysis was conducted to determine whether there were significant differences between baseline results and the outcomes two years post-surgery. Initially, the dataset for preoperative and postoperative measurements was examined separately for normality using the Shapiro-Wilk test. For both hip and knee surgeries, the p-values from this test were below 0.05, indicating that the EQ-5D values were not normally distributed.

Given the non-normal distribution of the data, the Wilcoxon Signed-Rank Test was used for comparing preop and postop results. This non-parametric test is suitable for data that does not meet normality assumptions. The results revealed p-values below 0.05 for both hip and knee surgeries, leading us to reject the null hypothesis (which posits that there is no difference between preop and postop outcomes). Therefore, we can conclude that there is a significant improvement in the EQ-5D values for both THA and TKA.

Quality-Adjusted Life Expectancy (QALE)

Before undergoing surgery, patients had a baseline QALE of approximately 8.9 years for hip arthroplasty and 8.0 years for knee arthroplasty (Table 4). Two years post-surgery, these figures notably increased to 13.0 years for hip patients and 11.7 years for knee patients, indicating substantial improvements in expected remaining years of life adjusted for health-related quality of life.

	Hip, Median (q_{25}-q_{75})	**Knee, Median (q_{25}-q_{75})**
Final QALE, Pre-operative	8.9 (6.0-11.5)	8.0 (5.1-10.5)
Final QALE, 2 years post-operative	13.0 (10.8-15.1)	11.7 (9.5-13.6)
QALY Gain	3.5 (1.8-6.4)	3.0 (1.3-5.6)
ICER (€ per QALY)	1981 (981-3413)	2678 (1245-5037)

Table 4: Final QALE values, total QALY gain and ICER for both hip and knee population. The table displays the median values and the interquartile range.

QALY Gain

The analysis revealed a significant increase in QALYs following both hip and knee arthroplasty procedures. On average, patients undergoing hip arthroplasty experienced a QALY gain of approximately 3.5 years, while knee arthroplasty patients gained about 3.0 years (Table 4). These findings underscore the profound impact of these surgical interventions in enhancing quality of life for individuals suffering from severe joint conditions. Figure 4: Average QALY Gain by Age Group and Body Structure. presents the average QALY gain across different age groups for both hip and knee surgeries, highlighting a downward trend with increasing age and demonstrating higher QALY gains for hip patients compared to knee patients.

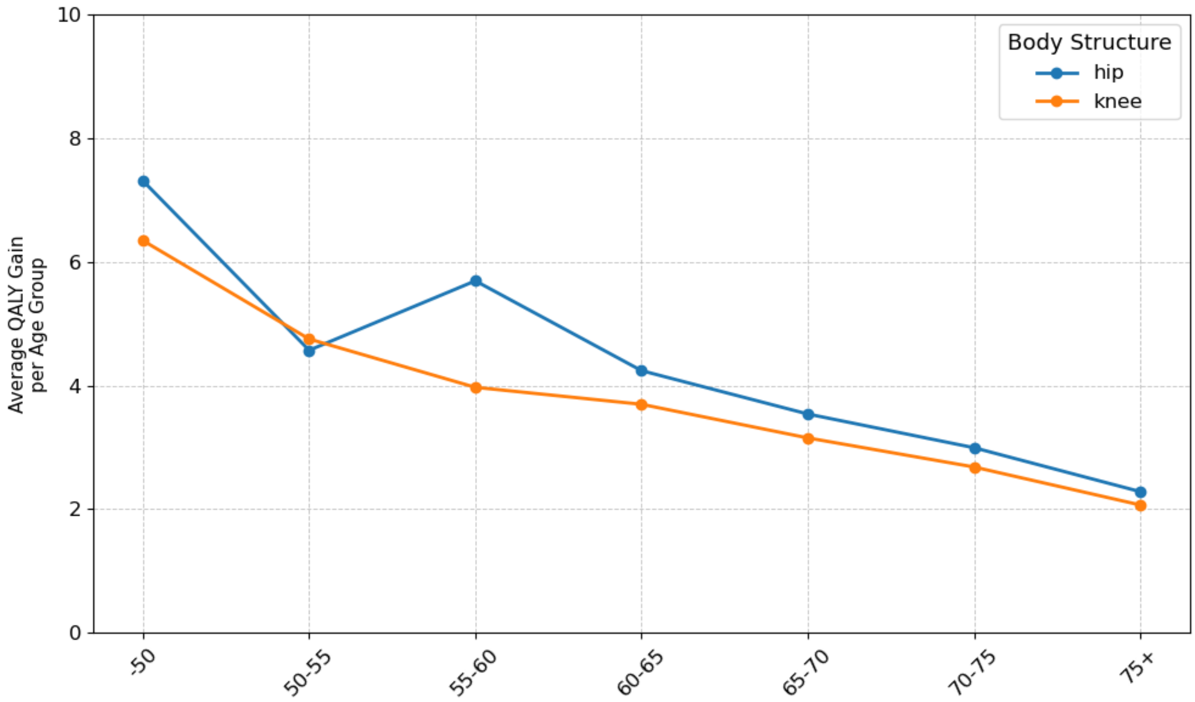

Figure 4: Average QALY Gain by Age Group and Body Structure.

ICER

In our analysis of the Incremental Cost-Effectiveness Rati, we utilized expert knowledge from Prof. Dr. Peter Verdonk to estimate the costs of THA and TKA interventions. The cost for a THA intervention was assumed to be €7500, while the cost for a TKA intervention was set at €9500.

The calculated median ICER values were €1981 per QALY gained for hip arthroplasty patients and €2678 per QALY gained for knee arthroplasty patients (Table 4). These ICER values are significantly below the €40000 threshold commonly used to determine cost-effectiveness. This indicates that both interventions are highly cost-effective within the Belgian healthcare context.

Conclusion

The study investigated the cost-effectiveness and quality of life outcomes for patients undergoing total hip arthroplasty (THA) and total knee arthroplasty (TKA) in Belgium. Using patient-reported outcome measures (PROMs) collected via the moveUP digital tool, we analyzed data from 482 hip arthroplasty patients and 392 knee arthroplasty patients, focusing on changes in EQ-5D scores from pre-operative to two years post-operative.

The results demonstrated significant improvements in health-related quality of life (HRQoL) for both THA and TKA patients, with mean EQ-5D scores increasing significantly post-surgery. The QALY gains were notable, with hip arthroplasty patients gaining an average of 3.5 QALYs and knee arthroplasty patients gaining 3.0 QALYs. These improvements translated into enhanced quality-adjusted life expectancy (QALE), reflecting the positive impact of these surgical interventions.

The cost-effectiveness analysis, measured through the Incremental Cost-Effectiveness Ratio (ICER), indicated that both THA and TKA are economically viable interventions within the Belgian healthcare context, with ICER values well within acceptable thresholds.

In conclusion, our study highlights the substantial benefits of THA and TKA in terms of both quality of life and cost-effectiveness. These findings support the continued use and funding of these procedures, emphasizing their value in improving patient outcomes and overall healthcare efficiency. Future research should focus on long-term outcomes and the potential benefits of enhanced perioperative care to further optimize these interventions.

Bibliography

1. *Evaluation of patient reported outcome measures and costs of managing osteoarthritis of the hip.* Dehanne, F, et al. s.l. : Acta orthopaedica belgica, 2024.

2. *An EQ-5D-5L Value Set for Belgium* . Bouckaert, Nicolas, et al. 2022, PharmacoEconomics - Open, pp. 823-836.

3. *Calculating QALYs, comparing QALY and DALY calculations* . Sassi, Franco. s.l. : Health Policy and Planning, 2006.

4. Discounting of health benefits in special circumstances. [Online] https://www.nice.org.uk/guidance/ta235/resources/osteosarcoma-mifamurtide-discounting-of-health-benefits-in-special-circumstances2.

5. Life Expectancy and Quality of Life in Belgium. [Online] https://www.healthybelgium.be/en/health-status/life-expectancy-and-quality-of-life).

6. België in cijfers. [Online] https://statbel.fgov.be/nl.

7. Demographic Comparison of BVOT QALY Data with Orthopride Trends. [Online] 2024. https://cdn.moveup.care/report-appendices/Demographic_Comparison_of_BVOT_QALY_Data_with_Orthopride_Trends.docx

8. *Quality-Adjusted Life Years After Hip and Knee Arthroplasty: Health-Related Quality of Life After 12,782 Joint Replacements.* Konopka, Joseph, et al. s.l. : JB JS Open Access, 2018.