Surgery performed by supervised registrars does not adversely affect medium-term functional outcomes after total knee replacement

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ABSTRACT

INTRODUCTION Although total knee arthroplasty (TKA) is an index procedure for orthopaedic registrars, there is a lack of published research as to the effects of surgery when performed by supervised trainees. The aim of this study was to compare functional outcomes up to five years after primary TKA performed by consultants and trainee surgeons.

METHODS A retrospective analysis was conducted of prospectively collected data for 609 consecutive patients (339 female, 270 male) undergoing TKA. Patients were assessed preoperatively as well as at 18 months, three years and five years postoperatively, and American Knee Society objective knee and functional scores (AKSK and AKSF) were recorded.

RESULTS Surgery was performed by a consultant in 465 cases and a supervised trainee in 144 cases. There were no significant differences between the two groups in preoperative patient characteristics, operative time ($p=0.15$), transfusion rates ($p=0.84$), length of stay ($p=0.98$), manipulation under anaesthesia ($p=0.69$), or mortality rates at one year ($p=0.73$) or five years ($p=0.81$). Postoperatively, the median magnitude of improvement in AKSK (48 points for consultant group vs 45 points for trainee group, $p=0.74$) and in AKSF (both groups 15, $p=0.995$) was similar between the groups. AKSK and AKSF scores were similar at all timepoints up to five years following surgery, and there was no difference in the median range of motion (both groups 100°, IQR: 18°) at five years ($p=0.43$).

CONCLUSIONS TKA performed by supervised registrars gives functional outcomes that are equivalent to consultant performed TKA, without affecting postoperative range of movement, or increasing operative time, length of stay or transfusion rates. Rates of postoperative MUA and mortality are also comparable.

KEYWORDS

Total knee arthroplasty – Trainee performed surgery – Surgical training – Functional outcomes

Accepted 5 June 2017

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Primary total knee arthroplasty (TKA) is a proven, well established treatment for end-stage arthritis of the knee joint. Several publications support its use clinically and demonstrate its cost effectiveness.^{1–5}

TKA is an essential competency required for the completion of training in orthopaedic surgery in the UK. Primary TKA is listed by the specialty advisory committee (SAC) as an index procedure in the orthopaedic training curriculum⁴ and registrars are expected to complete at least 40 of these procedures as the primary surgeon during their training. A sufficient number of competently trained surgeons is required to meet the increasing demand for TKA and their training must be achieved without compromising outcomes for patients or service efficiency.

Patients may harbour concerns about having their surgery performed by surgical trainees and surgeons must be able to address these issues with patients during the process of informed consent. The results following mesorectal resection for carcinoma⁵ and total hip replacement^{6–8} are

comparable for registrars and their trainers. However, no reports exist comparing functional outcomes between consultant performed and trainee performed TKA. The aim of this study was therefore to examine functional outcomes (as measured by the American Knee Society score) up to five years following primary TKA performed by either consultants or trainee surgeons. Secondary aims were to review operative time, transfusion rates and rates of manipulation under anaesthesia (MUA).

Methods

Retrospective analysis was undertaken of prospectively collected data for 609 consecutive patients undergoing primary TKA in our unit between 2003 and 2006. All patients who underwent primary TKA performed by a consultant or a supervised registrar were included in the study. All registrar cases were directly supervised by a consultant, who was scrubbed during the procedure and acted as an assistant to

the trainee. Trainees included in this study were in their first or second year of specialist training (Calman type I specialist registrars) in a UK approved orthopaedic surgical training programme.

A trainee was defined as the primary surgeon if he or she performed $\geq 70\%$ of the procedure, in keeping with national guidance from the SAC in trauma and orthopaedics.⁴ Patients undergoing complex primary TKA (ie TKA requiring augments, constrained prostheses or long-stem prostheses) were excluded from the study, as were those with inflammatory arthritides ($n=21$) and those undergoing simultaneous bilateral TKA (78 TKAs in 39 patients).

All patients underwent cemented, fixed bearing TKA with a PFC[®] Sigma[®] implant (DePuy, Warsaw, IN, US) via a medial parapatellar approach. A tourniquet was used in all cases and deflated after skin closure. No surgical drains were used. Throughout the study period, a blood transfusion protocol was in place: patients were transfused if their haemoglobin (Hb) concentration was below 8.5g/dl or if they were symptomatic with Hb levels between 8.5g/dl and 10g/dl. Patients received 5,000iu subcutaneous dalteparin daily for venous thromboprophylaxis starting 12 hours after surgery and this was continued for two weeks unless they were considered at high risk of thromboembolism, in which case it was administered for five weeks.

Patients were reviewed preoperatively as well as at 18 months, 3 years and 5 years postoperatively in a designated arthroplasty clinic. At review, patients were examined clinically to enable American Knee Society objective knee and functional scores (AKSK and AKSF) to be calculated.⁹ Functional scoring was undertaken by a consistent team of four experienced arthroplasty nurses and data were entered into a prospectively maintained database.

Sixty patients (9.9%) died within five years of their primary surgery. Of the remaining patients, 420 (76.5%) underwent functional scoring five years following surgery.

Statistical analysis

Statistical analysis was performed with SPSS[®] (IBM, New York, US). Shapiro–Wilk testing was employed to determine

whether data were normally distributed. Median values for non-normally distributed continuous data were compared using the Wilcoxon signed-rank test when samples were related and the Mann–Whitney U test when samples were unrelated. Mean values for normally distributed continuous data were compared with two-tailed Student’s t-tests. A chi-squared test was used to analyse nominal datasets unless any of the expected cell counts were <5 , when Fisher’s exact test was used instead. Odds ratios were calculated and a p -value of <0.05 was considered statistically significant.

Results

The median age for the whole cohort of 609 patients was 71.0 years (interquartile range [IQR]: 12 years), the median body mass index was 29.4kg/m² (IQR: 7.1kg/m²), the median ASA (American Society of Anesthesiologists) grade was 2 and the mean preoperative Hb was 13.6g/dl (range: 9.8–17.9g/dl). There were 339 women and 270 men. Surgery was performed by a consultant in 465 cases and by a supervised trainee in 144 cases. There were no statistically significant differences in preoperative characteristics between these two groups (Table 1). There were also no significant differences between the groups in terms of change in Hb concentration from the preoperative measurement to the first day after surgery, operative time, blood transfusion or length of stay (Table 2).

The median preoperative range of motion was 102° (IQR: 27°) in the consultant group and 105° (IQR: 26°) in the trainee group ($p=0.35$) while the median postoperative range of motion at five years was 100° (IQR: 18°) in both groups ($p=0.43$). Five patients in the consultant group and two in the trainee group underwent MUA within one year of surgery ($p=0.69$, Fisher’s exact test). Mortality data were available for 579 patients at one year and for 505 patients at five years. There were eight deaths in the consultant group and three in the trainee group during the first year after surgery ($p=0.73$, Fisher’s exact test). Within five years of surgery, there were 45 deaths in the consultant group and 15 in the trainee group ($p=0.81$).

Table 1 Patient characteristics			
Variable	Consultant group	Trainee group	p-value
Median age (years)	71 (IQR: 12)	70 (IQR: 12)	0.37*
Median BMI (kg/m ²)	29.3 (IQR: 7.4)	29.5 (IQR: 6.7)	0.72*
Male-to-female ratio	206:259	64:80	0.98**
ASA grade 1	51	9	0.31**
ASA grade 2	306	98	
ASA grade 3	105	36	
ASA grade 4	1	1	
Mean preoperative Hb (g/dl)	13.6 (SD: 1.4)	13.6 (SD: 1.3)	0.98***
BMI = body mass index; ASA = American Society of Anesthesiologists; Hb = haemoglobin; IQR = interquartile range *Mann–Whitney U test; **Chi-squared test; ***Student’s t-test			

American Knee Society scores were similar for the two groups at all timepoints, both preoperative and postoperative (Table 3). Both groups demonstrated a significant improvement in AKSK and AKSF between the preoperative and the 18-month postoperative review, and there was no significant difference in the magnitude of this improvement. The median improvement in AKSK was 48 points (IQR: 29 points) in the consultant group and 45 points (IQR: 32 points) in the trainee group ($p=0.74$) while the median improvement in AKSF was 15 points (IQR: 15 points) in both groups ($p=0.995$). Improvements in AKSK scores were maintained up to five years following surgery whereas AKSF scores in both groups exhibited a gradual decline over this time period after the initial improvement.

Discussion

This study shows that TKA performed by supervised registrars achieves functional outcomes that are comparable with those of consultant performed surgery at all postoperative timepoints up to five years. Furthermore, there was no significant difference in operative time, blood transfusion rates or length of stay in the immediate postoperative period. Rates of MUA and mortality at one year were also comparable between the two groups.

The preoperative characteristics of patients in both groups were similar to those reported in other studies¹⁰ and registry data.¹¹ This indicates that the population under review is representative of the wider population undergoing TKA.

Our study found no difference in operative time between registrar performed and consultant performed surgery. Increased surgical time for trainees has been reported in total hip replacement⁷ but the authors of that study did not specify whether surgery undertaken by trainees was supervised and to what level. Our findings have important implications for list management since they demonstrate that directly supervised registrar performed TKA does not result in increased operative time. National joint registry data indicate a significantly increasing demand for TKA^{11,12} and this demand must be met with a sufficient number of appropriately trained surgeons. There exists an inevitable tension between training needs and service provision in those hospitals that provide training for orthopaedic trainees.¹⁵ Our results show that orthopaedic training can be provided safely without reducing service throughput or length of hospital stay.

The median fall in Hb concentration between preoperative measurement and measurement on the first postoperative day ($p=0.89$) as well as subsequent rates of transfusion ($p=0.84$) were similar in both groups. Large systematic

Table 2 Perioperative events

Variable	Consultant group	Trainee group	p-value
Median operative time (minutes)	63 (IQR: 29)	65 (IQR: 19)	0.15*
Median change in Hb (g/dl)	-2.4 (IQR: 1.3)	-2.3 (IQR: 1.0)	0.89*
Median postoperative length of stay (days)	7 (IQR: 2)	7 (IQR: 2)	0.98*
Transfusion	48/465 (10%)	14/144 (10%)	0.84*

Hb = haemoglobin; IQR = interquartile range

*Mann-Whitney U test

Table 3 American Knee Society scores

Variable	Consultant group	Trainee group	p-value
Median preoperative AKSK	37 (IQR: 20)	37 (IQR: 19)	0.87*
Median preoperative AKSF	60 (IQR: 15)	60 (IQR: 15)	0.82*
Median 18-month AKSK	91 (IQR: 30)	90 (IQR: 29)	0.69*
Median 18-month AKSF	80 (IQR: 10)	80 (IQR: 6)	0.42*
Median 3-year AKSK	93 (IQR: 14)	94 (IQR: 9)	0.07*
Median 3-year AKSF	80 (IQR: 15)	80 (IQR: 20)	0.17*
Median 5-year AKSK	93 (IQR: 10)	93 (IQR: 13)	0.88*
Median 5-year AKSF	60 (IQR: 30)	70 (IQR: 40)	0.28*

AKSK = American Knee Society knee score; AKSF = American Knee Society functional score; IQR = interquartile range

*Mann-Whitney U test

reviews have demonstrated that transfusion can independently predict death and infection in surgical populations.^{14–17} It is therefore reassuring that registrar performed surgery was not associated with higher transfusion rates. Mortality at one year ($p=0.73$) and at five years ($p=0.81$) was also found to be equivalent.

There was no significant difference in preoperative or postoperative range of motion at five years between patients whose surgery was performed primarily by a trainee and those whose surgery was performed by a consultant. Similarly, rates of MUA at one year were comparable across the two groups ($p=0.69$). MUA has been shown to provide most benefit when carried out in the early postoperative period^{18,19} and is seldom undertaken beyond one year after surgery. This was the reason for our decision to report on MUA at this timepoint.

TKA has been found to result in significantly improved knee specific functional outcomes in patients with severe knee osteoarthritis.^{1,2,20} There was no difference between the two groups in our study in terms of the magnitude of improvement in AKSK and AKSF or in the absolute scores at any timepoint. Our reported improvements in knee specific functional outcomes are considerable, which is in keeping with other reports in the published literature.²¹ Patients can therefore expect similar joint specific and global functional improvements after TKA, irrespective of whether this is performed by a registrar under supervision or a consultant.

The only other report on the equivalence of functional outcomes after TKA performed by consultant surgeons and trainees is a small prospective study of computer navigated TKA,²² which clearly represents a small subset of TKAs performed nationally by trainees, and so the results cannot be extrapolated to non-navigated arthroplasty. The practice of navigated TKA is not currently widespread in the UK¹¹ and the majority of trainees are likely to be trained using conventional jigs. Consequently, our study constitutes an important addition to the existing literature and the results will be helpful when counselling patients prior to TKA as well as during the process of informed consent.

Improvements in AKSK scores were maintained up to five years after surgery while AKSF scores in both groups exhibited an initial improvement followed by gradual decline over this time. The clinical rating system recognises that patients' global functional status may be affected for reasons unrelated to the knee joint in question (eg other joint pathology or general frailty), which is the reason for the dual scoring system.^{9,23} The AKSF is influenced by other factors in addition to the status of the replaced knee joint. As the incidence of osteoarthritis in other joints,²⁴ co-morbidities and general frailty increase with age, it is not surprising that AKSF gradually declines with the passage of time and this finding is in agreement with other published studies.²⁵

With the increasing availability of surgeon specific functional outcomes following TKA, surgeons may have understandable concerns that allowing trainees to perform arthroplasty could impact negatively on their publicly reported results.²⁶ This could potentially lead to fewer training opportunities for trainees. Our results should provide reassurance to trainers that supervised registrar performed

TKA will not adversely affect their reported functional results. Similar findings have been documented in the context of total hip replacement^{6,8} and total mesorectal excision.⁵

The importance of repeated performance of surgical procedures by trainees in attaining competency to undertake these procedures independently has been stressed by others.²⁷ This allows development of not only dexterity but also intraoperative decision making skills.²⁸ Trainees can be reassured that they are not adversely affecting patient outcomes or operating list efficiency when undertaking appropriately supervised TKA. Increased surgical experience has also been linked to favourable patient outcomes.^{29–32}

Our study demonstrates that it is safe and practical for registrars to perform significant volumes of supervised TKA. This is important for their training and is required if future predicted increasing demand for TKA is to be met with a corresponding increase in competently trained orthopaedic surgeons.

Study limitations

There are some limitations to this study. It is a cohort study from a single unit with retrospective analysis of data. Nevertheless, all data were collected prospectively, and the study design allowed uniformity of technique, implant use and perioperative management. Furthermore, the preoperative demographics and perioperative characteristics were well matched across the two groups despite the non-randomised process of inclusion. Radiological analysis was not undertaken. Another limitation is the loss to follow-up although the magnitude is similar to rates described in other published series.^{33,34}

There may be a perception that owing to the retrospective nature of this study, consultants may have taken on the most challenging cases. However, the study excluded all patients undergoing complex primary TKA as well as those with inflammatory arthritides. These will account for the majority of the complex cases designated for consultant performed surgery. Moreover, there was equivalence between the groups in preoperative patient demographics, ASA grade, range of motion and American Knee Society scores. The AKSK is a measure of severity of knee disease that takes account of multiple physical variables. Having excluded the most complex cases and demonstrated equivalence of preoperative scores, the two groups should therefore be broadly comparable.

We recognise that even in the relatively homogenous group of patients included in this study, there could still be a small degree of case selection by consultants, which may be unquantifiable using conventional physical knee scores. Other authors reviewing trainee performed surgery have acknowledged that there may be a degree of case selection but note that this is in fact desirable in a well structured training programme since trainees should only perform procedures that are appropriate for their level of training, thereby maintaining patient safety.^{5,6,8}

The alternative of a prospective randomised study in this field may be unworkable since in reality, few consultants would watch a trainee struggle with a procedure that they

had been randomised to perform without intervening. Additionally, a research ethics committee would be unlikely to approve a study that placed patients at unnecessary risk and it would not be a reflection of true clinical practice, where a degree of case selection is inevitable.

Critics could question whether registrars might have performed only the simpler parts of a procedure and yet still have been recorded as the primary surgeon. In our institution, there has been a longstanding practice for the procedure to be performed either primarily by the consultant or primarily by the trainee and TKA cases are generally not 'shared'.⁶ As a result, trainee performed surgery is normally carried out entirely by the trainee while under the direct supervision and guidance of a consultant.

The consultant would only intervene and take over primary operating responsibilities if he or she felt that the trainee was about to make a critical mistake that would jeopardise final outcome, or if a significant intraoperative complication occurred. This is a very rare event but we do not feel it should be considered a limitation since it is a prerequisite of a safe and effective training programme as well as an integral part of the consultant's supervisory role. If the consultant were not to intervene in such situations, patient safety would be compromised. In addition, national guidelines from the trauma and orthopaedic SAC state that a trainee must perform $\geq 70\%$ of the procedure to be considered the primary surgeon.⁴ Our criteria to determine the primary surgeon in this study are therefore consistent and also clearly defined.

Particular strengths of this study include the large cohort size and the study design, with clinical review of patients at various timepoints across the follow-up period. Further research in this area should now seek to confirm our findings at longer-term follow-up and possibly explore patient satisfaction after trainee performed TKA.

Conclusions

TKA performed by supervised registrars gives functional outcomes that are equivalent to consultant performed TKA up to five years following surgery, without affecting postoperative range of movement, or increasing operative time, length of stay or transfusion rates. Rates of postoperative MUA and mortality are also comparable.

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