Impact of Arthroplasty Sequence on Functional Outcomes Following Ipsilateral Total Hip and Knee Arthroplasty

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Date of submission: 19th March 2025
Date of acceptance: 21st July 2025

ABSTRACT

Introduction: Osteoarthritic patients who undergo index total hip or knee replacement have higher likelihood of receiving subsequent arthroplasties. This study hypothesises that patients who receive THR first have better functional outcomes than patients who receive TKR before ipsilateral THR.

Materials and methods: This retrospective study analysed 60 patients with ipsilateral THR and TKR from January 1999 to December 2014. Group 1 underwent THR before TKR (n=27, interval between surgeries 50.4±37.8 months) while Group 2 underwent TKR first (n=33, interval between surgeries 42.1±34.4 months). Functional outcome scores – Short Form Health Survey (SF-36), Oxford Knee Score (OKS), Knee Society Score (KSSFS), Oxford Hip Score (OHS), Western Ontario and McMaster Universities Arthritis Index (WOMAC) – were recorded pre-operatively, six-months and two-years post-operatively.

Results: Pre-operatively, Group 1 patients had superior SF-36 physical component scores (33.8±10.4 vs 28.3±8.0, P=0.028) compared to Group 2. Group 1 patients had superior 6-month OKS (20.7±5.2 vs 26.8±10.9, P=0.035) and 2-year KSSFS (66.8±13.3 vs 56.2±24.1, P=0.020) post-TKR. Both groups demonstrated improvements in SF-36 scores after the 2nd surgery. Group 1 patients had superior satisfaction rates (1.9±0.6 vs 2.8±1.5, P=0.019) and expectations met (1.9±0.8 vs 2.8±1.8, P=0.04).

Conclusion: In patients with ipsilateral THR and TKR, those with THR first had superior early functional outcomes. This may be due to technical disease factors such as altered kinematics of the arthritic hip, or knee pain resulting from referred hip pain as a cognate joint. Further studies to evaluate long term outcomes of patients with ipsilateral TKR and THR is recommended.

Keywords:
total knee arthroplasty, total hip arthroplasty, ipsilateral total joint arthroplasty, osteoarthritis

INTRODUCTION

Total joint replacement is an effective option for end-stage osteoarthritis (OA) of the hip and knee. The prevalence of total hip replacement (THR) and total knee replacement (TKR) is rising[1] and expected to continue its trend over the next decade[2]. The increased utilisation rates of total joint replacement will predictably lead to an increased number of patients with ipsilateral TKR and THR[3], although there is a paucity in literature describing the incidence of patients with ipsilateral THR and TKR and their functional outcomes. A population-based study performed by Sanders *et al* revealed that after an index TKR or THR, patients had a 30 to 45% chance of a surgical procedure in a contralateral cognate joint and about a 5% chance of a surgical procedure in non-cognate joints within 20 years of initial arthroplasty[4].

Whilst high satisfaction rates can be achieved in both TKR[5] and THR[6], THR confers superior satisfaction rates[7] and better meets patients' expectations[8] compared to TKR. In the management of rheumatoid arthritis (RA) patients with polyarticular involvement, the accepted expert opinion is that the hip should be replaced before the knee as an adequate arc of hip motion is required for deep knee flexion, which is required for a successful TKR[9]. This opinion, however, is based on anecdotal experience with patients affected by rheumatoid arthritis, with a paucity in the literature on the outcomes after undergoing both THR and TKR[10]. This prevailing opinion also may not be applicable to patients who are affected by osteoarthritis.

As contiguous joints, abnormalities in the hip joint can affect knee function and vice versa. Biomechanical studies have demonstrated that impaired muscular control of hip, pelvis, and trunk can affect tibiofemoral and patellofemoral joint kinematics in multiple planes[11,12]; that hip strengthening protocols may help alleviate patello-femoral knee pain[13]. With greater relevance to an arthritic population, it has been shown that clinical severity of knee osteoarthritis correlates

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with decreased hip range of motion as well as hip moments during gait[14]. In addition, up to 60% patients who had THR experienced anterior knee pain, likely due to changes in limb length affecting patello-femoral kinematics[15].

Restoration of the mechanical axis of the lower limb is crucial in a successful TKR[16]. Patients with ipsilateral hip osteoarthritis often have abnormal hip centre of rotation, thus replacing the hip first and restoring anatomical hip centre of rotation may aid future mechanical alignment during TKR. Moreover, the hip joint, functioning as a ball-and-socket joint, has greater predictability in terms of kinematics and loading pattern, and is less susceptible to abnormalities in knee alignment. On the other hand, insertion of the intramedullary femoral guide for a TKR in a patient with previous THR may be challenging due the femoral prosthesis, which may consequently affect alignment[17].

We hypothesise that patients who received a THR first followed by a subsequent TKR will have superior general health and knee-specific outcomes after their TKR as compared to those patients who do their TKR first. Due to the greater reliability of THR, we anticipate that the order of THR surgery with respect to TKR will not significantly affect the general and hip-specific outcome measures after THR.

MATERIALS AND METHODS

A retrospective study was conducted on functional outcomes data from January 1999 to December 2014, identifying patients who initially presented with symptoms suggestive of either knee or hip osteoarthritis with subsequent pain in the cognate joint, and underwent ipsilateral TKR and THR in a tertiary institution for osteoarthritis. Joint replacement was performed for the more symptomatic joint first. Patients who underwent revision or bilateral hip/knee arthroplasty, arthroplasty for acute fractures and patients without a minimum of two years follow-up were excluded. Patients were grouped into those who received THR first (Group 1) versus those who received THR after TKR surgery (Group 2) (Fig. 1). Pre-operative demographic data collected include age, sex, height, weight, body mass index (BMI). Institutional Review Board (IRB) approval was obtained for this study prior to data collection.

The functional outcome scores and knee range of motion (ROM) values of the patients were recorded pre-operatively, at six months and two years follow-up by independent personnel from an institutional joint registry with requisite data protection integrity protocols. General health outcome measures were represented by the 36 item Short Form Health Survey (SF-36), reflecting quality of life and consists of eight scaled scores. Each scale was then transformed into a 0-100 scale on the assumption that each question carries equal weight; the higher the score, the less disability. The eight sections are: vitality (SFVI), physical functioning (SFPF), bodily pain (SFBP), general health perceptions (SFGHP), physical role functioning (SFPRF), emotional role functioning (SFERF), social role functioning (SFSF) and mental health (SFMH)[18]. Physical subcomponent (PCS) and mental subcomponent scores (MCS) were also derived from weighted items of the SF-36 score. Satisfaction and expectation fulfilment rates were indicated by a Likert scale.

Knee-specific outcome measures were represented by the Oxford Knee Score (OKS) and Knee Society Score (KSS), subdivided into functional score (KSSFS) based on how the patient perceives that the knee functions with specific activities and a knee score (KSSKS) based on clinical parameters. Hip-specific outcome measures were obtained via the Oxford Hip Score (OHS) Western Ontario and McMaster Universities Arthritis Index (WOMAC) which consists of 24 items divided into 3 subscales – Pain (WOMAC 1), Stiffness (WOMAC 2) and Physical Function (WOMAC 3).

Following TKR, long-leg standing radiographs were performed, where the hip-knee-ankle angle (HKAA)16 was measured. This represents the overall alignment of the lower extremity.

All procedures were performed by senior surgeons with at least 10 years of experience in performing TKR or THR procedures. The choice of implants and use of navigation was based on surgeon preference. All patients were managed on the institution's standardised hip and knee arthroplasty pathway and underwent the same physiotherapy regimen.

Power analysis was performed prior to the study. The anticipated means, standard deviation and minimal clinically important difference (MCID) of five points for the OKS and OHS was obtained from prior studies[19]. Based on an alpha (probability of type 1 error) and power of 80%, a sample size of 32 with 16 in each group was required.

The Statistical Package for the Social Sciences (SPSS) [IBM Corp. Released 2015. IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp] software was used to analyse data. Paired t-test was performed to compare parametric values (height, weight, BMI, age) between the two groups. Wilcoxon signed rank test was performed to compare the post-operative outcome scores at six months and two years (Short Form-36 questionnaire, OHS, OKS, KSS and WOMAC scores) to pre-operative values.

Normality tests (Kolmogorov-Smirnov) were conducted on outcome scores which showed that these variables did not follow a normal distribution. Therefore, Mann-Whitney U test was performed to compare the outcome scores between the two groups. Statistical significance was defined as a p value of <0.05.

Table I: Pre-operative demographics and time between surgeries.

	Group 1 (n=27)		Group 2 (n=33)		p-value
	Mean	Std. Deviation	Mean	Std. Deviation	
Age (years)	68.9	7.2	69.2	8.5	0.970
Gender (%females)	96.3		81.8		0.082
Weight (kg)	65.1	8.2	65.9	16.5	0.687
Height (cm)	152.0	8.1	154.5	8.0	0.505
BMI (kg/m²)	28.2	3.3	27.5	6.1	0.469
Difference in operative dates (Months)	50.4	37.8	42.1	34.4	0.462

Table II: Functional outcomes scores following TKR.

		Group 1 (n=27)		Group 2 (n=33)		p-value
		Mean	Std. Deviation	Mean	Std. Deviation	
Pre-operative	SF-36 PCS	33.8	10.4	28.3	8.0	0.028
	SF-36 MCS	49.1	11.4	49.8	11.9	0.705
	OKS	37.0	9.3	39.9	7.8	0.191
	KSSFS	48.5	15.9	41.8	18.1	0.192
	KSSKS	35.1	17.8	33.6	20.0	0.551
Six-month	SF-36 PCS	45.7	11.3	40.0	13.8	0.255
	SF-36 MCS	55.3	10.8	49.6	12.7	0.069
	OKS	20.7	5.2	26.8	10.9	0.035
	KSSFS	62.5	18.9	49.6	21.2	0.010
	KSSKS	84.0	12.3	77.4	16.5	0.065
	Satisfaction	2.4	1.0	3.0	0.9	0.033
	Expectations Met	2.5	1.1	3.0	1.6	0.343
Two-year	SF-36 PCS	42.7	11.9	41.6	13.1	0.562
	SF-36 MCS	43.3	25.1	53.4	13.3	0.246
	OKS	18.7	4.1	22.5	9.4	0.281
	KSSFS	66.8	13.3	56.2	24.1	0.020
	KSSKS	85.6	11.3	82.9	14.0	0.639
	Satisfaction	2.2	1.0	2.8	1.5	0.326
	Expectations Met	2.1	1.1	2.8	1.8	0.360

Table III: Functional outcome scores following THR.

		Group 1 (n=27)		Group 2 (n=33)		p-value
		Mean	Std. Deviation	Mean	Std. Deviation	
Pre-operative	SF-36 PCS	25.9	9.4	24.1	7.1	0.694
	SF-36 MCS	49.3	12.5	48.4	13.1	0.864
	OHS	43.6	8.7	45.2	8.2	0.435
	WOMAC1	48.2	24.8	46.1	25.1	0.806
	WOMAC2	59.4	35.0	66.4	31.9	0.504
	WOMAC3	39.5	20.8	35.3	20.3	0.353
Six-month	SF-36 PCS	42.5	11.1	40.0	12.5	0.535
	SF-36 MCS	57.0	12.3	52.4	10.7	0.085
	OHS	18.7	7.1	22.2	10.8	0.371
	WOMAC1	97.2	7.5	91.6	20.9	0.481
	WOMAC2	91.5	16.6	87.7	20.3	0.610
	WOMAC3	81.4	15.0	73.5	24.8	0.376
	Satisfaction	2.3	0.8	2.3	1.2	0.767
	Expectations Met	2.2	0.7	2.4	1.5	0.966
Two-year	SF- 36 PCS	45.2	9.9	41.4	13.3	0.400
	SF-36 MCS	54.0	9.4	54.5	10.4	0.748
	OHS	17.7	4.9	19.4	9.4	0.622
	WOMAC1	96.3	9.5	95.9	10.7	0.904
	WOMAC2	98.7	5.2	95.5	10.9	0.262
	WOMAC3	85.6	10.9	80.0	20.5	0.780
	Satisfaction	1.9	0.6	2.3	1.2	0.379
	Expectations Met	1.9	0.8	2.4	1.5	0.215

Table IV: Outcomes following second surgery.

		Group 1 (n=27) Mean	Group 1 (n=27) Std. Deviation	Group 2 (n=33) Mean	Group 2 (n=33) Std. Deviation	p-value
Pre-first surgery	SF-36 PCS	33.8	10.4	24.1	7.1	<0.001
	SF-36 MCS	49.1	11.4	48.4	13.1	0.822
Six-month post second surgery	SF- 36 PCS	42.5	11.1	40.0	13.8	0.473
	SF-36 MCS	57.0	12.3	49.6	12.7	0.042
	Satisfaction	2.3	0.8	3.0	0.9	0.029
	Expectations Met	2.2	0.7	3.0	1.6	0.099
Two-year post second surgery	SF- 36 PCS	45.2	9.9	41.6	13.1	0.234
	SF-36 MCS	54.0	9.4	53.4	13.3	0.829
	Satisfaction	1.9	0.6	2.8	1.5	0.019
	Expectations Met	1.9	0.8	2.8	1.8	0.040

RESULTS

From January 1999 to December 2014, 250 patients underwent ipsilateral THR and TKR. 60 patients were left for analysis after removing patients who did not fulfil the inclusion criteria. Group 1 had 27 patients while Group 2 had 33. The demographic data of the two groups (Table I) described a similar patient profile. Ten (37.0%) and 8 (24.2%) patients in Group 1 and Group 2, respectively underwent navigated TKR; this proportion was not statistically significantly different (p=0.397).

The differences in time between the two surgeries were also not significantly different with approximately four years between the procedures. There were no patients who received both THR and TKR in the same admission. A total of 33.3% of patients in both groups received their surgeries within 2 years of each other. Specifically, 2 patients (7.4%) in Group 1 and none in Group 2 received the surgeries within 3 months but this number was deemed to be low and insignificant.

The pre-operative knee outcome scores between the groups were similar except for SF-36 PCS (Table II). Group 2 had poorer OKS, KSSFS and satisfaction rates at six-month follow-up. At two years, Group 2 had poorer KSSFS, but OKS were not significantly different.

The pre-operative hip outcome scores between both groups were similar (Table III), and not significantly different at all follow-up time points. Both groups had significant improvements in their OKS and OHS (Fig. 2 and 3). This was mirrored in the other outcome scores and similarly plateaued towards the 2-year follow-up. However, there is superior improvement in six-month OKS in Group 1 compared to Group 2.

At six months after the second surgery, Group 2 had inferior SF-36 MCS scores and satisfaction rates. While SF-36 scores were not significantly different at the two-year follow-up, Group 2 persisted to have lower satisfaction rates and less satisfactory rates of expectations met (Table IV, Fig. 4 and 5).

In terms of the post-TKR mechanical alignment, the HKAA was 178.1±2.0 degrees in Group 1 and 178.0±2.3 in Group 2, which was not statistically significant (p=0.892).

Post-hoc power analysis revealed that the study was sufficiently powered at 81.2%. In terms of complications, there were no mortalities in the studied period; however, there was a case of peri-implant fracture in Group 2.

DISCUSSION

The results demonstrate that patients who had undergone sequential ipsilateral TKR and THR achieved significant improvement in outcome measures over two years in both groups. However, those who received a THR first had better six-month Oxford Knee Scores and two-year Knee Society function scores. Additionally, Group 1 patients had higher two-year satisfaction rates and better-met expectations despite there being no differences in general health measures using SF-36.

Both groups had patients of comparable age, gender and time difference between the two arthroplasties. However, Group 1 presented with superior SF-36 PCS scores despite similar knee-specific functional scores. While patients undergoing THR and TKR have previously been reported to have similar pre-operative SF-36 scores[20], the study group is dissimilar as Group 2 patients subsequently went on to receive THR. The residual or initially sub-clinical hip symptoms may have affected their baseline SF-36 PCS, possibly explaining why Group 1 had better SF-36 PCS scores contributed by a well-functioning replaced hip joint. Group 1 had superior OKS at six months that fulfilled the MCID for OKS[19] and better KSSFS at two years that was likewise above the MCID[21]. The functional outcomes after THR were unaffected by its sequencing with respects to TKR. This study demonstrates that in patients who received sequential ipsilateral hip and knee arthroplasty, those who received THR first had superior post-TKR outcome scores whilst post-THR outcomes were unaffected by sequence of surgery. This is dissimilar to a

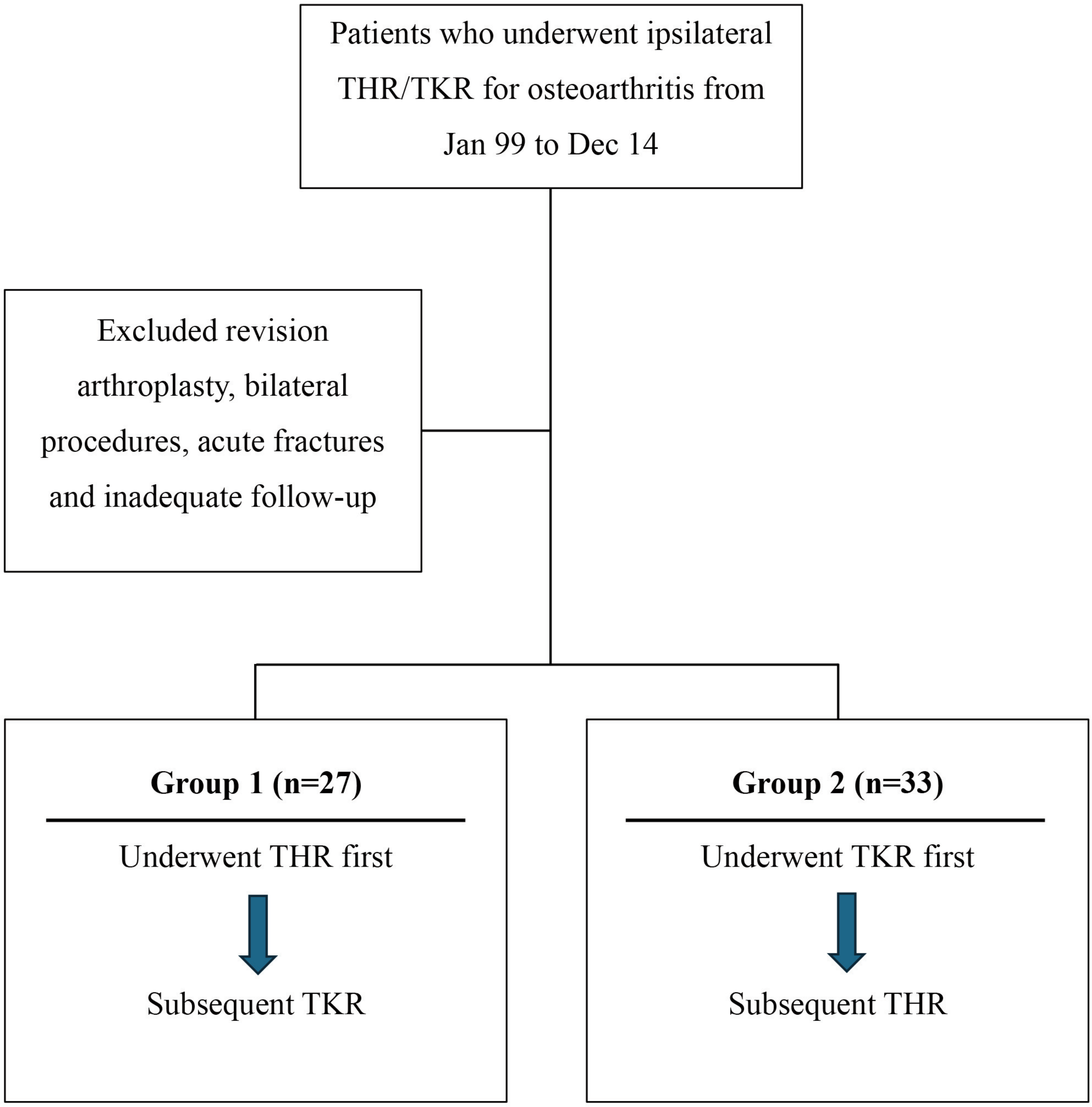

Fig. 1: Patient recruitment flowchart.

study by Liu *et al*, which described similar outcomes between both groups, although notably their study differs from ours by including both patients with osteoarthritis and rheumatoid arthritis, and only posterior-stabilised implants were used for TKR[22]. Nonetheless, our findings may be explained by patient, disease and technical factors.

Technical factors in an arthritic hip may affect outcomes after TKR, including abnormalities in hip centre or rotation, limb length discrepancy and the effect of reduced hip ROM. Patients with limb length discrepancy tend to externally rotate the shortened leg, leading to continued excessive medial strain[23] and increased loading[24] despite TKR. It is also possible that the decreased ROM of the arthritic hip may tax the soft tissue restraints in a replaced knee due to compensatory changes[25]. Computer-assisted navigation may help to overcome these challenges, although utilisation rates is surgeon-dependent and influenced by factors other than technical challenges. However, the technical goal of good mechanical alignment was similarly achieved in both groups as evident in the post-operative HKAA. This may suggest that the inferior outcomes in Group 2 is not due to technical challenges, although caveat being that this study did not evaluate rotational alignment factors, such as the Whiteside's axis, posterior condylar axis or transepicondylar axis which may also affect post-operative outcomes[26].

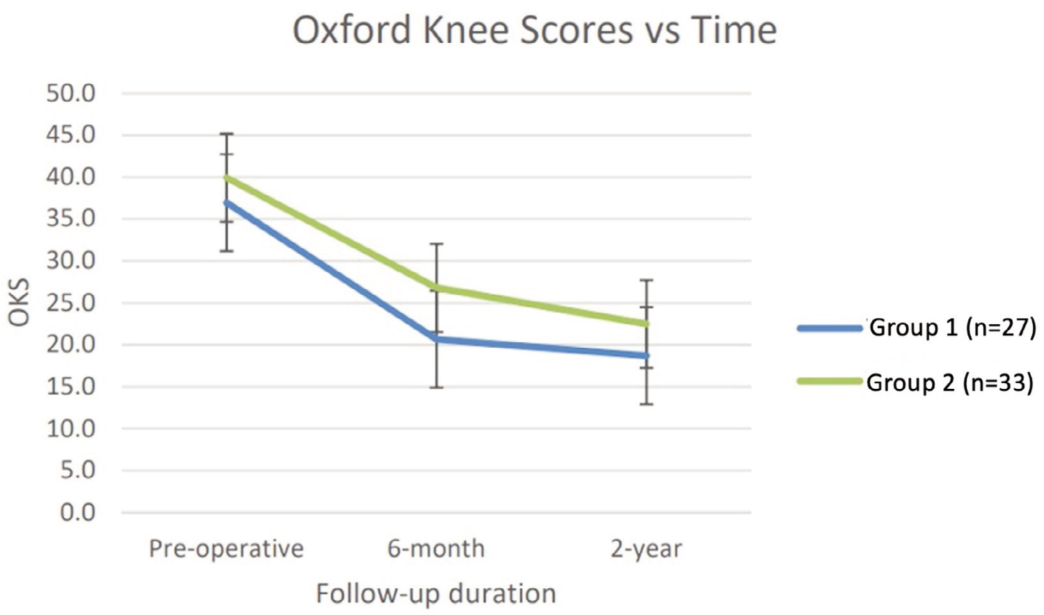

Fig. 2: Improvement in OKS over Time.

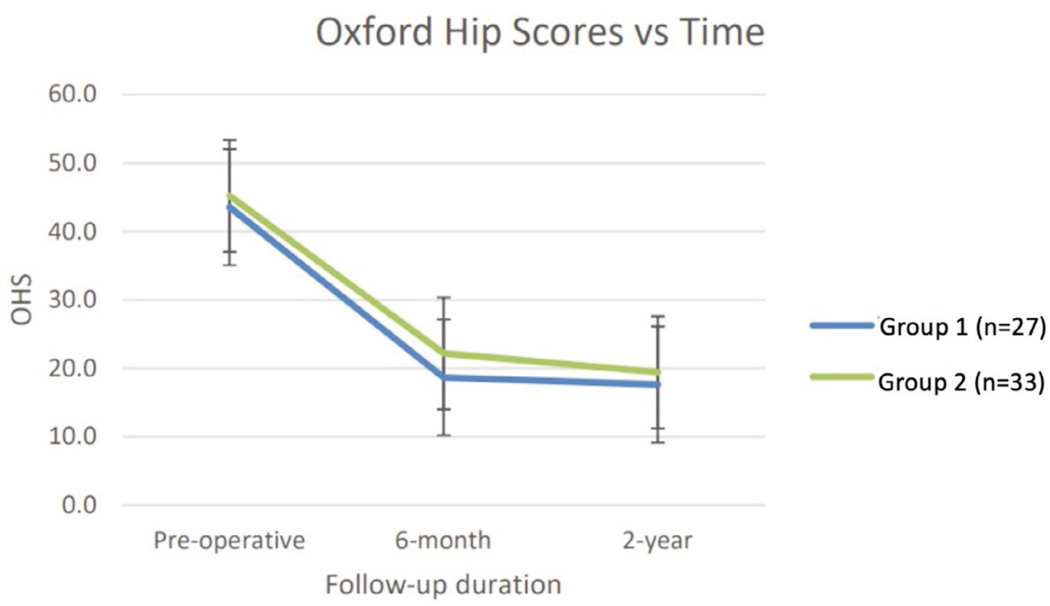

Fig. 3: Improvement in OHS over Time

Patients presenting with knee pain could have contribution from referred hip pain, thus they may still experience dissatisfaction from their TKR due to residual hip symptoms. The OKS cease to be significantly different two years after surgery, possibly as a significant proportion of patients would have received their eventual THR (36.4%). The authors also acknowledge that there may be diagnostic confusion in treating patients with ipsilateral hip and knee symptoms; it is possible that clinicians and patients focus on one joint at the expense of subtle symptoms in the contiguous joint[27].

Additionally, despite patients in both groups receiving their indicated hip and knee arthroplasties, Group 1 still had better satisfaction rates and met expectations two-years after the conclusion of their second surgery. However, this was not explained by the SF-36 PCS or MCS. A previous study demonstrated that patient expectations were highly correlated with satisfaction and that poor pre-operative MCS and poor improvement in OKS were predictors of poor satisfaction after TKR[28]. These elements were not demonstrated in the study population as the SF-36 MCS were similar and both groups achieved improvement in OKS.

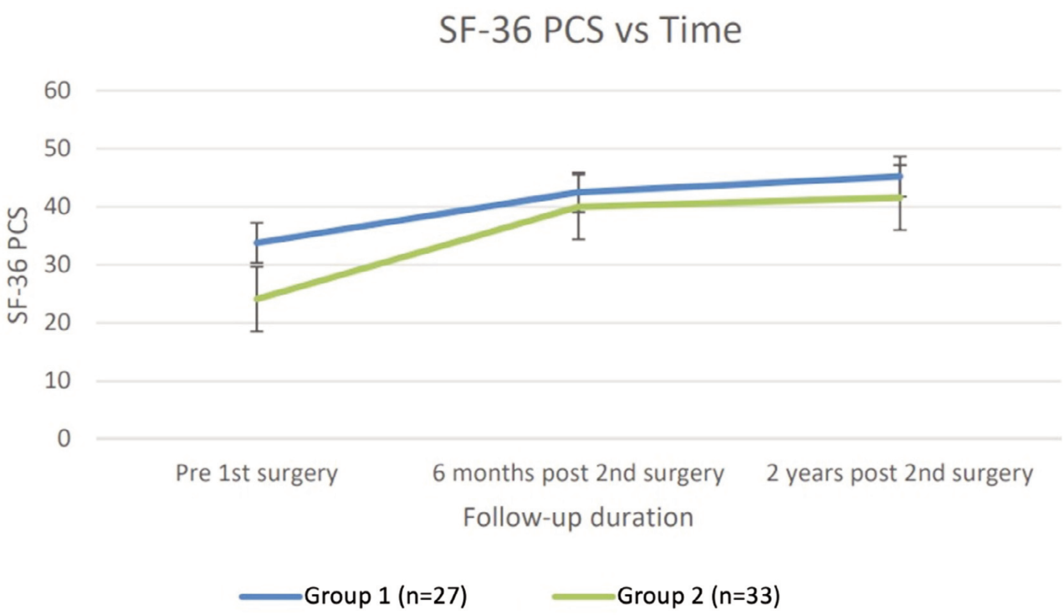

Fig. 4: SF-36 PCS over time after second surgery.

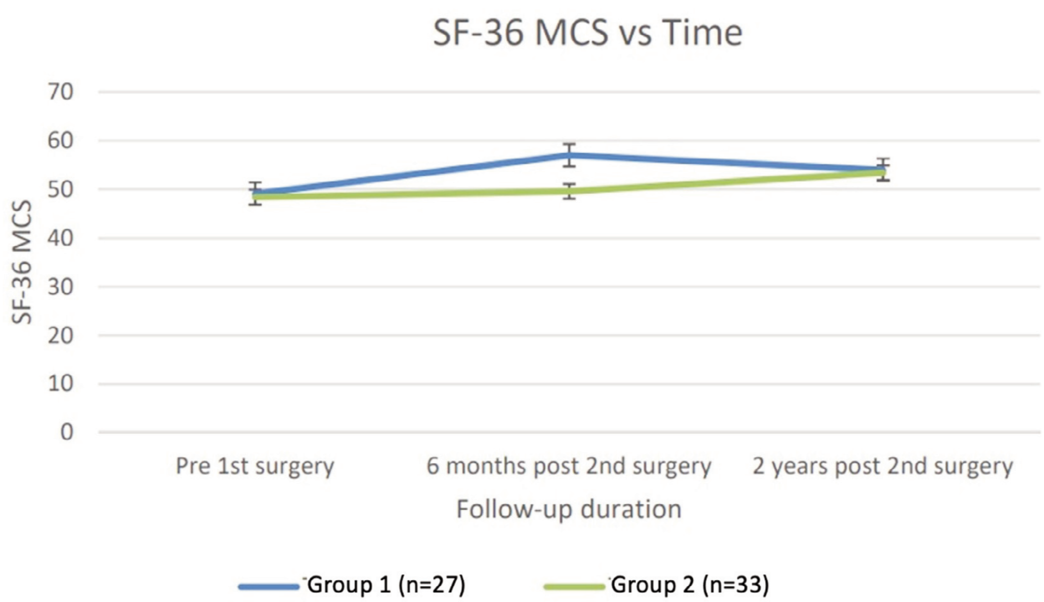

Fig. 5: SF-36 MCS over Time after second surgery.

The results of this study contribute to the understanding of osteoarthritis as a systemic disease and that patients who undergo index joint arthroplasty are at greater risk of subsequent arthroplasty. This emphasises the importance of screening for features of arthritic changes in the cognate joints. While this is an observational study, it provides evidence that in patients planned for ipsilateral hip and knee arthroplasties, replacing the hip first provides better outcomes after TKR without significant effects to post-THR outcomes. Further directions for research include multi-centre randomised studies to compare THR versus TKR first in patients presenting with ipsilateral hip and knee symptoms.

There are some limitations to the design of the study. Firstly, while the OKS and KSS are designed to be knee-specific outcome scores, it is inevitable that mild impairment in the hip joint affects the knee-specific outcome scores. On the other hand, the functional outcomes after THR are relatively unaffected by its sequence with regards to TKR and could possibly be explained by the superior functional outcomes after THR compared to TKR reported in existing literature[29].

Secondly, spinopelvic parameters were not assessed in this study due to unavailable imaging data. Spinopelvic mobility and alignment are known to influence implant positioning, stability, and biomechanics[30]. Abnormal spinopelvic dynamics—such as in stiff spines or sagittal imbalance—may cause altered biomechanics and affect recovery after THR, thereby influencing the outcomes in this study.

As a retrospective study, the enrolment of patients is subject to selection bias. The patients who underwent a subsequent joint arthroplasty in the same institution are likely to be satisfied after the index arthroplasty procedure. Patients who had a poor outcome after initial THR or TKR but require subsequent arthroplasty may choose to follow-up at other centres or refuse operation altogether. However, the satisfaction rates after TKR in our institution are high[31], thus the number of patients who refuse an indicated subsequent procedure is likely to be low.

In addition, this study did not include patients presenting with equally significant ipsilateral hip and knee symptoms concurrently and underwent different sequences of TKR and THR; this limits a more direct comparison regarding the sequence of arthroplasties, although such a population is sparse. In this vein, the authors also recognised there is a selection bias introduced as the arthroplasty sequence is based on patient symptoms rather than randomisation, thus confounding conclusions on whether differences observed are due solely to surgical sequence or contributed to by pre-existing disease burden.

Due to the relatively low incidence of THR in an Asian population[32], the number of patients with ipsilateral THR and TKR remains low; the actual prevalence warrants a larger nationwide study. The low patient numbers preclude a matched comparison, although the patient groups are well matched in terms of demographic and the majority of pre-operative functional scores.

Future directions of study include longer term reviews. While the study is sufficiently designed to capture early functional outcomes data, it is unable to address long term complications which may be affected by contiguous joint arthroplasty or lack thereof in an indicated patient, such as loosening and peri-prosthetic fractures. In addition, in a patient with an arthritic hip but refuses THR, failure of the TKR could occur due to compensatory strain from decreased ROM of the hip. As the prevalence of hip and knee arthritis increases, orthopaedic surgeons should always screen the hip in a patient presenting with end-stage knee osteoarthritis.

CONCLUSION

In summary, this study revealed that in patients who underwent sequential ipsilateral hip and knee arthroplasties for osteoarthritis, those who received a THR first had superior early functional outcomes post-TKR. Outcomes after total hip arthroplasty, however, are not significantly affected by the sequence of surgery.

CONFLICT OF INTEREST

The authors declare no potential conflict of interest.

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Cite this article:
Yang C, Jiang L, Goh J, Yeo SJ, Lo NN. Impact of Arthroplasty Sequence on Functional Outcomes Following Ipsilateral Total Hip and Knee Arthroplasty. *Malays Orthop J.* 2026; 20(2): xx-xx. doi: