Who Did the Arthroplasty? Hip Fracture Surgery Reoperation Rates are Not Affected by Type of Training—An Analysis of the HEALTH Database

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Objectives: This study compares outcomes for patients with displaced femoral neck fractures undergoing hemiarthroplasty (HA) or total hip arthroplasty (THA) by surgeons of different fellowship training.

Design: Retrospective review of HEALTH trial data.

Setting: Eighty clinical sites across 10 countries.

Patients/Participants: One thousand four hundred forty-one patients ≥50 years with low-energy hip fractures requiring surgical intervention.

Intervention: Patients were randomized to either HA or THA groups in the initial data set. Surgeons' fellowship training was ascertained retrospectively, and outcomes were compared.

Main Outcome Measurements: The main outcome was an unplanned secondary procedure at 24 months. Secondary outcomes included death, serious adverse events, prosthetic joint infection (PJI), dislocation, discharge disposition, and use of ambulatory devices postoperatively.

Results: There was a significantly higher risk of PJI in patients treated by surgeons without fellowship training in arthroplasty (P = 0.01), surgeons with unknown fellowship training (P = 0.03), and surgeons with no fellowship training (P = 0.02) than those treated by an arthroplasty-trained surgeon. There were significantly higher odds of being discharged to a facility rather than home in patients who underwent surgery by a surgeon with no fellowship training compared with arthroplasty–fellowship-trained surgeons (P = 0.03).

Conclusions: Arthroplasty for hip fracture can be performed by all orthopaedic surgeons with equivalent reoperation rates. Infection

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prevention strategies and use of "care pathways" by arthroplasty-fellowship-trained surgeons may account for the lower risk of PJI and higher rate of discharge to home. The authors advocate for the use of evidence-based infection prevention initiatives and standardized care pathways in this patient population.

Key Words: displaced femoral neck fracture, total hip arthroplasty, hemiarthroplasty, fellowship training

Level of Evidence: Prognostic Level II. See Instructions for Authors for a complete description of levels of evidence.

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INTRODUCTION

Femoral neck fractures are common injuries in the geriatric population, with an annual incidence projected to surpass 6.26 million worldwide by 2050.[1] This increasing incidence underscores the necessity for treatment strategies that optimize patient outcomes from a surgical and medical perspective. Despite the overall success in the current treatment of femoral neck fractures, devastating complications persist. These complications include, but are not limited to, thromboembolic events, infection, implant failures prompting revision surgery, and one-year mortality of approximately 30%.[2–5]

Nondisplaced femoral neck fractures are amenable to closed reduction and percutaneous pinning, but displaced fractures are typically treated with either hemiarthroplasty (HA) or total hip arthroplasty (THA). The decision to perform a HA or THA is driven by several factors, such as previous hip pain, activity level, risk for dislocation, and surgeon comfort or training. Although most displaced femoral neck fractures are still treated with HA, current studies have demonstrated an increasing trend and a potentially improved outcome in THAs.[6–9]

The field of orthopaedics has become progressively more subspecialized over time with >90% of the US orthopaedic residency graduates completing a fellowship as of 2013.[10,11] Recent literature has studied femoral neck fractures undergoing HA and compared outcomes based on surgeon fellowship training: arthroplasty, trauma, or general orthopaedics.[12] The data show decreased operative time with arthroplasty surgeons, higher complication rates with general orthopaedists, and higher mortality rates with trauma surgeons. However, this was a single-center series that included only 298 hip fractures.

The Hip Fracture Evaluation with Alternatives of THA versus Hemiarthroplasty (HEALTH) trial found no difference in outcomes in HA versus THA for femoral neck fractures at 2-year follow-up.[13] This prospective randomized multicenter study included patients undergoing HA and THA performed by surgeons with various training backgrounds. There are no studies examining the HEALTH data outcomes of patients treated by fellowship-trained orthopaedic surgeons versus those treated by non–fellowship-trained orthopaedic surgeons. This study serves to investigate a potential difference in outcomes for HA or THA after femoral neck fractures treated by fellowship-trained orthopaedic surgeons and non–fellowship-trained orthopaedic surgeons. Our hypothesis is that there is no difference in outcomes at 2 years for HA or THA after femoral neck fractures based on fellowship training.

METHODS

Our study was a retrospective review of the data from the HEALTH trial.

Both the primary surgeon and supporting institution were listed for every case in the database. Several resources were used to identify each surgeon's subspecialty training. The surgeon's profile on their hospital web site was the primary source of information. Several surgeons were contacted directly through telephone and/or e-mail, when their information could not be found otherwise. Professional networking web sites, such as LinkedIn and Doximity, were used as well.

The surgeons' level of training was classified in to 5 major groups as follows: trauma-fellowship trained, arthroplasty-fellowship trained, fellowship training outside of trauma or arthroplasty, unknown fellowship status, or no fellowship training. Fellowship was defined as subspecialized training completed after completion of an orthopaedic surgery residency. If a surgeon had completed individual fellowships in both trauma and arthroplasty or a combination fellowship focusing on trauma and arthroplasty, that surgeon was counted toward the arthroplasty group because the intervention in the HEALTH trial was arthroplasty. Surgeons for whom there was no available information regarding their training were included in the unknown fellowship group. A surgeon was only listed as having no fellowship if their training record clearly stated their residency training and did not identify a fellowship.

Participant demographics, baseline characteristics, major comorbidities, and outcomes of the population were summarized by fellowship training and treatment group. Descriptive statistics were used to summarize these data. Means and SDs were used for continuous data, and categorical data were presented as frequencies and percentages.

Cox regression analyses were then performed to investigate the association between fellowship training and 5 HEALTH data outcomes in all participants, using fellowship training as the independent variable in each model. We also included randomized treatment as a covariate and surgeon as a random effect in each model. We used the following outcomes as the dependent variable in each respective model: (1) the HEALTH trial primary outcome of unplanned secondary hip procedures within 24 months of initial surgery (yes vs. no), (2) hip dislocation (yes vs. no), (3) death (yes vs. no), (4) serious adverse events (yes vs. no), and (5) prosthetic joint infection (PJI) (yes vs. no). We also performed the 5 abovementioned analyses including only participants in the THA group and only participants in the HA group, separately. Randomized treatment was removed as a covariate when we performed analyses on the separate treatment groups. Results were reported as hazard ratios (HRs) with 95% confidence intervals (CIs). *T* tests were 2-tailed with alpha = 0.05.

We also performed 2 logistic regression analyses to investigate the association between fellowship training and 2

HEALTH data outcomes in all participants, using fellowship training as the independent variable in each model. We also included randomized treatment as a covariate and surgeon as a random effect in each model. We used the following outcomes as the dependent variable in each respective model: 1) discharge disposition (discharged to a facility vs. discharged home) and 2) use of ambulatory devices postoperatively (use of an ambulatory device vs. nonuse of an ambulatory device). Prefracture living status and prefracture functional status were also included as covariates in these 2 models, respectively. We also performed the 2 abovementioned logistic regression analyses including only patients in the THA group and only patients in the HA group, separately. Randomized treatment was removed as a covariate when we performed analyses on the separate treatment groups. Results were reported as odds ratios (ORs) with 95% CIs. *T* tests were 2-tailed with alpha = 0.05.

All data analyses were conducted using R (version 4.0.0, R Foundation for Statistical Computing, Vienna, Austria).

RESULTS

The HEALTH trial enrolled 1441 patients with 723 patients randomized to HA and 718 patients randomized to THA. Of these 1441 procedures, 281 cases were performed by orthopaedic surgeons who completed a fellowship in orthopaedic trauma, 394 cases were performed by orthopaedic surgeons who completed a fellowship in arthroplasty, and 139 cases were performed by orthopaedic surgeons who completed fellowship in specialties other than trauma or arthroplasty. There were 308 cases completed by orthopaedic surgeons who did not complete any further training after their residency and 319 cases completed by orthopaedic surgeons whose fellowship training status was unknown. Both HA and THA cases were performed by each training group. There was no difference in the body mass index, prefracture living setting, prefracture functional status, American Society of Anesthesiologists (ASA) score, or major comorbidities when the patients were grouped by surgical training ($P > 0.05$ for all). There were differences among the groups about age, sex, and ethnicity ($P < 0.05$ for all). These demographic data are detailed in **Supplemental Digital Content 1** (**Appendix 1**, http://links.lww.com/JOT/B210).

There was no difference in the incidence of unplanned secondary procedure, dislocation, death, or serious adverse events among the different groups ($P > 0.05$ for all). When analyzing the HA and THA patients separately, there was still no difference in these end points ($P > 0.05$ for all) between the fellowship training groups.

There was a difference in PJI among the fellowship training groups ($P = 0.02$). The patients treated by surgeons who completed fellowships outside of trauma or arthroplasty (HR 4.06, 95% CI 1.46–11.33; $P = 0.01$), surgeons with unknown fellowship training (HR 3.69, 95% CI 1.11–12.27; $P = 0.03$), and surgeons with no fellowship training (HR 3.42, 95% CI 1.20–9.74; $P = 0.02$) had a higher risk of PJI than those treated by an arthroplasty-trained surgeon. When looking specifically at the THA patients, there was a higher risk of PJI in the no fellowship group as compared to the arthroplasty-trained group (HR 4.49, 95%, CI 1.20–16.81; P = 0.03). In the HA patients, there was no difference in PJI among the various fellowship groups ($P > 0.05$).

There were significantly higher odds of being discharged to a facility rather than home postoperatively for the patients who underwent surgery with a surgeon with no fellowship training (OR 1.43, 95% CI 1.02–1.99; $P = 0.03$) as compared to undergoing surgery with an arthroplasty–fellowship-trained surgeon. This difference was not demonstrated when looking at HA and THA groups separately ($P > 0.05$ for all). There was no difference in the use of assistive devices postoperatively, when comparing the fellowship training groups ($P > 0.05$ for all). These results are summarized in Tables 1–3.

DISCUSSION

We found no difference relative to surgical training when comparing the risk of unplanned secondary procedure, dislocation, death, and serious adverse events for patients who underwent HA or THA for displaced femoral neck fractures. However, there was a significantly higher risk of PJI in patients treated by surgeons who completed fellowships outside of arthroplasty, surgeons with unknown fellowship training, and surgeons with no fellowship training than those treated by an arthroplasty-trained surgeon. Specifically, in the THA group, being treated by a surgeon with no fellowship training was associated with a higher risk of PJI as compared to those treated by an arthroplasty-trained surgeon.

Previous literature has suggested a difference in numerous outcomes related to surgical training; our data did not support this. Mabry et al reviewed 298 displaced femoral neck fractures treated with HA and studied outcomes comparing surgeons trained in arthroplasty, trauma, or no fellowship ("generalists"). Their series demonstrated that arthroplasty-trained surgeons had the shortest operative time, generalists had the highest overall complication rate, and trauma-trained surgeons had the highest mortality rate at one year.[12] In addition, there was no difference in PJI in their study. Our study also showed no difference in PJI for patients undergoing HA for hip fracture. However, there was a significantly higher risk of PJI in the THA patients (Table 3). Considering there was no overall difference in reoperation rates among groups, PJIs in the THA patients were not causing a significant rate of return to the operating room, and thus, the clinical implications of this finding in our study are uncertain. Given this finding, it would be rather drastic to recommend that THA for hip fracture be avoided by surgeons with no fellowship training. Instead, our group recommends all surgeons performing these procedures follow the most current infection prevention guidelines.

There were several limitations in the Mabry et al study as it was a single-center series of only 298 patients with 35 surgeons performing only hip HA. The HEALTH trial included nearly 5 times the number of patients in 80 centers across 10 countries undergoing both HA and THA.[13] With a much larger and more diverse study group of both patients

TABLE 1. Association Between Fellowship Training and HEALTH Outcomes in all Arthroplasty Patients

Outcome	HR (95% CI)	P
Unplanned secondary procedure		Overall: 0.82
Trauma vs. arthroplasty	1.11 (0.64–1.95)	
Other vs. arthroplasty	1.35 (0.80–2.26)	
Unknown vs. arthroplasty	1.34 (0.70–2.57)	
None vs. arthroplasty	0.81 (0.45–1.46)	
Dislocation		Overall: 0.66
Trauma vs. arthroplasty	0.88 (0.38–2.04)	
Other vs. arthroplasty	1.02 (0.47–2.22)	
Unknown vs. arthroplasty	0.76 (0.25–2.32)	
None vs. arthroplasty	0.82 (0.37–1.82)	
Death		Overall: 0.85
Trauma vs. arthroplasty	1.14 (0.74–1.75)	
Other vs. arthroplasty	1.24 (0.83–1.86)	
Unknown vs. arthroplasty	1.15 (0.68–1.97)	
None vs. arthroplasty	1.14 (0.75–1.73)	
Serious adverse event		Overall: 0.18
Trauma vs. arthroplasty	1.02 (0.80–1.31)	
Other vs. arthroplasty	1.02 (0.80–1.30)	
Unknown vs. arthroplasty	1.18 (0.87–1.60)	
None vs. arthroplasty	0.98 (0.77–1.26)	
Prosthetic joint infection		Overall: **0.02**
Trauma vs. arthroplasty	3.77 (0.91–8.37)	0.07
Other vs. arthroplasty	4.06 (1.46–11.33)	**0.01**
Unknown vs. arthroplasty	3.69 (1.11–12.27)	**0.03**
None vs. arthroplasty	3.42 (1.20–9.74)	**0.02**
	OR (95% CI)	**P**
Discharged to facility postoperatively		Overall: **0.04**
Trauma vs. arthroplasty	1.34 (0.96–1.88)	0.09
Other vs. arthroplasty	1.26 (0.91–1.74)	0.17
Unknown vs. arthroplasty	1.46 (0.95–2.24)	0.08
None vs. arthroplasty	1.43 (1.02–1.99)	**0.03**
Use of ambulatory devices postoperatively		Overall: 0.11
Trauma vs. arthroplasty	0.45 (0.04–5.05)	
Other vs. arthroplasty	0.90 (0.01–9.01)	
Unknown vs. arthroplasty	0.48 (0.03–7.95)	
None vs. arthroplasty	0.19 (0.02–1.63)	

Other, fellowship not in trauma or arthroplasty; Unknown, unknown fellowship status; None, no fellowship training.
Significance = $P < 0.05$.
CI, confidence interval; HR, hazard ratio; OR, odds ratio.

TABLE 2. Association Between Fellowship Training and HEALTH Outcomes in HA Patients

Outcome	HR (95% CI)	P
Unplanned secondary procedure		Overall: 0.14
Trauma vs. arthroplasty	0.78 (0.36–1.65)	
Other vs. arthroplasty	1.39 (0.63–3.08)	
Unknown vs. arthroplasty	0.91 (0.45–1.84)	
None vs. arthroplasty	0.34 (0.12–0.95)	
Dislocation		Overall: 0.54
Trauma vs. arthroplasty	0.50 (0.12–2.01)	
Other vs. arthroplasty	0.66 (0.13–3.44)	
Unknown vs. arthroplasty	0.60 (0.16–2.24)	
None vs. arthroplasty	0.58 (0.13–2.52)	
Death		Overall: 0.15
Trauma vs. arthroplasty	1.39 (0.69–2.77)	
Other vs. arthroplasty	2.12 (0.99–4.54)	
Unknown vs. arthroplasty	1.85 (0.97–3.54)	
None vs. arthroplasty	1.49 (0.71–3.15)	
Serious adverse event		Overall: 0.39
Trauma vs. arthroplasty	0.87 (0.67–1.39)	
Other vs. arthroplasty	1.31 (0.86–2.00)	
Unknown vs. arthroplasty	0.90 (0.63–1.29)	
None vs. arthroplasty	0.86 (0.57–1.28)	
Prosthetic joint infection		Overall: 0.20
Trauma vs. arthroplasty	1.69 (0.31–9.26)	
Other vs. arthroplasty	2.57 (0.42–15.52)	
Unknown vs. arthroplasty	3.48 (0.75–16.14)	
None vs. arthroplasty	2.03 (0.36–11.37)	
	OR (95% CI)	**P**
Discharged to facility postoperatively		Overall: 0.15
Trauma vs. arthroplasty	1.49 (0.92–2.39)	
Other vs. arthroplasty	2.21 (1.21–4.03)	
Unknown vs. arthroplasty	1.57 (0.98–2.52)	
None vs. arthroplasty	1.47 (0.89–2.44)	
Use of ambulatory devices postoperatively		Overall: 0.73
Trauma vs. arthroplasty	1.22 (0.07–19.92)	
Other vs. arthroplasty	0.72 (0.04–11.79)	
Unknown vs. arthroplasty	0.91 (0.01–13.09)	
None vs. arthroplasty	0.57 (0.06–5.79)	

Other, fellowship not in trauma or arthroplasty; Unknown, unknown fellowship status; None, no fellowship training.
Significance = $P < 0.05$.
CI, confidence interval; HR, hazard ratio; OR, odds ratio.

and surgeons, our results are more generalizable to the entire population.

Although there is an overall scarcity of literature focusing specifically on fellowship training and correlation with surgical outcomes in the treatment of hip fractures, there have been numerous studies examining outcomes about surgeon volume. Ames et al compared HA for hip fracture outcomes in surgeons in relation to their yearly volume. The study team divided the surgeons ranging from no volume (0 cases/year) to high volume (25+ cases/year).[14] When comparing no volume with high volume, this group found that the high-volume group had significantly lower rates of mortality, dislocation, and superficial infection. Revision surgery rates were significantly higher for the high-volume surgeons compared with no-volume surgeons; however, this may simply be due to the fact that the high-volume surgeons were more comfortable in performing revision surgeries. Nonetheless, these findings were likely not observed in our study due to the fact that more than 95% of the surgeons who participated in the HEALTH trial met the threshold for surgical expertise.[13,15] Very few, if any, of the HEALTH trial surgeons are low-volume surgeons in regard to arthroplasty.

TABLE 3. Association Between Fellowship Training and HEALTH Outcomes in THA Patients

Outcome	HR (95% CI)	P
Unplanned secondary procedure		Overall: 0.29
Trauma vs. arthroplasty	1.44 (0.63–3.28)	
Other vs. arthroplasty	0.84 (0.24–2.92)	
Unknown vs. arthroplasty	1.81 (0.86–3.80)	
None vs. arthroplasty	1.38 (0.66–2.89)	
Dislocation		Overall: 0.98
Trauma vs. arthroplasty	1.10 (0.40–3.06)	
Other vs. arthroplasty	0.75 (0.16–3.45)	
Unknown vs. arthroplasty	1.25 (0.49–3.22)	
None vs. arthroplasty	0.95 (0.37–2.44)	
Death		Overall: 0.81
Trauma vs. arthroplasty	1.06 (0.59–1.90)	
Other vs. arthroplasty	0.59 (0.23–1.49)	
Unknown vs. arthroplasty	0.86 (0.48–1.55)	
None vs. arthroplasty	1.01 (0.61–1.69)	
Serious adverse event		Overall: 0.52
Trauma vs. arthroplasty	1.08 (0.76–1.54)	
Other vs. arthroplasty	0.95 (0.59–1.52)	
Unknown vs. arthroplasty	1.17 (0.85–1.63)	
None vs. arthroplasty	1.08 (0.79–1.46)	
Prosthetic joint infection		Overall: **0.04**
Trauma vs. arthroplasty	3.94 (0.92–16.81)	0.06
Other vs. arthroplasty	4.54 (0.91–22.64)	0.06
Unknown vs. arthroplasty	4.00 (0.98–16.33)	0.053
None vs. arthroplasty	4.49 (1.20–16.81)	**0.03**
	OR (95% CI)	**P**
Discharged to facility postoperatively		Overall: 0.26
Trauma vs. Arthroplasty	1.25 (0.76–2.06)	
Other vs. Arthroplasty	0.92 (0.50–1.69)	
Unknown vs. Arthroplasty	0.99 (0.62–1.57)	
None vs. Arthroplasty	1.43 (0.93–2.22)	
Use of ambulatory devices postoperatively		Overall: 0.13
Trauma vs. Arthroplasty	1.90 (0.01–20.09)	
Other vs. Arthroplasty	2.10 (0.03–19.87)	
Unknown vs. Arthroplasty	1.87 (0.05–18.91)	
None vs. Arthroplasty	1.89 (0.07–19.54)	

Other, fellowship not in trauma or arthroplasty; Unknown, unknown fellowship status; None, no fellowship training.
CI - confidence interval, HR - hazard ratio, OR - odds ratio
Significance = $p < 0.05$

Another difference noted in our study was a higher odds of discharge to a facility rather than home postoperatively for cases performed by nonarthroplasty–fellowship-trained surgeons. This finding may be explained by the utilization of standardized "care pathways" by arthroplasty-trained surgeons with their hip fracture patients. Many arthroplasty surgeons use these evidence-based algorithms for their elective arthroplasty cases to optimize patient care and ultimately improve outcomes and reduce cost.[16–19] Previous studies have substantiated the implementation of these pathways because they significantly decrease both cost and length of stay.[20] In addition, the data show that these pathways lead to a higher rate of discharge to home.[21] Arthroplasty surgeons using their "care pathways" despite these cases not being a part of their elective practice may explain this group's higher rate of discharge to home postoperatively. Given the data supporting the use of these pathways for elective joint arthroplasty patients, the authors advocate for utilization of these pathways in hip fracture patients as well.

There are several limitations to this study. Given that the HEALTH trial was international, there were numerous surgeons where details regarding surgical training were particularly difficult to ascertain. This was challenging for some of the surgeons in Europe, partially because of a language barrier and a lack of hospital web sites clearly displaying the surgeon's training history. This created a large "unknown fellowship" group that may have included surgeons with subspecialized training. In addition, the surgeons labeled as "no fellowship" may be somewhat misleading and imply that these surgeons are not specialized in one area or lack expertise. In this study, completion of fellowship was used as an objective marker of "expertise" in a specific subspecialty. Regardless of completing a fellowship, many orthopaedic surgeons focus on specific areas of practice. Some more senior surgeons did not complete a fellowship because fellowship training was not as common as it is today; these surgeons are still "experts" in their field. As such, this may have skewed the data because some surgeons may have been "misrepresented" if their training information could be not obtained or if they did not complete a fellowship.

Our study supports that arthroplasty for hip fracture can be performed by all orthopaedic surgeons with no difference in reoperation rates at 2 years. The authors advocate for the utilization of the most current infection prevention strategies and standardized care pathways when treating these patients. The surgeons performing these procedures, regardless of fellowship training, should remain up-to-date on the current operative and postoperative recommendations in caring for these patients.

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