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The Impact of Resident Teaching on Total Hip Arthroplasty

Raymond P. Robinson, MD, FACS

The author asked whether THA cases performed with major resident participation in a private practice setting were associated with greater use of health care resources, higher rates of technical errors, or a reduction in quality of outcome compared to THA cases performed without major resident involvement. Eighty-eight primary THA cases performed with major resident participation were compared to 61 cases without major resident participation. Resident cases took 20 minutes longer, required a second assistant more frequently (92% versus 23%) but did not have higher transfusion rates or result in a longer hospital stay. Resident cases did not have more complications or increased technical errors. Resident cases also did not have lower Harris hip scores or inferior Short Form SF-12 physical ratings at minimum 1-year followup.

Concerns about orthopaedic resident education have increased as financial pressures on surgeons and hospitals have intensified.[3,5–7,10] Gofton and Regehr[3] commented that in teaching hospitals in today's environment, faculty have less time for teaching because of these financial realities. Lavernia et al[6] demonstrated TKA cases treated in an academic service took longer and consumed more resources than those in a private service. Woolson and Kang[10] reported longer surgical times in THA and TKA cases performed on a teaching service.

Surgeon-educators, like other physicians, are expected to increase productivity, reduce costs, improve outcomes, eliminate errors, and improve patient satisfaction. However, they are also expected to train the next generation of surgeons. Traditionally, most of the training of surgical residents has relied on the apprenticeship model established by Halsted in the late 1800s.[2,3] Such a model has been central to my approach to resident teaching in a private practice setting. It relies on a close working relationship between a resident and a surgeon-educator progressing through a sequence of surgical steps and thought processes while maintaining an optimal challenge point for each individual learner.[3,8] Although each resident must learn, it is not clear whether this teaching process in a private practice setting influences patient outcome and utilizes more health care resources.

I therefore asked whether primary THA teaching cases performed in a private practice setting with major resident participation used more health care resources, resulted in more technical errors, or resulted in inferior outcomes compared to primary THA cases performed in the same private practice without major resident participation.

MATERIALS AND METHODS

I retrospectively reviewed the data and radiographs of 142 patients in whom I had performed 149 primary THA procedures during 2002 and 2003. One hundred thirty-five patients underwent unilateral procedures, and seven patients underwent bilateral hip replacements under a single anesthetic. Data from each case, including resident participation, had been recorded prospectively as part of a routine ongoing total joint database. The study cohort was divided into Group A (cases performed with major resident participation) and Group B (cases performed without major resident participation). There were 83 unilateral cases in Group A and 52 in Group B (Table 1). Upon review of the available Harris hip score data, the success rate was 94% for Group B cases. The degree of difference regarded as clinically unimportant was 12.5%. Applying Blackwelder's method, using a type I error of 5% (one-sided) and type II error of 20% (80% power) with a 2:1 randomization ratio yielded a sample size of 77 cases in Group A and 39 cases in Group B.[1] Thus, the data were sufficient for the evaluation of Harris hip scores to be appropriately powered. Groups A and B were similar with re-

From the University of Washington, Section of Orthopaedics, Virginia Mason Medical Center, Seattle, WA.
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The author certifies that his institution has approved the human protocol for this investigation, that all investigations were conducted in conformity with ethical principles of research, and that informed consent was obtained.
Correspondence to: Raymond P. Robinson, MD, FACS, Section of Orthopaedics, Virginia Mason Medical Center, 9th Avenue, Seattle, WA 98101. Phone: 206-223-7530; Fax: 206-515-5846; E-mail: ortrpr@vmmc.org.
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TABLE 1. Group A and Group B Comparison

Variables	Group A	Group B	p Value*
THA unilateral (number of hips)	83	52	
THA bilateral	4	8	
THA one side of a bilateral case	1	1	
Patient age in years (unilateral patients)	65 ± 12 (range, 35–85)	63 ± 13 (range, 36–84)	NS
BMI (unilateral patients)	29 ± 5 (range, 20–48)	28 ± 6 (range, 16–48)	NS
Gender (unilateral cases)			
Male	41	19	
Female	42	33	
Diagnoses (unilateral cases)			
Primary osteoarthritis	59	37	
Secondary osteoarthritis	14	8	
AVN	2	0	
AVN + DJD	6	2	
Inflammatory arthritis	1	2	
Posttraumatic arthritis	1	1	
Coxa vera	0	2	

*NS = not significant

spect to patient age at surgery, gender, body mass index (BMI), and diagnoses (Table 1). Patients were informed and surgical consent obtained, allowing resident involvement in surgical procedures as deemed appropriate by the attending surgeon. Consent was routinely obtained from each patient undergoing total joint surgery allowing prospective entry of data pertaining to their surgery. These data were entered into an Institutional Review Board-approved and HIPAA-compliant computerized database. Institutional Review Board approval was again obtained to review all primary THA cases I performed during 2002 and 2003.

The years 2002 and 2003 were unique in my practice. Two things occurred during this time that allowed the present study. First, I reduced my usual teaching responsibilities. This resulted in a group of primary total hip cases that did not involve the resident. Second, at the time of surgical scheduling it was unknown whether at the time of surgery I would be with or without a resident. This resulted in an informal random assignment of residents to my cases. If a resident did participate in a case, their degree of involvement was determined by me, based solely on my judgment of the resident's progression through the teaching sequence described below. No case was diverted from resident involvement.

When the resident had implanted either the femoral or acetabular component and performed the exposure and closure, the case was designated as a resident "yes" (Group A) case in the database. Cases in which the resident did not do these steps, even if he or she was scrubbed, were designated as resident "no" (Group B) cases. The "talk-through" cases (see below) were resident "no" cases. Primary THA cases in this study were not diverted from the resident for any reason. Four bilateral hip cases in two patients were resident "yes" cases. Eight bilateral hip cases were resident "no" cases. One bilateral hip patient had one resident "yes" hip and one resident "no" hip. Because of the small numbers and to simplify statistical comparisons of data, the bilateral cases in this study were only included when comparing radiographic measurements assessing the accuracy of implant placement and cement techniques, complications, and implant selection. All other comparisons were restricted to those hips operated on unilaterally. A resident did scrub in 13 of the resident "no" cases but did not participate actively in the steps of the surgery. Most of these cases were the "talk-through" teaching cases referred to earlier. "Talk-through" cases were believed best listed in Group B because the author was mainly interested in seeing the effect of actual resident hands-on involvement in cases.

Individual residents worked with me for 3 months. During that time, they were progressed through an orderly sequence of steps beginning with preoperative hip templating and planning. They were then taken through a lengthy "talk-through" teaching case in which I performed the surgery and described each step. Depending on his or her surgical skill level, the resident was then allowed to progress to performing the exposure and closure, femoral stem insertion, and acetabular implantation. No step of any operation was performed without my direct involvement and control.

I advise patients to donate autologous blood before surgery if medically appropriate. Autologous units are routinely returned to the patient postoperatively. Careful control of all steps of each operation by the attending was believed critical. For cemented stems, I allowed the experienced resident to broach the femoral canal, ream the femoral calcar, and perform a trial reduction based on the preoperative plan prepared with the attending. I then assessed possible changes in implantation geometry and positioning before final implant selection and implantation. The resident was then allowed to prepare the canal, inject and pressurize the cement, and insert the stem with a distal centralizer. Cemented stem insertion was stopped 2 to 3 mm short of final position, allowing the attending a chance to change any aspect of the final implant placement. Femoral anteversion was measured with a protractor using the tibial shaft as a reference just prior to complete stem placement and again at final implant insertion.

Final degrees of anteversion were recorded in the database. A collared femoral component was used in cemented cases to provide a predictable and reproducible end point to insertion.

During insertion of uncemented stems, the experienced resident was allowed to broach the canal, ream the calcar, and perform a trial reduction as well. However, the preliminary trial reduction was often performed with a broach smaller than the final implant so that changes in implant geometry and positioning could again be made by the attending surgeon. This teaching approach was facilitated by using both cemented and uncemented femoral components that are designed with the same proximal geometries despite changes in stem size. As a result, changes in stem sizes made at the point of final implant selection do not change the proximal positioning and geometry decisions made during trial reductions.

The experienced resident was allowed to excise the acetabular soft tissue rim and initiate acetabular reaming. Final reaming was controlled by me. All sockets were reamed 2 mm in diameter less than the implant. The prosthetic acetabulum was then mounted on the insertion-positioning jig and the resident was allowed to initiate implant impaction. In each case, the resident was expected to commit to a component position. The attending surgeon would then switch places with the resident, check the position of the implant, and complete the seating of the acetabular component. All patients had implantation of a Trilogy (Zimmer, Warsaw, IN) fiber-metal mesh ingrowth acetabular component and one of three Acumatch (Exactech, Gainesville, FL) femoral components (Table 2). Ninety percent of the Group A cases and 80% of the Group B cases were hybrid hips.

Patients in both groups went through identical preoperative total hip classes. Postoperative care and followup routines were also identical, following the total hip pathways established for the medical center.

Prospective data were accumulated preoperatively, intraoperatively, 6 weeks after surgery, 3 months after surgery, and a minimum of 1 year postoperatively. Data were collected using physician data sheets, including Harris hip ratings and patient questionnaires, including Short Form-12 (SF-12) questions.[4,9]

Intraoperative data were complete in all cases. Postoperative physician data sheets including Harris hip scores at minimum 1 year followup were available in 75 of 83 (90%) of the unilateral Group A cases and 47 of 52 (90%) of the unilateral Group B cases. Complication data in both unilateral and bilateral cases were complete in 86 (98%) of the 88 Group A cases and 59 (97%) of the 61 Group B cases.

I reviewed all available routine radiographs from each case to first confirm radiographic measurements prospectively recorded in the total joint database. Leg length differences were determined by comparing lesser trochanter positions with respect to a transischial line. I then measured stem varus and valgus angles on anteroposterior radiographs and examined the cementing technique on both anteroposterior and lateral radiographs. Cement filling defects were measured with a caliper. Defects greater than 2 mm in greatest diameter were recorded. Complete radiographs were available in 79 (90%) of the 88 Group A cases and 56 (92%) of the 61 Group B cases. Other cases had only anteroposterior views.

Resource variables, technical variables, and outcome variables (Table 2) from both groups were compared. Resource variables compared were operative time (skin to skin), number of surgical assistants, transfusion requirements, and length of hospital stay. Technical variables compared were acetabular abduction angle, femoral anteversion angle, stem varus/valgus alignment greater than or equal to 2°, postoperative leg length difference of more than 5 mm, cement filling defects, and intraoperative complications. Outcome variables compared were postoperative complications, Harris hip scores, and short form SF-12 physical and mental scores.[4,9] Statistical analyses were performed with Microsoft Excel 2003 (Microsoft Corp, Redmond, WA) for continuous variables. Continuous variables were reported with a mean, standard deviation, and range and statically analyzed with a Student's t-test. Discrete variables were reported with counts and percentages and statistically analyzed with a 2 × 2 chi-square test. A $p < 0.05$ was considered significant.

RESULTS

Unilateral Group A cases on average took 17 minutes longer to perform than Group B cases. The "talk-through" cases in Group B were, at times, very lengthy. One was 144 minutes. If one eliminated these instructive teaching cases Group A cases took on average 20 minutes longer. A wide range of surgical times was seen in Group A. This reflected the varied skills of individual residents. A greater percentage of cemented stems were used in Group A cases. If one compared surgery time in cases with cemented stems alone, Group A cases took on average 19 minutes longer. A second assistant was required more frequently in Group A cases. Group A cases did not have a higher percentage of autologous or homologous transfusions or a longer hospital stay.

Group A cases had, on average, a slightly more vertical acetabular component ($p = 0.0111$) and a higher incidence of cement filling defects than Group B. Group A and Group B cases had similar femoral anteversion angles, stem varus/valgus alignment and leg length discrepancies. Intraoperative complications were similar (Table 2).

Group A and Group B cases had similar Harris hip scores, pain and function scores, and SF-12 norm-based physical component (Table 2). Group A did have, however, lower ($p = 0.0208$) SF-12 mental norm-based components. The two groups had similar incidences of postoperative complications. Two patients in Group A had transient sciatic nerve symptoms that were not seen in Group B cases. Both of these cases were mild and resolved completely.

DISCUSSION

My study demonstrates the impact of select aspects of resident surgical teaching on the process and outcome of

TABLE 2. Resource, Technical, and Outcomes Variables, Group A and Group B

Variables	Group A	Group B	p Value*
Implants Used (unilateral and bilateral)			
Acetabular component			
Trilogy	88 (100%)	61 (100%)	
Femoral component			
Acumatch C (cemented)	79 (90%)	49 (80%)	
Acumatch P (porous)	8 (9%)	11 (18%)	
Acumatch M (modular)	1 (1%)	1 (2%)	
Resource Variables (unilateral cases)			
Operative time, mean (range)	89 ± 12 (61–125)	72 ± 15 (50–144)	p < 0.00001
Operative time (cemented stems)	90 ± 11	71 ± 11	p < 0.00001
Operative time (cases without “talk through”)	89 ± 12	69 ± 9	p < 0.00001
Second surgical assistant required	76 (92%)	12 (23%)	p < 0.0001
Transfusion Rates (unilateral cases)			
Autologous blood	51 (61%)	37 (71%)	
Homologous blood	11 (13%)	8 (15%)	
Length of hospital stay in days, mean	3.3 ± 0.8	3.2 ± 0.5	NS
Technical Variables (unilateral and bilateral)			
Acetabular abduction angle, mean (range)	46 ± 4° (39–59)	44 ± 4° (36–55)	p = 0.0111
Femoral anteversion	22 ± 4°	23 ± 4°	NS
Postoperative leg length difference ≤ 5 mm	67 (85%)	49 (87%)	NS
Stem varus/valgus > 2°	6 (7.5%)	5 (8.9%)	NS
Femoral cement filling defects	11 (14%)	4 (7%)	p = 0.0288
Interoperative Complications (unilateral and bilateral)			
Nondisplaced fracture greater trochanter	1	0	
Femoral shaft fracture	1	0	
Partial laceration of abductor muscle	1	0	
Femoral split to extract partially impacted cementless stem	0	1	
Calcar crack during reaming	0	1	
Broken imbedded drill bit	0	1	
Perforation of both surgical gloves	0	1	
Outcomes Variables (unilateral cases)			
Harris hip score, mean (range)	92 ± 11 (37–100)	94 ± 6 (15–100)	NS
Pain and function score	83	84	NS
SF-12 Physical	46	49	NS
SF-12 Mental	53	56	p = 0.0208
Postoperative Complications (unilateral and bilateral)			
Dislocation	1	2	
Superficial thrombosis	0	1	
Deep vein thrombosis	0	1	
Pulmonary embolism	0	0	
Superficial infection	2	2	
Deep infection	0	0	
Transient sciatic nerve symptoms	2	0	
Hematoma	1	0	
Other (unrelated to surgery)	3	1	

*NS = not significant

THA surgery performed in a private practice setting. Data were collected prospectively and resident involvement was random. Understanding the effect of teaching on patient care is important because it provides an understanding of the resources required to continue to educate future orthopaedic surgeons in today’s intense healthcare environment. It is also important to know we are not harming our patients.

There were several limitations to this study. No formal prospective randomization process was used to determine resident involvement. Rather, an informal randomization occurred since at the time of surgical scheduling it was not known whether a resident would or would not be participating in any given case. In addition, the amount of resident participation in a case was determined by the surgeon-educator’s opinion of the resident’s surgical skills and progress. Although this was not a scientifically structured selection process it was based on a very structured sequence of teaching steps performed by the author with residents over many years. Resident involvement was not determined by patient factors. Radiographic measurements were only performed by a single observer and therefore would be vulnerable to bias. The study also reports only minimum 1-year followup data. Longer followup might demonstrate differences in outcome variables not seen in 1-year results.

Time is an important healthcare resource. The average length of surgery in this study was 17 minutes longer when the resident was allowed to participate in the actual process of the operation. If the teaching "talk-through" cases were eliminated, there was an average 20-minute difference. The difference was not explained by the higher use of cemented stems in the resident cases. Longer surgical times in teaching cases have been reported by Woolson and Kang[10] but they were reporting cases performed on a teaching service and comparing them to cases on a private practice service. Lavernia et al[6] also documented longer surgery times for TKA cases performed on an academic service compared to a private service. In this study the THA cases being compared were all contained within the same private practice.

The magnitude of the increase in surgical time in this study reflects the author's approach to teaching. Each resident is taken through a series of similar cases. He or she is given time to briefly ponder selected steps of each operation. Successive operations focus on different aspects of the total procedure until the resident has been given an opportunity to think through all of the steps of the procedure. The surgeon-educator must have considerable patience to provide such opportunities to learn. He or she must also know when to step in and return the operation to a proper tempo. In this manner, the length of teaching surgery can be controlled to some degree. Although 20 minutes of added surgery time does not seem like much, during a full day of surgery, it clearly has an impact on the number of cases that can be scheduled. As a result, there is a negative impact on a surgeon's productivity.

Another important resource is manpower. A second surgical assistant was necessary 91% of the time in resident cases. This represents additional use of healthcare resources. When teaching, the surgeon-educator must have hands free to demonstrate techniques and protect tissues. Structures such as the abductor muscle group nicked and listed as an intraoperative complication in Group A can, at times, be inadvertently injured by the most experienced surgeon. Nevertheless, these types of errors must be kept to a minimum. In teaching cases avoiding such errors requires constant hands-free vigilance by the attending.

There was no difference in the length of hospital stay. Woolson and Kang as well as Lavernia et al made the same observation when looking at cases performed on a teaching service.[6,10] Length of hospital stay in this study may be more a reflection of the medical center total hip pathway and patient preoperative expectations and teaching than whether the case involved the resident. All patients were on the same private service and were progressed along the same institutional total joint pathway. However, hospital stays were not longer as a result of resident involvement in cases.

Efforts to identify measurable differences in technical details of the operation were believed important. Great care was taken, during teaching cases, to control not only the length of the surgery but also the details of the procedure. There were no differences in leg length, femoral anteversion, stem varus/valgus, or intraoperative complications, but Group A cases had, on average, a slightly more vertical acetabulum. Woolson and Kang[10] also reported more vertical sockets in resident cases. This was surprising in my study because I performed the final impaction of the acetabular implant in both group A and B cases. However, although the difference was statistically significant, an average difference of only 2° abduction would not likely be clinical important and even within the error of the technique used to measure the angle from standard radiographs. The cement filling defects seen in each group were also believed to be of no clinical importance.

One observation made during this period was the impact of teaching on implant selection. Standardizing implant choices in an institution has been important in controlling one component of cost in healthcare. Collarless cemented stems pose a problem in teaching cases because the implant may be inserted beyond the ideal position by the resident leaving no recourse for the surgeon-educator to recover. Collared stems, on the other hand, have a predictable endpoint to insertion and allow the attending to be in more control. Highly grit-finished acetabular components also can present a problem. The initial impaction position of such components by the resident can be very difficult to change. Implants believed more appropriate for teaching may be different than those chosen by other surgeons. Therefore standardization of implants can be more difficult and result in increased cost.

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