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Title:
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Date:
2016-12-01

Citation:
Wilson, M. D., Dowsey, M. M., Spelman, T. & Choong, P. F. M. (2016). Impact of surgical experience on outcomes in total joint arthroplasties. ANZ Journal of Surgery, 86 (12), pp.967-972. https://doi.org/10.1111/ans.13513.

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https://hdl.handle.net/11343/291695

The impact of surgical experience on outcomes in total joint arthroplasties

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Text word count: 2,055
Full text word count (including abstract, tables and references): 4,001

This is the author manuscript accepted for publication and has undergone full peer review but has not been through the copyediting, typesetting, pagination and proofreading process, which may lead to differences between this version and the Version of Record. Please cite this article as doi: 10.1111/ans.13513

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Abstract wordcount: 241
Number of tables: 5

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Abstract

Introduction: Outcomes of primary total hip and knee arthroplasties performed by consultant surgeons were compared with those performed by orthopaedic trainees. Furthermore, outcomes of these procedures performed by senior trainees were compared with those performed by juniortrainees.

Methods: Data from the St. Vincent's Melbourne Arthroplasty Outcomes Registry and the surgical log kept by trainees was reviewed to investigate if an association exists between surgical experience and clinical outcomes following primary total hip and knee arthroplasties.Multivariate logistic regression analyses were undertaken to produce odds ratios with 95% confidence intervals to assess these relationships.

Results: Arthroplasties performed by trainees were not significantly different from those performed by consultant surgeonsin regards to medical, surgical and wound complications. Trainee-performed primary total hip arthroplasties were associated with a 30% increase in the risk of requiring a transfusion compared with consultant-cases. Primary total knee arthroplasties performed by junior trainees were associated with a 50% increase in the risk of developing a wound complication compared with those performed by senior trainees.

Conclusions: Overall, senior orthopaedic trainees working independently and junior orthopaedic trainees under supervision as the primary surgeon have the ability to achieve a level of clinical outcomes similar to a consultant surgeon. Junior trainees with supervision have the ability to achieve a level of clinical outcomes similar to senior trainees. These findings can be used to further improve orthopaedic training to reduce adverse events during supervised surgery.

Keywords

Orthopaedics, education, competency, arthroplasty, outcomes

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Introduction

Orthopaedics follows an apprenticeship model, where trainees are taught surgical procedures and then supervised at a varying level until they can independently perform these procedures. Therefore, the skills required by surgical trainees are primarily obtained through direct participation in the operating room. This system of graduated responsibility has been a part of surgical training for a substantial period of time(1, 2). While these programs have been shown to be successful in the education of trainees, the implications on patient outcomes need to be considered.

Multiple studies have evaluated the effect of both hospital and surgeon volume on a variety of outcomes following a number of orthopaedic procedures(3-6). Given the wide range of procedures, patient outcomes and patient samples studied, the variability and inconsistency of results amongst the current literature may in part be as a result of differences in study design. A recent systematic literature review demonstrated that in regards to lower limb arthroplasties, the association between primary surgeon-experience and clinical outcomes remains contentious(3-17).

The ageing population has facilitated the need for an increase in the number of joint arthroplasty procedures. Total hip and knee arthroplasties are both common elective procedures that a capable trainee surgeon should be able to perform. Therefore, these procedures provide a good model for addressing the effect of surgical experience on clinical outcomes. Based on previous evidence, we hypothesise that the clinical outcomes will be similar amongst consultants and trainees.

Patients and Methods

Data Sources and Patient Sample

This retrospective cohort study was performed at St Vincent's Hospital Melbourne, Victoria, Australia over a 12-year period (January 1st, 2002 through December 31st, 2013) and included all primary total hip and knee arthroplasties. Data was extracted from the St. Vincent's Melbourne Arthroplasty Outcomes (SMART) Registry. SMART is a clinical registry that houses clinical and patient reported outcome data for all elective lower limb arthroplasties. Registry data is prospectively collected and includes patient demographics, diagnoses and self-reported co-morbidities. In addition, the surgical log of activity kept by orthopaedic trainees has been used to determine their respective roles. Patients were excluded if there was missing data from either of the data registries. The study

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design was reviewed and approved by St Vincent's Hospital Melbourne Human Research Ethics Committee.

Data Elements

We studied surgical, medical and wound complications, transfusions and surgical readmissions over a one-year follow-up period. Complications were categorised into the select outcomesby clinical judgement and their association with the index procedure. Surgical complications included events such as intraoperative fractures, vessel damage, implant error, broken implant and intraoperative skin tear. Medical complications included events such as respiratory infections, delirium, urinary tract infections and septicaemia. Wound complications included events such as wound ooze, wound infections, wound breakdown and stitch abscess.Transfusions were recorded as a categorical variable as those requiring or not requiring a transfusion during the index procedure admission.

Information from the surgical log kept by orthopaedic trainees was used to define consultant and registrar cases according to a four-role classification system defined by St Vincent's Hospital. For role one,the trainee is unsupervised and makes all the intraoperative decisions. For role two, the trainee is the primary surgeon with a consultant assisting/supervising the intraoperative decision-making. For role three, the consultant surgeon performs the majority of the case with minimal input from the trainee. For role four, the consultant performs the procedure and the trainee observes. Roles one and two (most trainee involvement) were categorised as trainee cases and roles three and four (least trainee involvement) were categorised as consultant cases. Trainee seniority was defined by the number of years a trainee had undertaken on the Orthopaedic Surgical Training Program. Senior trainees were defined as those who had undertaken three or more years on the training program and junior trainees as those who had undertaken two or fewer years on the training program.

Statistical Analysis

Descriptive statistics were used to summarise and report the data with percentages and frequencies for categorical variables and medians and interquartile range for skewed continuous variables. Wilcoxon rank sum tests and χ^2-square tests were used, where appropriate, to assess equivalence amongst the consultant and trainee groups. The primary outcome variables were dichotomous indicators of whether aprocedure resulted in the outcomes of interest following each

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procedure. We examined each of the five outcomes of interest separately. The principal predictor variable of interest was primary surgeon seniority: consultant and trainee cases or senior trainee and junior trainee. Logistic regression was performed to produce odds ratios with 95% confidence intervals for the association between consultant and trainee cases or senior and junior trainee cases and the select outcomes. Multivariate logistic regression techniques assessed these associations by including potential associated risk factors for the select outcomes as identified in the published literature. Covariates in both primary total hip and knee arthroplasties were age at surgery, Body Mass Index (BMI), ASAClassificationand smoking status. For the hip arthroplasty cohort, surgical covariates included surgical approach, femoral head size and operation length. For the knee arthroplasty cohort, surgical covariates included stability, image-guided surgery and operation length. All reported p-values were two-tailed and for each analysis $p < 0.05$ was considered statistically significant. All analyses were performed using Stata 13.1 (StataCorp, College Station, Texas, USA, 2015).

Results

Over the study period, 2,682 primary total hip arthroplasties and 3,140primary total knee arthroplasties were performed. Of these, there were 410 hip arthroplasties and 494 knee arthroplasties with missing data. These cases were excluded.Of the primary total hip arthroplasties, trainees were more likely to operate on patients who smoked cigarettes compared to consultant surgeons.There were no differences in regards to patient characteristics amongst the trainee or consultant groups for primary total knee arthroplasties.

Surgeon Experience

Total Hip Arthroplasties

There were differences in regards to the approach, femoral head diameter and operative duration (Table 1). Consultant surgeons were more likely to undertake an anterior approach compared with the trainee surgeons (p-value < 0.001). Trainee surgeons were more likely to have longeroperative times and utilise larger femoral head components (p-value < 0.001).Senior traineeswere more likely to undertake hip arthroplasties unsupervised and make all of the intraoperative decisions (p-value<0.001).

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Total Knee Arthroplasties

There were differences in regards to the stability and image-guided aspects of the procedures (Table 2). Trainee surgeons were more likely to undertake posteriorly-stabilised and ultra-congruent knee arthroplasties (p-value < 0.001). Trainee surgeons were less likely to undertake knee arthroplasties with image-guided assistance (p-value < 0.001).Senior trainees were more likely to undertake knee arthroplasties unsupervised and make all of the intraoperative decisions (p-value<0.001).

Primary Total Hip Arthroplasties

Trainee Compared with Consultant

There were no differences in the rates of measured complications or surgical readmissions performed by trainees compared with consultants. Trainee-performed cases were associated with a 30% increase in the risk of requiring a transfusion in the post-operative period compared with consultant-cases(p-value = 0.015). Further analysis of this result demonstrated that trainees were more likely to operate on patients with slightly higher body mass indexes with a 1.2 kg/m^2 difference between the trainee and consultant groups (p-value = 0.02). However, there were no differences in regards to ASA Classification between the two groups.

Junior Trainee Compared With Senior Trainee

There were no associations between any of the outcomes examined and the seniority of the trainee surgeon.

Primary Total Knee Arthroplasties

Trainee Compared with Consultant

There were no associations between themeasured complications, transfusion rates or surgical readmissions amongst trainees and consultants (Table 4).

Junior Trainee Compared With Senior Trainee

There were no associations between surgical complications, medical complications, transfusions or surgical readmissions and the seniority of the trainee surgeon.However, those performed by junior trainees were associated a 50% increase in the risk of developing a wound

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complication compared with those performed by senior trainees(p-value = 0.008). Further investigation of this finding demonstrated that there were no differences in patient characteristics between the senior and junior trainee cohorts.

Discussion

Our analyses of primary surgeon experience and clinical outcomes following primary total hip arthroplasties indicate that there are no significant differences for surgical, medical and wound complications and these findings are similar to existing literature(3-5, 7-9, 18).In addition, our results demonstrate that there are no differences in clinical patient outcomes for junior traineesunder supervision performing primary total hip arthroplasties compared with senior trainees.Therefore, we have demonstrated that good outcomes can be achieved with appropriate supervision in a teaching hospital.

Contrary to Moran et al (4), we found greater primary surgeon experience was associated with a 30% reduction in the risk of requiring a transfusion when comparing consultant- and trainee-performed procedure. Possible explanations forthis finding are that trainee surgeons perform larger incisions or potentially more extensive surgical dissections compared to the consultant surgeonsor there are differencesin managing intraoperative haemostasis between the two groups.Further research needs to be conducted in order to determine the specific mechanisms that link trainee-cases with increased risks of transfusions following primary total hip arthroplasties. However, given the increased rate of transfusions for trainee-cases, haemostasis may be an important point on emphasise when developing the skills of trainees.

In regards to knee arthroplasties, our result for wound complications amongst junior trainees compared with senior trainees was similar to that published by Katz et al (10). These authors demonstrated that deep wound infections significantly decreased amongst patients undergoing procedures performed by higher volume surgeons (10). The finding of a 50% increase in the risk of developing a wound complication for procedures performed by junior trainees is especially important as a number of epidemiological studies have consistently implicated superficial wound complications in the development of deep prosthetic joint infections(19, 20).This finding could indicate the need to more thoroughly emphasise the prevention of wound complications in the education of orthopaedic trainees. This would ultimately aim to not only prevent wound complications, but to also prevent

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subsequent procedures and readmissions. Further research needs to be conducted in order to determine the specific mechanisms that link junior trainee cases with increased risks of wound complications following primary total knee arthroplasties.

Our results for surgical complications are similar to those reported within the literature, which have shown no association between surgical experience and implant survival (16), prosthesis alignment (17) and mortality(6, 10). Furthermore, analyses of primary surgeon experience and clinical outcomes following primary total knee arthroplasties indicate that there are no statistically significant differences for surgical complications, medical complications, surgical readmissions or transfusions.

The study has some important limitations, most notably is the potential case selection bias. Junior trainees are more likely to perform the relatively simpler surgical cases. Difficult cases are much more likely to be performed by a consultant. Therefore, this may have the effect of reducing the difference seen between the two populations. This type of selection bias is seemingly unavoidable and perhaps, in reality, is appropriate for a surgical education program. In addition, senior trainees were more likely to undertake the arthroplasty proceduresunsupervised, allowing them to make all the intra-operative decisions. However, junior trainees were more likely tohave more thorough supervision from a consultant. Therefore, this may limit the ability to definitively draw conclusions on the increased risk of complications between the two groups.Lastly, the exclusion of patients with missing data from our study has the potential to impact the significance of the findings.

Conclusions

We demonstrated that primary total hip and knee arthroplasties are relatively low-risk surgical procedures in terms of surgical, medical and wound complications and surgical readmissions at the studied institution. A number of results validated our hypothesis that, in a large representative cohort, there would be similar results for surgeons of differing levels of experience. However, in regards to transfusions following primary total hip arthroplasties,the results demonstrated increased rates among trainee surgeons. In addition, we found increased rates of wound complications amongst junior trainees performing primary total knee arthroplasties. The reasons for these adverse findings are unclear and it is important to continue to research these areas to ensure we continue to achieve a high level of patient care. Overall, the results from our study demonstrate the effectiveness of the

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education program and the ability of the orthopaedic trainees when supervised appropriately to achieve results similar to those of consultant surgeons.

Acknowledgements

Dr Dowsey holds an NHMRC Early Career Australian Clinical Fellowship (APP1035810)

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Table 1: Demographic information of patients who underwent primary total hip arthroplasties from January 1, 2002 through December 31, 2012

	Total Cohort	Consultant	Trainee	p-value
	2272	1240	1032	
Age	69 (62, 75)	70 (62, 76)	69 (62, 75)	0.176
Female Gender	1349 (59.4%)	723 (58.3%)	626 (60.7%)	0.256
BMI	29.4 (25.8, 33.3)	29.4 (25.6, 33.2)	29.4 (26, 33.6)	0.367
Smoking Status				0.002
▪ **Non-smoker**	1620 (72.3%)	921 (74.3%)	699 (67.7%)	
▪ **Ex-smoker**	448 (19.7%)	223 (18.0%)	225 (21.8%)	
▪ **Smoker**	204 (9.0%)	96 (7.7%)	108 (10.5%)	
ASA				0.203
▪ **1**	88 (3.9%)	57 (4.6%)	31 (3.1%)	
▪ **2**	1304 (57.4%)	698 (56.3%)	606 (58.7%)	
▪ **3**	841 (37.0%)	465 (37.5%)	376 (36.4%)	
▪ **4**	39 (1.7%)	20 (1.6%)	19 (1.8%)	
Aetiology				0.099
▪ **Osteoarthritis**	1976 (87.0%)	1072 (86.4%)	904 (87.6%)	
▪ **Rheumatoid Arthritis**	101 (4.4%)	52 (4.2%)	49 (4.7%)	
▪ **Avascular Necrosis**	127 (5.6%)	69 (5.6%)	58 (5.6%)	
▪ **Congenital Dislocation of the Hip**	68 (3%)	47 (3.8%)	21 (2.1%)	
Approach				<0.001
▪ **Hardinge**	1353 (59.6%)	689 (55.6%)	664 (64.3%)	
▪ **Posterior**	861 (37.9%)	499 (40.2%)	362 (35.1%)	
▪ **Anterior**	58 (2.5%)	52 (4.2%)	6 (0.6%)	
Femoral Head Diameter (cm)				<0.001
▪ **22**	10 (0.4%)	9 (0.7%)	1 (0.1%)	
▪ **28**	1217 (53.6%)	738 (59.5%)	479 (46.4%)	
▪ **32**	743 (32.7%)	384 (31.0%)	359 (34.8%)	
▪ **36**	302 (13.3%)	109 (8.8%)	193 (18.7%)	
Operation Length (minutes)	100 (85, 115)	95 (85, 115)	100 (90, 115)	<0.001

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Wilcoxon rank sum tests and χ^2-square tests were used, where appropriate, to assess equivalence amongst the consultant and trainee groups.

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Table 2: Demographic information of patients who underwent primary total knee arthroplasties from January 1, 2002 through December 31, 2012

	Total Cohort	Consultant	Trainee	p-value
	2646	1365	1281	
Age	71 (65, 77)	70 (62, 76)	69 (62, 75)	0.934
Female Gender	1729 (65.3%)	882 (64.6%)	847 (66.1%)	0.416
BMI	32 (28.2, 36.4)	29.4 (25.6, 33.2)	29.4 (26.0, 33.6)	0.210
Smoking Status				0.113
▪ **Non-smoker**	1882 (71.1%)	994 (72.8%)	888 (69.3%)	
▪ **Ex-smoker**	602 (22.8%)	296 (21.7%)	306 (23.9%)	
▪ **Smoker**	162 (6.1%)	75 (5.5%)	87 (6.8%)	
ASA				0.071
▪ **1**	61 (2.4%)	33 (2.4%)	28 (2.2%)	
▪ **2**	1492 (56.4%)	804 (58.9%)	688 (53.7%)	
▪ **3**	1056 (39.9%)	509 (37.3%)	547 (42.7%)	
▪ **4**	35 (1.3%)	18 (1.3%)	17 (1.3%)	
Aetiology				0.289
▪ **Osteoarthritis**	2486 (93.9%)	1278 (93.2%)	1208 (94.3%)	
▪ **Rheumatoid Arthritis**	153 (5.8%)	85 (6.2%)	68 (5.3%)	
▪ **Avascular Necrosis**	7 (0.3%)	2 (0.1%)	5 (0.4%)	
Stability				<0.001
▪ **Minimally Stabilised**	1196 (45.2%)	753 (55.2%)	443 (34.6%)	
▪ **Posteriorly Stabilised**	1325 (50.1%)	576 (42.2%)	749 (58.5%)	
▪ **Ultra-congruent**	125 (4.7%)	36 (2.6%)	89 (6.9%)	

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Image Guided Surgery	371 (14.0%)	283 (20.7%)	88 (6.9%)	<0.001
Operation Length (minutes)	95 (80, 110)	95 (80, 110)	95 (85, 110)	0.1422

Wilcoxon rank sum tests and χ^2-square tests were used, where appropriate, to assess equivalence amongst the consultant and trainee groups.

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Table 3: Select outcomes followingprimary total hip and knee arthroplasties from January 1, 2002 through December 31, 2012

	Total Hip Arthroplasties			Total Knee Arthroplasties		
	Total Cohort	Consultant	Trainee	Total Cohort	Consultant	Trainee
	2272	1240	1032	2646	1365	1281
Surgical Complication	110 (4.8%)	59 (4.8%)	51 (4.9%)	128 (4.8%)	66 (4.8%)	62 (4.8%)
Medical Complication	236 (10.4%)	123 (9.9%)	113 (10.9%)	343 (13.0%)	172 (12.6%)	171 (13.3%)
Wound Complication	237 (10.4%)	124 (10.0%)	113 (10.9%)	234 (8.8%)	135 (9.9%)	99 (7.7%)#
Surgical Readmission	48 (2.1%)	26 (2.1%)	22 (2.1%)	98 (3.7%)	51 (3.7%)	47 (3.7%)
Transfusion	498 (21.9%)	244 (19.7%)	254 (24.6%)*	519 (19.6%)	252 (18.5%)	267 (20.8%)

* Comparison with χ^2-square test giving a statistically significant p-value of 0.005.

Comparison with χ^2-square test giving a p-value of 0.050.

Comparisons with χ^2-square tests giving non-significant results for all other groups with p-values > 0.05.

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Table 4: Associations between the primary surgeon and select outcomes following primary total hip and knee arthroplasties between January 1, 2002 and December 31, 2012

Outcome	Primary Surgeon	Total Hip Arthroplasties: Adjusted Odds Ratio (95% Confidence Intervals)*	Total Hip Arthroplasties: p-value	Total Knee Arthroplasties: Adjusted Odds Ratio (95% Confidence Intervals)*	Total Knee Arthroplasties: p-value
Surgical Complication	Consultant	1.00		1.00	
	Trainee	1.20 (0.80, 1.78)	0.380	0.97 (0.67, 1.41)	0.890
Medical Complication	Consultant	1.00		1.00	
	Trainee	1.08 (0.81, 1.44)	0.579	1.09 (0.86, 1.39)	0.462
Wound Complication	Consultant	1.00		1.00	
	Trainee	0.98 (0.74, 1.30)	0.886	0.77 (0.58, 1.03)	0.076
Transfusion	Consultant	1.00		1.00	
	Trainee	1.31 (1.05, 1.62)	**0.015**	1.10 (0.90, 1.35)	0.361
Surgical Readmission	Consultant	1.00		1.00	
	Trainee	1.21 (0.67, 2.18)	0.521	0.94 (0.62, 1.44)	0.778

* Odds ratios for total hip arthroplasties are adjusted for age, BMI, smoking status,ASA Classification, approach, femoral head diameter and length of operation.

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Odds ratios for total knee arthroplasties are adjusted for age, BMI, smoking status, ASA) Classification, stability, image-guided surgery and length of operation.

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Table 5: Associations between the primary surgeon and select outcomes following primary total hip and knee arthroplasties between January 1, 2002 and December 31, 2012

Outcome	Primary Surgeon	Total Hip Arthroplasties: Adjusted Odds Ratio (95% Confidence Intervals)*	Total Hip Arthroplasties: p-value	Total Knee Arthroplasties: Adjusted Odds Ratio (95% Confidence Intervals)*	Total Knee Arthroplasties: p-value
Surgical Complication	Senior Trainee	1.00		1.00	
	Junior Trainee	0.70 (0.45, 1.09)	0.114	1.11 (0.75, 1.65)	0.590
Medical Complication	Senior Trainee	1.00		1.00	
	Junior Trainee	0.84 (0.64, 1.15)	0.285	1.18 (0.91, 1.52)	0.208
Wound Complication	Senior Trainee	1.00		1.00	
	Junior Trainee	0.91 (0.67, 1.24)	0.557	1.51 (1.11, 2.04)	**0.008**
Transfusion	Senior Trainee	1.00		1.00	
	Junior Trainee	0.94 (0.74, 1.19)	0.599	0.90 (0.72, 1.11)	0.329
Surgical Readmission	Senior Trainee	1.00		1.00	

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	Junior Trainee	0.75 (0.38, 1.48)	0.406	1.28 (0.82, 2.01)	0.273

* Odds ratios for total hip arthroplasties are adjusted for age, BMI, smoking status, ASA Classification, approach, femoral head diameter and length of operation. Odds ratios for total knee arthroplasties are adjusted for age, BMI, smoking status, ASA Classification, stability, image-guided surgery and length of operation.

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