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Observational Study

Comparison of clinical outcomes between total hip replacement and total knee replacement

Green A *et al.* Comparison of patient reported outcome measures

Abstract

BACKGROUND

Total hip replacements (THR) and total knee replacements (TKR) are effective treatments for severe osteoarthritis (OA). Some studies suggest clinical outcomes following THR are superior to TKR, the reason for which remains unknown. This study compares clinical outcomes between THR and TKR.

AIM

To compare the clinic outcomes of THR and TKR using a comprehensive range of patient reported outcome measures (PROMs).

METHODS

A prospective longitudinal observational study of patients with OA undergoing THR and TKR were evaluated using a comprehensive range of generic and joint specific PROMs pre- and post-operatively.

RESULTS

A total of 131 patients were included in the study which comprised the THR group (68 patients) and the TKR group (63 patients). Both groups demonstrated significant post-operative improvements in all PROM scores ($P < 0.001$). There were no significant differences in post-operative PROM scores between the two groups: Hip and Knee Osteoarthritis Outcome scores ($P = 0.140$), Western Ontario and McMaster Universities Osteoarthritis Index pain ($P = 0.297$) stiffness ($P = 0.309$) and function ($P = 0.945$), Oxford Hip and Knee Score ($P = 0.076$), EuroQol-5D index ($P = 0.386$) and Short-Form 12-item survey physical component score ($P = 0.106$). Subgroup analyses showed no significant difference ($P > 0.05$) between cruciate retaining and posterior stabilised prostheses in the TKR group and no significant difference ($P > 0.05$) between cemented and uncemented fixation in the THR group. Obese patients had poorer outcomes following TKR but did not significantly influence the outcome following THR.

CONCLUSION

Contrary to some literature, THR and TKR are equally efficacious in alleviating the pain and disability of OA when assessed using a comprehensive range of PROMs. The varying knee prosthesis types and hip fixation techniques did not significantly influence clinical outcome. Obesity had a greater influence on the outcome following TKR than that of THR.

Key Words: Obesity; Osteoarthritis; Patient reported outcome measures; Total hip arthroplasty; Total knee arthroplasty

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Core Tip: Previous literature has suggested that the when comparing outcomes of total hip and knee replacements , on symptoms, function, and quality of life, as assessed by patient reported outcome measure (PROM) scores, total hip replacement have superior benefits to total knee replacements. This study has demonstrated, when a comprehensive range of PROM scores are used, both procedures are equivocally and very effective for the treatment of severe osteoarthritis. Sub-analysis in the study has confirmed that whilst obese patients have poorer outcomes, they can still greatly benefit from surgical intervention.

INTRODUCTION

Osteoarthritis (OA) is a heterogenous disorder of joints which is characterised by degradation and loss of articular cartilage, osteophyte formation, subchondral remodelling and synovial inflammation which leads to symptoms of joint stiffness, instability, swelling, weakness and, most commonly, pain^[1]. Globally, an estimated 240 million people globally suffer from the chronic sequelae of OA and is a leading cause of

global disability^[2,3]. Risk factors for OA include female gender^[4], obesity^[5], increasing age^[6], and soft tissue trauma including meniscal tears^[7]. As the United Kingdom population ages and becomes increasingly obese, rates of OA prevalence have increased from 8.2% to 10.7% in the past 20 years^[4]. Over 90000 primary total knee replacements (TKR) and over 95000 primary total hip replacements (THR) were performed in 2019 in the United Kingdom^[8].

First line conservative treatment of OA includes analgesia, physiotherapy, activity modification, viscosupplementation, orthotics, steroid injections, topical gels, *etc.*^[9]. When symptoms are refractory to a consented period of non-operative treatment, surgical intervention is indicated in patients considered anaesthetically fit to undergo the procedure^[10]. TKR and THR are the most common surgical procedures for the management of end-stage OA^[8]. The major aims of joint arthroplasties are to improve symptoms of pain and functionality whilst improving the biomechanical and kinematic milieu of the joint^[11].

Primary TKRs involve replacing the articular surface of the femur and tibia using either a cruciate retaining (CR) or posterior stabilized (PS) prosthesis. Primary THRs involve reaming the articular surface of the acetabulum and also removing the head and proximal neck of the femur and implanting cup and stem prosthetic components into the acetabulum and femur respectively, using either a cemented or uncemented technique^[12,13]. Alternatively, a hybrid approach of a cemented femoral stem and an uncemented acetabular component can be utilised.

Lower limb joint arthroplasty also aims to improve the individual's quality of life (QoL). Patient reported outcome measures (PROMs) are validated instruments which assess the symptoms, function and wellbeing of patients from their own perspective^[14]. These offer a more detailed analysis than overall satisfaction rates. Published satisfaction rates following TKR average 81%^[15] and range from 75% to 92%^[16] whereas slightly higher rates, 86% to 95%, are reported following total hip arthroplasty^[17]. A few studies have compared TKR and THR using PROMs to identify which is associated with the greatest improvement in clinical outcomes^[18-20]. These studies suggest THRs

are associated with superior outcomes however they are limited by a lack of variety of PROM instruments.

Wylde *et al*^[18] compared the midterm clinical outcomes for TKR and THR procedures between 5 and 8 years post-operatively using the Oxford Knee Scores (OKS) and Oxford Hip Scores (OHS) respectively for 1725 patients. This showed clinical outcomes following THR were statistically superior to those following TKR. However, the use of only a single PROM score, despite the vast cohort size, provides a weak comparison of the two surgical procedures. Equipoise remains over the clinical outcomes following TKR and THR in this cohort when using additional PROM instruments, particularly joint-specific PROMs that do not consider comorbidities.

Current literature provides clear justification comparing TKR and THR using a more extensive selection of PROM instruments than previous studies which will help to identify if results remain similar under a more scrutinous comparison. Previous research has suggested that an increased body mass index (BMI) is associated with worse post-operative functional scores and increased complications following TKR than patients of normal BMI^[21]. Similarly, clinical outcomes following THRs were worse for obese and morbidly obese patients than those who were non-obese^[22]. Furthermore, increasing levels of obesity have been shown to increase total stress and stress distribution in hip implants^[23]. The impact of obesity using PROMs following TKR and THR also requires further investigation. The aim of this study was to quantitatively evaluate patients with OA of the hip and knee before and after joint replacement surgery using validated PROMs and to compare the clinical outcomes between THR and TKR.

MATERIALS AND METHODS

This was a prospective longitudinal observational study of adult patients with advanced hip and knee OA, that was refractory to initial conservative treatment, who underwent elective primary THR and primary TKR, respectively, by a single consultant orthopaedic surgeon between August 2015 and March 2019. All patients included in

this study completed PROM forms at their initial outpatient clinic consultation and also 12 mo following their surgery at their final post-operative follow-up clinic appointment. This study was exempt from institutional review board and ethics committee approval as it was a pragmatic study evaluating the existing clinical practice of the senior author. This observational study constituted part of the second author's Masters dissertation.

All TKR's were implanted *via* a standard medial para-patellar approach using Palacos + Gentamycin PMMA cement (Heraus Medical GmbH, Hanau, Germany). The TKR prosthesis used for the TKR group was Genesis II (Smith & Nephew Inc., Memphis, Tennessee, United States) for both the CR and PS implants and all patients also had patella resurfacing (round resurfacing onlay patella). All THR's were implanted *via* standard posterior approach using Palacos + Gentamycin PMMA cement (Heraus Medical GmbH, Hanau, Germany) for the cemented hip components. The cemented THR prosthesis used was the cemented Exeter V40 femoral stem (Stryker Corp., Michigan, United States) and the cemented Exeter X3 RimFit acetabular cup (Stryker Corp., Michigan, United States). The uncemented THR prosthesis used was the uncemented anthology femoral stem (Smith & Nephew Inc., Memphis, Tennessee, United States) and the uncemented R3 acetabular cup (Smith & Nephew Inc., Memphis, Tennessee, United States). The hybrid THR used the cemented Exeter V40 femoral stem along with the uncemented R3 acetabular cup. Generic PROM scores for all patients included: (1) EuroQol-5D index (EQ-5D)^[24-27]; (2) Short Form 12-item Survey (SF-12)^[28]; and (3) Self-assessment Co-Morbidity Questionnaire (SCQ)^[29]. Knee specific PROM scores for TKR patients included: (1) Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC)^[30,31]; (2) Knee Osteoarthritis Outcome Score (KOOS)^[32,33]; and (3) OKS^[34,35]. Hip specific PROM scores for THR patients included: (1) WOMAC^[30,31]; (2) Hip Osteoarthritis Outcome Score (HOOS)^[36,37]; and (3) OHS^[35,38].

All data was scored and analysed according to the instructions in the original publications for each PROM, and any missing data was handled in line with the current literature. The OKS and the OHS were calculated using the updated standardised scoring system; 0 to 48 as described by Murray *et al*^[35].

Statistical analysis

An a priori power calculation for this study was derived from previously published literature of the WOMAC score^[39] with a minimal clinically important change of 10 and a standard deviation of 15. The sample sizes were based on a conventional type I error of 5% and a type II error rate of 10% (*i.e.*, 90% power). The calculation revealed that a sample size of approximately 49 subjects per group was required for a clinically relevant between group mean difference. Plotted histograms with fitted curve lines, box-plots, normal Q-Q plots and the Shapiro-Wilk statistic were used to test normality of data distribution. Almost all the continuous variables in the study displayed a skewed distribution and therefore the relevant non-parametric statistical tests were used for the data analysis. The Mann-Whitney *U* test was used for the between group statistical analyses and the Wilcoxon Signed Rank test was used for the within group analyses. The Kruskal-Wallis *H* test was used for the three-group hip prosthesis data analysis and the BMI analysis. The level of statistical significance was set at $P < 0.05$. Statistical analysis was performed using SPSS for Windows version 26.0 (IBM Corp., Armonk, New York). The power calculation was performed using Minitab statistical software version 18 (Minitab LLC, State College, Pennsylvania).

RESULTS

Patient demographics

A total of 131 patients were included in the study which constituted the TKR group ($n = 63$) and the THR group ($n = 68$). Table 1 shows their demographics, which overall, were very similar between the two groups. On average both groups were approximately 70 years old, overweight to obese, predominantly female and had undergone unilateral joint replacements. Both groups had similar American Society of Anaesthesiologist Physical Classification System classifications and SCQ scores.

TKR vs THR

Tables 2 and 3 (within-group analyses) show that all PROM scores significantly improved post-operatively as compared to their pre-operative results for both TKR and THR, respectively, with the only exception being the SF-12 MCS sub-score for THR (Table 3). Table 4 (between-group analysis) show no statistically significant differences in any of the PROM analyses between the two groups pre-operatively (with the only exception being KOOS/HOOS sports and recreation) or post-operatively.

TKR prostheses type

Of the 63 TKR patients, 36 had CR TKRs and 27 had PS TKRs. When comparing CR to PS TKRs there were no statistically significant differences in PROM scores between the two implants, neither pre-operatively nor post-operatively as shown in Table 5.

THR prosthesis type

Of the 68 THR patients, 36 had cemented THRs, 28 had uncemented THRs, 4 had hybrid THRs. The comparisons of pre-operative and post-operative PROM score are shown in Table 6. As the sample size of the hybrid group was small, no upper bound interquartile range value was produced during statistical analysis, thus only the lower quartile value is given. The different types of fixations showed no statistically significant differences pre-operatively or postoperatively. The difference in HOOS symptoms score did generate a P -value of 0.046 however given the borderline statistical significance and being the only identified difference between any of the THR subgroups, it is likely to reflect a type I statistical error.

Obesity

Comparisons of pre-operative and post-operative PROM scores of the TKR group and the THR group by BMI classification are shown in Tables 7 and 8 respectively. In the TKR group (Table 7) there were no significant differences between BMI classifications pre-operatively. However, higher BMI classifications (more obese patients) scored significantly worse following TKR in the KOOS Pain ($P = 0.046$), KOOS QoL ($P = 0.032$)

and WOMAC pain ($P = 0.045$) sub-scores. Overall, there were no statistically significant differences pre- or post-operatively in the THR group (Table 8) pertaining to BMI classifications with the only exception being patients with a higher BMI had poorer OHS pre-operatively, however this was of borderline statistical significance ($P = 0.046$).

DISCUSSION

This study showed that both primary THR and primary TKR significantly improved patient reported outcomes following surgery in patients with advanced hip and knee OA. Overall, there was no significant difference in PROM scores post-operatively between the two procedures and are therefore considered to be equally efficacious in this regard. A large effect size, and of strong statistical significance was seen as found in recent United Kingdom studies^[40].

The TKR group and THR group had similar baseline demographics in terms of age and gender as well as general health pertaining to anthropometric measures and prevalence of medical comorbidities, thereby allowing for a valid direct comparison of their PROM scores. The between-group pre-operative comparison of outcome scores showed no significant differences, reflecting the impact of pain, function, and QoL of severe hip and knee OA can be equally debilitating. The post-operative scores also showed no significant differences between the two groups suggesting that two procedures are equally effective at improving pain, function, and QoL. This is contrary to the findings of other studies^[18-20] whereby THR outcomes have been shown to be superior to TKR outcomes. Bachmeier *et al*^[19] found superior WOMAC and Medical Outcomes Study Short Form-36 (MOS SF-36) scores in the THR group. The conclusion of that study is limited, as it had approximately 50% dropout rate at 12 mo, the use of only a small range of PROM scores and was conducted 22 years ago where much has changed in the field of arthroplasty surgery. Choi *et al*^[20] also found superior clinical outcomes for THR at 2 years using WOMAC and SF-12 scores. That study was limited by its unequal demographics between the two cohorts as the TKR group were older, more overweight and contained a much higher proportion of females. Additionally,

only one disease specific (WOMAC) and one generic (SF-12) PROM score was assessed. The WOMAC score uses generic joint-related questions to compare clinical outcomes but are not joint specific^[30]. The MOS SF-36 and SF-12 are generic health PROM scores, therefore co-factors such as medical comorbidities^[41] may confound the overall end results as unhealthier patients will have worse scores irrespective of the clinical outcomes of their osteoarthritic joints post-operatively. Additionally, the THR group in one study were significantly older, more overweight and had a higher proportion of females, than the TKR group^[20]. Wylde *et al*^[18] compared only the Oxford Hip and Knee Scores but were able to demonstrate greater improvements in the THR group at 5-8 years despite a response rate of 72%.

This study explored the differences in PROM scores between CR and PS TKR implants. These procedures have their respective advantages and can impact post-operative clinical outcomes differently. The implant utilised is dependent upon patient eligibility as well as surgeon training and experience^[42]. In principle, a CR TKR retains the posterior cruciate ligament (PCL) which preserves the femoral rollback mechanism thereby improving stability and proprioception which provides a more natural gait than a PS prosthesis^[43,44]. PS TKRs involve replacing the PCL by inserting an articulating femoral cam and tibial spine mechanism^[45] which is considered to be more mechanically stable with improved knee flexion^[46]. CR TKR may be contra-indicated in the presence of a degenerated, deficient or chronically ruptured PCL, a PCL with poor elasticity, significant coronal and sagittal knee malalignment or in patients with a history of knee trauma where soft tissue balancing may prove difficult^[42]. This study demonstrated there are no significant differences in post-operative PROM scores between the two implants. This confirms previous findings of no differences in PROMS between these types of knee arthroplasty^[47,48].

THR techniques involve cemented, uncemented or a hybrid approach. Each has benefits depending on patient eligibility. Cementing is associated with improved overall survival and all-cause revision rates compared to uncemented and hybrid fixations^[49] and has less complications in elderly patients with low bone density^[50].

However, uncemented fixation may have superior survivorship than cemented fixations in younger patients, and overall, uncemented fixation is slightly more commonly practiced than cemented in England and Wales^[51]. Uncemented fixation removes the risk of cement fragmentation and subsequent implant loosening requiring revision, and importantly prevents the possibility of bone cement implantation syndrome which can cause cardiovascular collapse and can be fatal^[52]. Hybrid THR avoids the complication of acetabular cement fragmentation whilst retaining the aforementioned advantages of a cemented femoral stem^[53]. There is little evidence demonstrating superior overall outcomes of hybrid THRs to other fixations^[54]. This study showed none of the implantation techniques demonstrated superior or inferior PROM scores as compared to each other. This is contrary to some previous evidence that uncemented THRs have better EQ-5D scores and pain relief^[55,56].

This study has demonstrated hip and knee arthroplasty remain highly effective treatments for severe OA and greatly improve pain, function, and QoL regardless of the surgical method used. Results suggest that all prostheses for TKR and fixations for THR in this study, considering patient eligibility, remain as effective options for treating hip and knee OA to provide good clinical outcomes.

Obesity was associated with higher pain and poorer QoL following TKR as shown by the KOOS and WOMAC scores respectively in the present study. Obesity has previously been associated with a higher rate of post-operative complications including pain, superficial wound infections, deep joint infections, deep vein thrombosis, mechanical failure and dislocations as well as worse clinical outcomes such as more chronic pain, more disability and a higher risk of revision^[57-59]. This study confirmed these findings as demonstrated by worse post-operative scores in KOOS pain, KOOS QoL, and WOMAC pain instruments for overweight and obese patients following TKR.

Si *et al*^[21] found poorer post-operative clinical outcomes following TKR in obese patients using the Knee Society Score only, and Deakin *et al*^[22] demonstrated obesity to be associated with worse clinical outcomes following both TKR and THR using the OKS and OHS respectively. These studies found significant differences between those

considered: Not obese (BMI < 30), obese (BMI 30-40) and morbidly obese (> 40). In the present study, weight categories of normal (BMI < 25), overweight (BMI 25-30), obese (BMI > 30) and morbidly obese (BMI > 40) were used, thereby not conflating 'normal' and 'overweight' patients. Obese patients with hip OA had worse symptoms pre-operatively according to only one instrument (OHS) however this difference was not significant post-operatively. Conversely, in the TKR group, worse post-operative outcomes were demonstrated in obese patients for KOOS pain, KOOS QoL and WOMAC pain sub-scores.

For obese patients, pre-operative weight loss is routinely advocated as part of their conservative management. Overall, this study demonstrates good outcomes, as shown by improvements across multiple PROM scores, can be achieved in obese patients. Patients that are categorised as overweight or obese should not be denied arthroplasty based on BMI alone as obese patients obtained improved clinical outcomes and alleviation of their OA symptoms, however, caution should be exercised in the morbidly obese category of patients. The loss of functionality, associated with OA, may be a factor in patients being unable to lose weight through regular exercise. However, weight loss is primarily driven by diet, much more so than exercise, although the two combined approaches yield the best results. Therefore, it is reasonable to consider total joint replacement if similar outcomes to patients of normal BMI are attainable. Furthermore, the previous studies measure one disease specific PROM each, the present study adds a more extensive insight into the impact of obesity on post-operative outcomes.

A strength of this study is its comparison of multiple disease specific PROMs and (KOOS, HOOS, WOMAC, OKS and OHS) as well as generic PROMs (EQ-5D scores and SF-12). The use of this variety of scores can provide a more holistic and detailed assessment of clinical outcomes than that available in the current literature. Appropriate power calculations prove this study is adequately powered and less likely to produce a type-II statistical error. An additional strength of this study is that the hip and knee OA

cohorts had similar demographics and severity of OA disease, allowing for direct comparison of improvements between the two arthroplasty procedures.

There are some potential limitations of this study. The relative impact of arthroplasty on hip and knee OA were compared directly using HOOS and KOOS in Table 4, despite them being separate instruments. Whilst different, they are comprised of the same metrics and sub-scores which enable direct comparisons. This method has previously been used^[18] for comparing OHS against OKS, as was the case in the present study too. PROMS provide clinicians and researchers with a tool to translate a qualitative description of patient's symptoms into quantitative measures that can be used to tailor an individual's management or assess and compare treatment methods in broader populations. However, PROM questionnaires are subject to missing data and errors due to patient factors such as willingness to complete all the questionnaires and comprehension of the wording of the individual items within each instrument. Inherently, studies using PROMs carry the potential for bias from these factors. Missing data was handled using established methods accordingly^[30,60]. This study was conducted using data from a single surgeon at a single centre which may limit the generalisability of the findings but had the advantage of ensuring uniform procedures so that all other factors of the patient's care remained consistent. Longer term follow-up of clinical outcomes after surgery would also be advantageous to evaluate if the parity of results persisted in the long-term too.

CONCLUSION

THR and TKR are greatly effective at improving pain, function, and QoL in patients with severe OA. The clinical outcome of both procedures was found to be equally efficacious in this regard post-operatively. No significant difference was found in the outcome between CR and PS TKR implants, nor was a significant difference found between cemented and uncemented THRs. Obesity had a greater influence on the outcome following TKR than that of THR.

ARTICLE HIGHLIGHTS

Research background

Patient report outcome measures (PROMs) quantitatively assess patient's symptoms, function and quality of life (QoL). It is known severe osteoarthritis (OA) can be alleviated by joint replacement. To what extent these procedures improve symptoms, function, and QoL can vary depending on the joint, type of procedure, and patient co-factors. Additionally, it is important to maintain a contemporary assessment of the impacts of current surgical practice. The significance of this study is it is the first study of its type to assess the impact of total hip replacements (THR) and total knee replacements (TKR) using a large range of PROMS, in a modern cohort, which also provides sub-analysis on the impact of implant type and obesity.

Research motivation

Previous literature on the impact of THR and TKR is either out-of-date or very narrow in its scope. As an orthopedic surgeon, it is important to predict the impact of these procedures, in order to tailor management for each patient. Therefore, knowing the impact of modern arthroplasty on symptoms, function, and QoL should be explored and available in the literature. Additionally, factors such as obesity can significantly deter surgeons from offering surgery to patients due to known peri-operative risks without fully appreciating the long term benefits patients can achieve. It is therefore our motivation to explore if THR and TKR can offer good outcomes to patients and begin to explore which patient, implant and operative factors can lead to the best outcomes or pose particular risks. Future research can use the approach of this study identify which of the factors should be considered when counseling patients with severe OA.

Research objectives

The primary objective of this study was to explore patient reported outcome measures in patients before and after total hip and knee replacement procedures. This was achieved with a sufficiently powered study to detect statistical and clinic significance,

and comparison of the two groups was also achieved. Future research can monitor the impact of these procedures as surgical technology continues to improve. Additionally, further research can proceed determine which other factors impact patient outcomes following joint arthroplasty.

Research methods

This study is a pragmatic clinic study of real time clinical practice. The PROMs used in this study are routinely collected in clinical practice and some contribute to data collected by the United Kingdom National Joint Registry. The range of PROMs, although used in a different context, have been utilised in the MD thesis of the senior author. These studies shared similar methodologies to the studies cited. The value of using a range PROMs could be incorporated into national joint registries to allow for research which is highly powered and diverse in its assessment of outcomes.

Research results

This study contributes to the modern literature by demonstrating that hip and knee arthroplasty are equally effective at treating the symptoms of severe OA, and equally successful at improving patient function and QoL. This study reflects more recent clinical practice, more comparable clinical cohorts and a broader range of PROMS than the current literature offers. These results can be built upon to establish which other factors impact patient outcomes following joint arthroplasty.

Research conclusions

This study proposes the theory that hip and knee OA can be equally symptomatic in severity, and limiting in QoL and function to patients. Furthermore, arthroplasty is equally effecting at improving these outcomes, regardless of the method used (cruciate retaining *vs* posterior stabilized, cemented *vs* uncemented). This study compares established outcome measures for established surgical procedures. Whilst no new or

novel methodology is proposed, a comprehensive assessment has been demonstrated for the first time in the literature.

Research perspectives

Broadly speaking, research should aim to establish which patient, operative and implant factors can be optimised in order to produce the best outcomes, and mitigate risk, for patient undergoing joint arthroplasty for OA.

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