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Balancing training and outcomes in total knee replacement: a ten-year review

A. Faulkner, M. J. Reidy, P.S.E. Davies, W. Wang, N. Buddhadev, L. Johnston, B. Clift

NHS Tayside, Ninewells Hospital, Dundee, United Kingdom

Tayside Orthopaedics and Rehabilitation Technology Centre

Abstract

Introduction: 10-year study examining the total knee arthroplasty (TKA) functional outcomes and survivorship in patients operated on by consultant and trainee orthopaedic surgeons.

Method: Data was prospectively collected from all elective TKAs performed at our three linked institutions. Patient demographics, surgeon grade, and length of hospital stay were recorded. Outcomes pre-operatively and at 1, 3, 5, 7 and 10 years included mortality, need for revision surgery and function as documented by the patients' Knee Society Score.

Results: 686 patients were included in the study. 450 (65.5%) patients were operated by consultant surgeons and 236 (34.4%) by trainees. On multivariate analysis no significant differences were observed between groups in length of hospital stay (p=0.695), implant survival (p=0.422), and function (p=0.507) at 10 years. On Cox regression analysis no significant difference was observed in mortality (p=0.209) at 10 years. 4 patients over this time period were lost to formal follow up.

Conclusion: No significant difference was observed in the TKA outcomes between consultants and trainees up to 10 years post-operatively.

Introduction

Total knee arthroplasty (TKA) is one of the most common procedures performed by orthopaedic surgeons**;** 160,000 such operations are performed each year in England and Wales alone[1]. For trainee surgeons, the development of competence through operative experience is fundamental[2].

A delicate balance remains between the trainer and trainee to ensure the needs of the patient are met and that training opportunities are optimised. Over the last few decades, surgical training has had to address a number of challenges including a change in working patterns following the introduction of the European Working Time Directed (EWTD). Furthermore, with unit level and potentially surgeon level data being made publically available in registries, consultants and their operative outcomes are under closer scrutiny.[2] [3]. The literature surrounding this area remains contentious, with a review of 43,343 patients finding increased risk of 30-day complications with trainee involvement in arthroplasty.[4]

This study aims to investigate whether there is any significant difference in function, complications and implant survival up to 12 years in cases performed by a consultant or a trainee.

Methods

All elective primary TKAs performed in three linked institutions within our region in 2003-2004 were included. Patients requiring revision TKAs were excluded. A retrospective review of prospectively obtained data through the regional arthroplasty database was conducted, after obtaining Institutional Caldicott guardianship. Primary outcomes were patient survival, implant survival and Knee Society Scores (KSS). Surgeon grade was determined by the primary surgeon in the operating note and recorded as either consultant or trainee. Patients weren't randomised in this study.

Patient demographics including age, sex, body mass index (BMI), surgeon grade, and length of hospital stay, were recorded. Outcomes including revision rate and mortality were also recorded. Pre-operative KSS and post-operative score at 1, 3, 5, 7 and 10 years were documented.

Statistical analysis. This was performed using Statistical Package for Social Sciences (SPSS) version 22.0 (manufactured by IBM corporation, Armonk, New York) for Windows. Univariate analysis (ANOVA) was used to identify variables for multivariable analysis (MANOVA) to compare length of hospital stay within groups. Cox regression carried out was used to compare implant and patient survival between consultants and trainees. Univariate analyses were first carried out to identify variables of interest in multivariable analysis. The Mann Whitney U test was conducted for non-parametric data between groups. Significance of 5% and confidence of 95% were used in all analyses.

Results

Losses to follow–up, mortality and revision surgery are listed in Table I. 686 patients were included: 321 males and 365 females. Mean age 69.92 (Range 30-94, SD 9.079). and mean BMI 29.8kg/m^2 (Range 15.1-48.3, SD 5.31). The primary diagnoses for TKA were osteoarthritis (639, 93.1%), rheumatoid arthritis (35, 5.1%), post-traumatic arthritis (5, 0.7%), tibial platueau fracture (2, 0.3%), graft versus host disease (1, 0.1%), juvenile idiopathic chronic arthritis (1, 0.1%), osteonecrosis (2, 0.3%), and tuberculosis (1, 0.1%). Loss of follow up is detailed in Table I.

A total of 450 patients (65.6%) were operated by consultants and 236 (34.4%) by trainees. Breakdown of age, BMI and length of hospital stay between consultant and trainee is detailed in table II and details of the type of implants used are detailed in table III. Those who withdrew from functional follow up had their implant and mortality documented.

Length of stay. The mean length of hospital stay for all patients was 8.13 days (Range 2-55, SD 4.098). For consultants it was 8.0 days and for trainees it was 8.39 days. In the univariate analysis age, gender, implant and knee society score pre-operatively reached the threshold for significance in the multivariate model. In multivariate analysis the choice of implant and post-operative protocol was significant. Surgeon grade did not have a significant effect on length of stay (p=0.113 and 0.695 respectively). There were no interactions with other dependent variables (Table IV).

Patient survival. In the univariate analysis patient diagnosis reached threshold for significance in the multivariate model (Table V). Surgeon grade did not have a statistically significant effect on patient survival (p=0.209, p=0.298) (Table VI).

Implant survival. 34 revision procedures were performed during the study period. Of the primary surgeries 26 cases were performed by consultants and 8 by trainees. In univariate analysis, complication and length of hospital stay reached significance for inclusion in multivariate model. In multivariate analysis the development of a complication was significant in implant survival (Table VII). Surgeon grade did not have an effect on implant survival to revision (p=0.422). Figure 1 demonstrates the Kaplan Meier curve for implant survival.

Function. The KSS are shown in table VIII. In univariate analysis, knee society score pre-operatively reached the threshold of significance in the multivariate model. The multivariate model, no variables were significant. Surgeon grade was not significant in either outcome (p=0.507).

Complications. 10 patients developed infection: 7 were a deep infection and 1 was a wound infection – these were operated by consultants. The remaining two patients had infection documented and were operated by trainees. The nature of these latter infections weren't recorded. 5 patients were recorded to have had pulmonary embolisms in this cohort.

1 patient had tibial base plate loosening which was operated by a trainee which required revision. 1 patient had a documented fracture, 1 patient had a peri-prosthetic fracture, 2 patients had instability, 2 patients had symptomatic malalignment, 1 patient had limited mobility and 1 patient's complications weren't recorded. All these cases were operated by consultants and required revision.

Discussion

We found no significant differences between operative surgeon grades in patient mortality (p=0.209), implant survival to revision (p=0.422), function (p=0.507) and length of hospital stay (p=0.695) at 10 years. This is the first long term study to address this topic and this information is new to the literature when previous studies have only examined the short and medium term outcomes of up to 5 years**.**[7].

These results are consistent with existing literature surrounding trainee involvement in TKA. An analysis of 24,529 patients undergoing TKA demonstrated that resident involvement did not increase the risk of complications.[5] A recently published randomised controlled trial also reported no significant difference in coronal alignment, blood loss or functional scores in TKA performed with computer assistance between consultants and trainees at 5-years.[6] Furthermore, trainees have been shown to achieve similar implant alignment compared with consultants with computer-aided navigation. [7]

The findings of our study are consistent with other areas of orthopaedic research. In total hip arthroplasty (THA), no significant differences were found in early clinical outcome in patients operated on by residents and the dislocation rate between trainee and consultant groups at 18 months.[8] [9] A multicentre study of 879 patients undergoing THA in our region also demonstrated no significant differences in Harris Hip Score (HHS), mortality, dislocation rate or infection rate at 10 year follow up.[10] Furthermore, a prospective study of 1501 patients undergoing hip arthroplasty found no differences in Oxford Hip Score (OHS) at 5 years.[11]

In a large review of 43,343 patients undergoing one of 12 orthopaedic procedures, sub analysis of 23,783 patients undergoing arthroplasty demonstrated a mild to moderate risk for complications with trainee involvement including post-op sepsis and pulmonary embolism but not including mortality**.**[5] The authors did not clarify if they analysed the patient demographics between consultants and trainees in this sub group, and only inpatient complications were recorded with no record of functional outcomes or long-term follow up. It is therefore possible that the cases with trainee involvement were a higher risk group than those with no trainee involvement. No clarification was made as to whether trainees were considered the primary surgeon or the assistant.

It has been consistently demonstrated that operative time tended to be higher in trainee-led operations most likely due to the learning curve associated with this operation.[6, 7, 8, 9, 12] Khaka demonstrated tourniquet times were 17 minutes longer in 4th year residents (with the consultant unscrubbed) compared to consultants but no differences in functional outcomes at 5 years were seen.[7] Whist we would expect so see something similar in our own study however in our institution the operative times were not recorded and cannot be commented upon.

In this study, no evidence was found that surgeon grade had any effect on the development of complications. Trainees in this cohort operated on older patients compared with consultants which did appear statistically significant. It is important to note however that the level of trainees was not stratified intentionally, as a higher or lower training grade was not felt to be a good surrogate for level of experience. Our rationale for this is that the trainee had been deemed competent by the responsible consultant to undertake the procedure either with or without direct supervision. Consequentially, the level of supervision was also excluded as this seemed an artificial categorisation of what is usually a spectrum of supervision ranging from direct supervision through 'coffee room' supervision to independent operating. This approach is a purposely pragmatic study of what occurs in most training hospitals allowing this cohort to be representative of common clinical practice.

In the univariate and multivariate analysis: age, pre-op PF pain and pre-op KS pain were demonstrated to be significant factors in the development of complications. This is consistent with the literature as pre-operative pain, level of deprivation and history of depression were the most important predictors of outcome following TKA.[12] Furthermore age, sex, BMI, and the presence of diabetes were reported as the best predictors for the need for TKA revision.[13] Overall, patient factors rather than surgeon grade are better predictors of post-operative mortality and morbidity in TKA.

This study has limitations. We were reliant on prospectively collected data and patients were not randomised. As a result, selection bias may have occurred with consultants electing to operate on more challenging cases or those with higher American Society of Anaesthesiologists (ASA) grades.[14] This data however is unavailable in our cohort. Finally this study analysed patients in one region and other variables affecting surgical performance (e.g. training, supervision, calibre of consultants and trainees) may differ between areas.

This study demonstrates that under appropriate supervision trainees can perform TKA with similar clinical outcomes as consultants up to 10 years. This suggests there is an opportunity to train whilst ensuring a good outcome for the patient.

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Post-operative year	Died	Revision	Withdrawal from follow up	Loss to follow up	Patients remaining (n)
1	2	4	1	0	679
3	19	11	5	2	642
5	36	6	16	2	582
7	34	4	23	0	521
10	65	6	13	0	437
>10	21	3	7	0	406
Totals	177 (25.8)	34 (4.95)	65 (9.47)	4 (0.58)	

Table I. Loss of follow up during study period

	Trainee mean values	Consultant mean values	Mann-Whitney U	p-value[+]
Age/years	71.4 Range 44-94 (SD 8.48)	69.1 Range 30.0-92.0 (SD 9.28)	45410 (Z=-3.12)	0.002
BMI/ kg/m^2	27.8 Range 0.00-48.30 (SD 8.05)	27.5 Range 0.00-47.30 (SD 9.97)	50756 (Z=-0.951)	0.342
Length of stay/days	8.4 Range 3-34 (SD 4.34)	8.0 Range 2-55 (SD 3.96)	51920 (Z=-0.345)	0.730

+ asymptotic 2-tailed p-value with significance as p<0.05

Table II. Patient age, BMI, and length of hospital stay between consultant and trainee groups

	Trainee	Percentage	Consultant	Percentage
Genesis II	0	0.0	1	.2
Kinemax	59	25.0	143	31.8
LCS	10	4.2	26	5.8
LCS RP	7	3.0	29	6.4
Link Rotating Hinge	0	0.0	2	0.4
MBK	1	0.4	3	0.7
NexGen LCCK	0	0.0	1	0.2
NexGen LPS Fixed Bearing	125	53.0	202	44.9
NexGen Rotating Hinge	1	0.4	1	0.2
Search	33	14.0	36	8.0
NexGen LPS Flex Fixed Bearing	0	0.0	6	1.3
Total	440		236	

Table III. Types of knee implant used

Variable	Univariate analysis (p value)	multivariate analysis (p value)
Surgeon grade	0.113	0.695
Age	<0.001	0.072
BMI	0.514	
Gender	0.005	0.706
Implant	0.007	0.023
Post-op protocol	0.061	0.002
KSS-Pre-op pain	0.792	0.667
KSS-Range of movement pre-op	0.663	
KSS-Function pre-op	0.008	0.327
KSS-Pre-op	0.522	
Diagnosis	0.188	0.938

Surgeon group as a fixed factor/main effect and other as random factor/interactive effect or covariate.
KSS = Knee Society Score.

Table IV. Table of significance of factors on length of stay

Variable	Univariate analysis (p value)	multivariate analysis (p value)
Surgeon grade	0.610	0.298
Age	0.506	0.087
BMI	0.883	0.082
Gender	0.206	0.822
Implant	0.325	0.324
protocol	0.143	0.482
KS-PreOpPain	0.932	0.841
KS-RoMPreOp	0.158	0.687
KS-functionPreOp	0.402	0.864
KS-PreOp	0.752	0.709
diagnosis	0.020	0.236
complication	0.449	0.691
length of stay	0.075	0.441

Table V. Table of significance of factors on patient survival

	Sig.	Hazard ratio	95.0% CI for hazard ratio	
			Lower	Upper
Age	0.835	1.003	0.979	1.027
Gender	0.369	0.848	0.591	1.216
BMI	0.728	1.007	0.969	1.046
Diagnosis group (OA:other)	<0.001	0.302	0.148	0.615
Surgeon grade	0.209	1.250	0.882	1.771
Protocol group (normal:other)	0.048	2.758	1.009	7.536
KSS Range of Motion pre-op	0.118	1.008	0.998	1.018
KSS Function pre-op	0.337	0.993	0.979	1.007
KSS Score pre-op	0.471	1.005	0.992	1.017
Length of stay (days)	0.769	1.007	0.962	1.054
Complication	0.199	0.649	0.336	1.255

Table VI Significance of independent variables in patient survival with hazard ratio (HR) and upper and lower 95% confidence intervals

	Sig.	Hazard Ratio	95.0% CI for Hazard Ratio	
			Lower	Upper
Age	0.205	0.97	0.926	1.017
Gender	0.177	1.788	0.769	4.154
BMI	0.887	1.005	0.933	1.083
Diagnosis Group	0.682	1.407	0.275	7.206
Surgeon grade	0.422	1.461	0.58	3.679
Protocol group	0.928	0.882	0.056	13.766
KSS Range of motion pre-op	0.304	0.988	0.965	1.011
KSS Function pre-op	0.413	1.012	0.984	1.041
KSS Score pre-op	0.157	1.023	0.991	1.056
Length of stay (days)	0.060	1.071	0.997	1.15
Complication (Y:N)	<0.001	4.997	2.205	11.326

Table VII. Significance of independent variables on implant survival with hazard ratio (HR) and upper and lower 95% confidence intervals

		n	Minimum	Maximum	Mean	Std. Deviation
Consultant	KSS pre-op	429	0	80	26.12	15.180
	KSS 1 year	394	9	100	85.66	14.545
	KSS 3 years	276	26	100	86.91	14.600
	KSS 5 years	329	29	100	86.85	12.953
	KSS 7years	85	42	99	88.36	13.067
	KSS 10years	200	23	100	87.74	13.422
Trainee	KSS pre-op	228	0	67	27.61	13.563
	KSS 1 year	219	13	100	84.29	16.706
	KSS 3 years	159	16	100	85.88	16.270
	KSS 5 years	178	28	100	85.63	14.828
	KSS 7 years	44	50	99	90.00	11.606
	KSS 10 years	103	41	100	88.31	14.768

Table VIII. Knee Society Score (KSS) by surgeon grade throughout study period

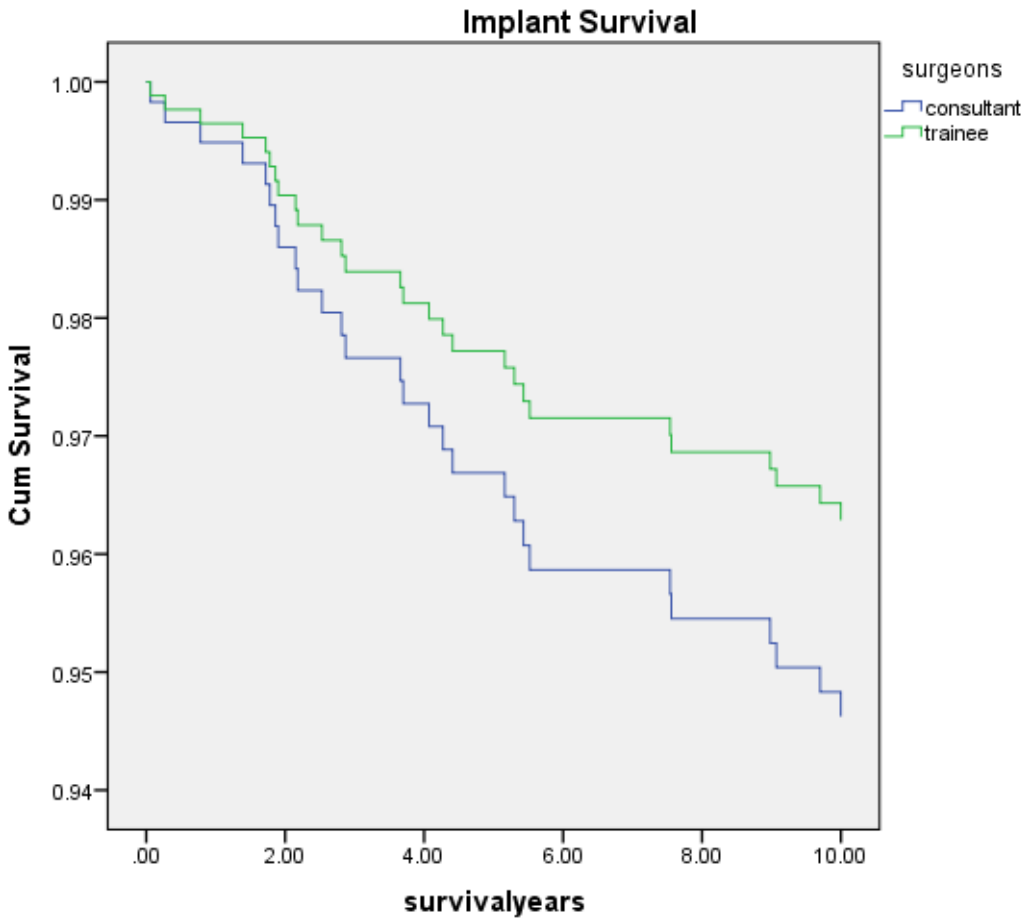

Figure 1. Kaplan Meier curve demonstrating implant survival between consultants and trainees