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Original Research

Perioperative Outcomes of Intramedullary Nail vs Hemiarthroplasty vs Total Hip Arthroplasty for Intertrochanteric Fracture: An Analysis of 31,519 Cases

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A B S T R A C T

Background: The purpose of this study is to compare 30-day perioperative outcomes following treatment of intertrochanteric (IT) fractures with intramedullary nail (IMN), total hip arthroplasty (THA), or hemiarthroplasty (HA).

Methods: Using the National Surgical Quality Improvement Program database, we conducted a retrospective cohort study of patients who had sustained an IT fracture treated with primary IMN, THA, or HA between 2017 and 2020. International Classification of Diseases, 10th Revision codes S72.141-S72.146, subtypes A through C, were used to identify eligible patients and were cross-referenced to primary Current Procedural Terminology codes, used to identify the following procedure types: 27245: IMN; 27130: THA; and 27236: HA. Revision cases and patients who underwent arthroplasty for osteoarthritis were excluded. Outcomes of interest included reoperation, readmission, operative time, length of stay, and major and minor complications. Multivariate regression was used to evaluate differences in postoperative outcomes between groups.

Results: There were 29,809 IT fractures treated with IMN (94.6%), 1493 treated with HA (4.7%), and 217 treated with THA (0.70%). There was a statistically significant increase in 30-day reoperation rates (adjusted odds ratio [aOR] = 1.99 [95% confidence interval = 1.51, 2.63], $P < .001$) when combining all arthroplasty patients compared to IMN. There was no statistically significant difference in the overall complication rate between IMN (13.58%) and HA (14.60%, aOR = 1.09, $P = .315$) or THA (11.98%, aOR = 1.00, $P = .998$). When compared to IMN (0.12%), there was a statistically significantly decreased need for transfusion in the HA group (aOR = 0.71 [95% confidence interval = 0.61, 0.80], $P < .001$).

Conclusions: Primary HA is associated with an increased 30-day reoperation rate and decreased need for blood transfusion, but there were no other significant differences in postoperative morbidity identified among IMN, THA, and HA in the treatment of IT fractures. Given the challenges and inferior outcomes associated with conversion arthroplasty, the lack of significant difference in morbidity between the 3 groups suggests that primary arthroplasty may be a safe and viable treatment option in selected patients with IT fractures. Comparative studies with longer clinical follow-up will be necessary to establish the appropriate indications and further evaluate the clinical outcomes of primary arthroplasty in the treatment of IT fractures.

Introduction

Geriatric hip fractures continue to become increasingly prevalent, carrying significant morbidity, mortality, and associated costs to the healthcare system [1]. The incidence of hip fractures has been projected to reach 6 million per year globally by the year 2050 [2,3].

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Intertrochanteric (IT) hip fractures account for 50% of all hip fractures, with reported mortality rates of up to 20%-30% within the first postoperative year and 24%-34% of patients being unable to return to their preinjury function [4-8]. Intramedullary nail (IMN) fixation has become the predominant treatment option used to treat IT fractures; however, screw cutout, malunion, and nonunion are relatively common, however, with reported rates as high as 10% [9-16]. Furthermore, unstable IT fracture patterns, such as Orthopaedic Trauma Association/Association of the Study of Internal Fixation 31-A2 and 31-A3, have been shown to have inferior outcomes, increased complications, and higher failure rates than stable fracture patterns when surgically managed with intramedullary fixation [17].

Primary total hip arthroplasty (THA) traditionally has been avoided in treating such fractures given technical challenges such as stem fixation and complications associated with arthroplasty (dislocation, infection, bone loss, etc.). Yet there is interest in primary hip arthroplasty as a treatment option for those patients with IT fractures, as fixation failure may be as high as 9.6% following IMN and outcomes following conversion arthroplasty may be inferior to outcomes after primary arthroplasty in these patients [18,19]. Smith et al. analyzed 56,522 patients who had undergone conversion THA following failed IMN for IT fracture and found that the conversion THA group had a longer length of stay (LOS) compared to those who underwent primary THA [20]. Additionally, in a small retrospective propensity-matched analysis, Lee et al. found that operative times, blood loss, and intraoperative fractures are all increased in the conversion arthroplasty setting when compared to primary arthroplasty in the treatment of IT fractures [21]. Factors that led to the technical challenges of conversion arthroplasty following IMN include poor bone stock, distorted soft tissue, broken hardware, and nonunion [12].

The American College of Surgeons National Surgical Quality Improvement Program (NSQIP) is a multi-institutional outcomes database that collects information on outcomes and factors contributing to perioperative complications for patients undergoing surgical procedures in the United States [22,23]. It consists of validated, risk-adjusted data on 30-day postoperative events, such as patient morbidity, mortality, reoperation, and readmission on more than 900,000 patient cases annually [24]. Thus, this outcome-based database has become popular in the recent orthopaedic literature, as it allows for the analysis of risk-adjusted outcomes for multiple types of orthopaedic procedures, such as meniscectomy or femoral neck fixation [25,26].

The purpose of this study is to compare the 30-day postoperative outcomes following treatment of IT hip fractures with IMN, primary THA, or hemiarthroplasty (HA), using the NSQIP database. We hypothesize that there is no difference in covariate-adjusted rates of postoperative complications and surgical outcomes between patients treated with IMN, THA, and HA.

Material and methods

We conducted a retrospective cohort study with the use of the NSQIP database. This study was Institutional Review Board−exempt. The NSQIP database was initially queried for patients who had sustained an IT femur fracture between 2017 and 2020 and were treated with IMN, THA, or HA, using the International Classification of Diseases, 10th Revision (ICD-10) codes. ICD-10 codes S72.141-S72.146, subtypes A through C, were used to identify patients aged more than 65 years who sustained IT hip fractures. Identified patients were cross-referenced to primary Current Procedural Terminology (CPT), which was used to identify the following procedure types: 27245: IMN, 27130: THA, and 27236: HA (Table 1). To isolate patients treated with primary THA, we included only patients with CPT code 27130 who did not have a concurrent "Removal of implant, deep" procedure. Similarly, to isolate patients treated with primary HA, we included only patients with CPT code 27236 who did not have a concurrent "Removal of implant, deep" procedure. Patients with ICD-10 code subtypes D through S were excluded as these represented revision cases. Patients who lacked the corresponding ICD and CPT codes or underwent THA and HA for osteoarthritis were excluded.

Patient demographic data, such as age, sex, height, weight, smoking status, diabetes, preoperative functional status (independent, partially dependent, totally dependent), and American Society of Anesthesiologists (ASA) score (1, 2, 3, ≥ 4) were extracted from NSQIP. Operative time was defined as the time from the first incision to closure. LOS was defined as the number of days from surgery to hospital discharge. Readmission was defined as readmission to the hospital within 30 days of the primary surgical procedure. Reoperation was defined as an unplanned return to the operating room within 30 days of the index procedure. Reason for reoperation was not specified within the database. Major complications included in the analysis were sepsis, septic shock, pulmonary embolism, myocardial infarction, cardiac arrest requiring cardiopulmonary resuscitation, and stroke with neurological deficit. Minor complications included wound dehiscence, superficial surgical site infection (SSI), deep SSI, urinary tract infection, and deep vein thrombosis (DVT). The NSQIP database defines superficial SSI as an infection only involving the skin or subcutaneous tissue of the surgical incision, and deep SSI as an infection that involves the deep soft tissues of the surgical incision (such as the fascial and muscular layers).

Statistical analysis was conducted using R Data Analysis Software. Continuous variables were recorded as mean and standard deviation. Categorical variables were recorded as counts and proportions. Following the identification of patient demographics, analysis of variance and chi-squared tests were used to identify any baseline differences among the IMN, THA, and HA cohorts. Multivariate regression was used to evaluate differences in postoperative outcomes between the 3 groups. Statistical significance was set to $P < .05$. Covariates included in the regression models included age, sex, body mass index (BMI), smoking status, diabetes, functional status, and ASA score.

Results

Demographics

Overall, 31,519 IT fractures met the inclusion criteria. There were 29,809 IT fractures treated with IMN (94.6%), 1493 treated with HA (4.7%), and 217 treated with THA (0.70%). Patient demographics are presented in Table 2. There were 28,204 displaced IT fractures, 2726 nondisplaced IT fractures, and 589 IT fractures of unspecified displacement. There was a statistically significant lower mean age in the THA cohort at baseline (79.4 $\pm$ 7.6 years) compared to the IMN (82.7 $\pm$ 7.2 years, $P < .001$) and HA groups (82.8 $\pm$ 7.2 years, $P < .001$). Across all patients, there was a higher percentage of female patients (69.1%, $P < .01$). There was also a statistically significant greater percentage of females in the IMN group compared to the HA cohort (IMN: 71.2%; HA: 67.7%; $P = .007$). The overall mean BMI was 24.8 $\pm$ 5.9, with a statistically significant greater baseline BMI found in the THA cohort (26.3 $\pm$ 6.19) compared to the IMN (24.8 $\pm$ 5.9, $P = .001$) and HA cohorts (24.8 $\pm$ 5.8, $P = .001$). There was a lower proportion of patients with ASA score ≥ 4 among the THA cohort (13.8%) compared to the IMN (21.6%, $P = .002$) and HA cohorts (22.6%, $P = .003$). There was a statistically significantly lower proportion of patients within the THA cohort who were functionally dependent (1.8%) compared to patients within the IMN (3.8%, $P = .004$) and HA cohorts (3.2%, $P = .045$). There were no statistically

Table 1
ICD-10 codes and fracture pattern descriptions.

ICD code	Fracture pattern description
S72.141	Displaced intertrochanteric fracture of right femur, initial encounter
S72.141A	for closed fracture
S72.141B	for open fracture type I or II
S72.141C	for open fracture type IIIA, IIIB, or IIIC
S72.142	Displaced intertrochanteric fracture of left femur, initial encounter
S72.142A	for closed fracture
S72.142B	for open fracture type I or II
S72.142C	for open fracture type IIIA, IIIB, or IIIC
S72.143	Displaced intertrochanteric fracture of unspecified femur, initial encounter
S72.143A	for closed fracture
S72.143B	for open fracture type I or II
S72.143C	for open fracture type IIIA, IIIB, or IIIC
S72.144	Nondisplaced intertrochanteric fracture of right femur, initial encounter
S72.144A	for closed fracture
S72.144B	for open fracture type I or II
S72.144C	for open fracture type IIIA, IIIB, or IIIC
S72.145	Nondisplaced intertrochanteric fracture of left femur, initial encounter
S72.145A	for closed fracture
S72.145B	for open fracture type I or II
S72.145C	for open fracture type IIIA, IIIB, or IIIC
S72.146	Nondisplaced intertrochanteric fracture of unspecified femur, initial encounter
S72.146A	for closed fracture
S72.146B	for open fracture type I or II
S72.146C	for open fracture type IIIA, IIIB, or IIIC

significant baseline differences in diabetes or smoking status between all 3 cohorts.

Operative time

There was a statistically significant increase in operative time with THA (99.3 ± 2.2 minutes) compared to IMN (54.5 ± 0.89 minutes, $P < .001$) and HA (67.0 ± 0.89 minutes, $P < .001$) after adjusting for covariates (Fig. 1). Across all groups, an increase in operative time was associated with an increase in BMI (0.63 ± 0.03 minutes per point, $P < .01$).

Length of stay

When unadjusted for age, BMI, sex, diabetes, smoking, ASA status, and functional status, there was a statistically significant decrease in postoperative LOS with THA (4.89 ± 4.44 days) compared to IMN (5.41 ± 4.66 days, $P < .001$) and HA (5.60 ± 4.90 days, $P < .001$). However, there was no significant difference in covariate-adjusted means of LOS (THA = 3.66 ± 0.29 days, HA = 3.70 ± 0.12 days, $P = .71$; IMN = 3.66 ± 0.54 days, $P = .99$) (Fig. 2). Across all groups, increases in LOS were associated with age (0.012 ± 0.004 days per year, $P < .001$), insulin-dependent diabetes (0.53 ± 0.09 days, $P < .001$), male gender (0.34 ± 0.087 days, $P < .001$), smoking (0.34 ± 0.087 days, $P < .001$), functional status (partially dependent 0.42 ± 0.06 days, $P < .01$), and ASA score ≥ 4 (1.01 ± 0.43 days, $P < .01$).

Readmission

Overall, there were 2796 readmissions (8.02%). When compared to IMN, there was no difference in adjusted readmission rates with

Table 2
Patient demographics by implant type.

Patient demographics	Overall (n = 31,519)	IMN (n = 29,809)	THA (n = 217)	HA (n = 1493)	*P* value
Age (y)	82.7 ± 7.2	82.7 ± 7.2	79.4 ± 7.6	82.8 ± 7.2	**<.001**
Sex					
Female, n (%)	22,380 (69.1%)	21,223 (71.2%)	146 (67.3%)	1011 (67.7%)	**.0073**
Male	9139 (30.9%)	8586 (28.8%)	71 (32.7%)	482 (32.3%)	
Body mass index	24.8 ± 5.9	24.8 ± 5.9	26.3 ± 6.2	24.8 ± 5.8	**.0026**
Diabetes					.88
Nondiabetic	25,459 (80.8%)	24,062 (80.7%)	175 (80.7%)	1222 (81.9%)	
Noninsulin-dependent diabetic	3593 (11.4%)	3408 (11.4%)	25 (11.5%)	160 (10.7%)	
Insulin-dependent diabetic	2467 (7.8%)	2339 (7.9%)	17 (7.8%)	111 (7.4%)	
Smoking status					.62
Nonsmoker	28,366 (90.0%)	26,829 (90.0%)	199 (91.7%)	1338 (89.6%)	
Smoker	3153 (10.0%)	2980 (10.0%)	18 (8.3%)	155 (10.4%)	
ASA					**.011**
ASA 1	111 (0.4%)	107 (0.4%)	1 (0.5%)	3 (0.2%)	
ASA 2	4488 (14.2%)	4228 (14.2%)	47 (21.7%)	213 (14.3%)	
ASA 3	20,104 (63.8%)	19,026 (63.8%)	139 (64.1%)	939 (62.9%)	
ASA 4/5	6816 (21.6%)	6448 (21.6%)	30 (13.8%)	338 (22.6%)	
Functional status					**.0036**
Independent	23,767 (75.4%)	22,420 (75.2%)	185 (85.3%)	1162 (77.8%)	
Partially dependent	6329 (20.1%)	6028 (20.2%)	27 (12.4%)	274 (18.4%)	
Totally dependent	1169 (3.7%)	1117 (3.8%)	4 (1.8%)	48 (3.2%)	
Unknown	254 (0.8%)	244 (0.8%)	1 (0.5%)	9 (0.6%)	

Bolded values indicate statistical significance at $P < .05$.

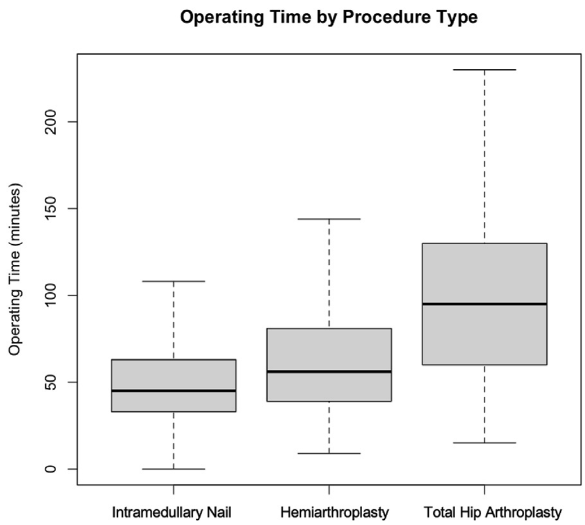

Figure 1. Operating time (unadjusted) by procedure type. The center line of each box plot represents the median, with the upper and lower margins of the box defining the interquartile range. The whiskers were set at a distance above and below the box equal to 1.5 multiplied by the interquartile range. Outliers were excluded from this boxplot.

HA (8.3%, adjusted odds ratio [aOR] = 1.08, $P = .48$) or THA (6.9%, aOR = 0.89, $P = .78$) (Table 3). Significant covariate predictors of readmission included age (aOR = 1.02 [95% confidence interval {CI} = 1.01, 1.03], $P < .001$), male sex (aOR = 1.20 [95% CI = 1.09, 1.31], $P < .001$), insulin-dependent diabetes (aOR = 1.47 [95% CI = 1.27, 1.69], $P < .001$), functional status (partially dependent aOR = 1.17 [95% CI = 1.06, 1.30], $P < .001$), and ASA score (ASA score 3 aOR = 1.54 [95% CI = 1.33, 1.79], $P < .001$; ASA score ≥ 4 aOR = 1.96 [95% CI = 1.66, 2.31], $P < .01$).

Thirty-day reoperation rate

There were 549 reoperations overall (1.72%) within 30 days of the primary surgical procedure. When compared to IMN, there was a statistically significant increase in the aOR for reoperation in the HA group (aOR = 2.17 [95% CI = 1.6, 2.95], $P < .001$), but no significant difference in the THA group (aOR = 1.50 [95% CI = 0.61, 3.67], $P = .375$) (Table 3 and Fig. 3). Smoking was the only significant covariate associated with reoperation within 30 days (aOR = 1.34 [95% CI = 1.01, 1.77], $P = .046$). There was a statistically significant increase in 30-day reoperation rates (aOR = 1.99 [95% CI = 1.51, 2.63], $P < .001$) when combining all arthroplasty patients compared to IMN. This was the only statistically significant difference found when pooling all arthroplasty patients compared to IM.

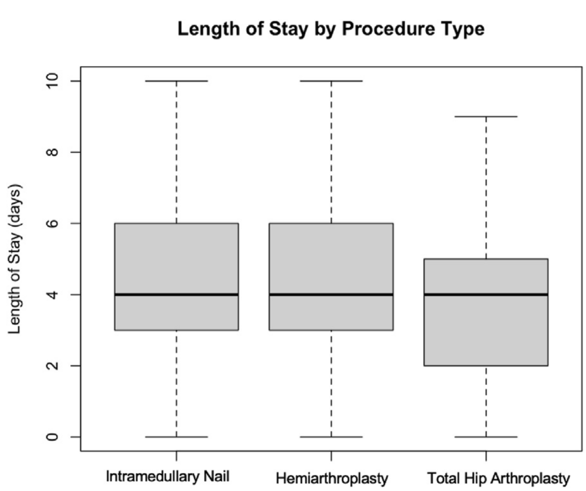

Figure 2. Length of stay (unadjusted) by procedure type. The center line of each box plot represents the median, with the upper and lower margins of the box defining the interquartile range. The whiskers were set at a distance above and below the box equal to 1.5 multiplied by the interquartile range. Outliers were excluded from this boxplot.

Transfusion requirement

Overall, 9492 cases (30.12%) required at least 1 transfusion. When compared to IMN, there was a statistically significantly decreased need for transfusion in the HA group (aOR = 0.71 [95% CI = 0.61, 0.80], $P < .001$), and no significant difference in the THA group (aOR = 0.86 [95% CI = 0.62, 1.19], $P = .359$) (Table 3 and Fig. 4). Significant covariate predictors of the need for transfusion included age (aOR = 1.03 [95% CI = 1.02, 1.03], $P < .001$), female sex (aOR = 1.39 [95% CI = 1.30, 1.47], $P < .001$), smoking (aOR = 1.27 [95% CI = 1.15, 1.39], $P < .001$), insulin-dependent diabetes (aOR = 1.21 [95% CI = 1.1, 1.34], < .001), partially dependent functional status (aOR = 1.20 [95% CI = 1.12, 1.27], $P < .001$), and ASA score (ASA score 3 aOR = 1.44 [95% CI = 1.33, 1.56], $P < .001$; ASA score ≥ 4 aOR = 1.66 [95% CI = 1.52, 1.83], $P < .01$).

Complications

Multivariate analysis results for complications are presented in Table 3. When compared to IMN (1.15%), there was no statistically significant difference in adjusted DVT rates with HA (0.94%, aOR = 0.67, $P = .20$) or THA (0.46%, aOR = 0.41, $P = .37$). The only significant covariate predictor of DVT was increased BMI (aOR = 1.02 [95% CI 1.00, 1.04], $P = .02$). When compared to IMN (0.75%), there was no statistically significant difference in the rate of pulmonary embolism with HA (0.54%, aOR = 0.49, $P = .115$) or THA (0.65%, aOR = 0.65, $P = .67$). When compared to IMN (0.70%), there was no statistically significant difference in the adjusted rate of superficial SSI with HA (0.87%, aOR = 1.37, $P = .293$) or THA (0%, $P = .96$). Significant covariate predictors of superficial SSI included BMI (aOR = 1.03 [95% CI = 1.01, 1.06], $P = .003$), fully dependent functional status (aOR = 1.88 [95% CI = 1.03, 3.43], $P = .04$), and ASA score (ASA score 3 aOR = 1.76 [95% CI = 1.04, 2.99], $P = .036$; ASA score ≥ 4 aOR = 2.42 [95% CI = 1.36, 4.29], $P = .003$). When compared to IMN (0.12%), there was a statistically significant increase in the aOR of deep SSI with HA (0.33%, aOR = 3.08, $P = .02$). There was no statistically significant difference when compared to THA (0%, $P = .99$), and no significant covariate predictors. There was no statistically significant difference in the overall complication rate between IMN (13.58%) and HA (14.60%, aOR = 1.09, $P = .315$) or THA (11.98%, aOR = 1.00, $P = .998$). There was also no statistically significant difference in major complication rate (IMN 6.03%; HA 7.23%, aOR = 1.18, $P = .32$; THA 5.07%, aOR = 1.04, $P = .90$) or minor complication rate (IMN 9.54%; HA 10.11%, aOR = 1.18, $P = .315$; THA 8.76%, aOR = 1.04, $P = .90$) between the groups.

Discussion

This study used the NSQIP database to compare 30-day outcomes following the operative management of 31,519 IT fractures with IMN, THA, or HA. When pooled together, those who underwent primary THA or HA had increased reoperation rates within 30 days of the primary surgical procedure compared to those treated with IMN. Furthermore, patients treated with primary HA for an IT fracture were likely to have an increased risk of reoperation and decreased need for transfusion within 30 days of the operation compared to IMN. Finally, those treated with primary THA were

Table 3
Multivariate analysis for complications, IMN vs THA vs HA.

Variable	IMN	THA	HA	aOR (IMN vs THA)	*P* value	aOR (IMN vs HA)	*P* value
Readmission	8.01%	6.91%	8.31%	0.89	.78	1.08	.48
Reoperation	1.65%	2.30%	3.42%	1.5	.375	2.17	**<.001**
Need for transfusion	30.48%	23.50%	23.78%	0.86	.359	0.71	**<.001**
Overall complications	4048 (13.6%)	26 (12.0%)	218 (14.6%)	1.09	.99	1.09	.32
Major complications (total)	1796 (6.0%)	11 (5.1%)	108 (7.2%)	1.04	.9	1.18	.13
Pulmonary embolism	228 (0.76%)	1 (0.46%)	8 (0.54%)	0.65	.67	0.49	.12
Deep incisional infection	37 (0.12%)	0 (0%)	5 (0.33%)	0	.99	3.08	**.02**
Minor complications (total)	2843 (9.5%)	19 (8.8%)	151 (10.1%)	1	.99	1.07	.46
Deep vein thrombosis	348 (1.2%)	1 (0.46%)	14 (0.93%)	0.41	.37	0.67	.2
Superficial incisional infection	210 (0.70%)	0 (0%)	13 (0.87%)	0	.96	1.37	.29

Confidence interval values in parentheses. Bold numbers indicate statistical significance.

likely to experience longer operative times, but similar postoperative LOS, readmission, reoperation, blood transfusion rates, and overall medical complication rates to those treated with IMN or HA. Given the largely similar outcomes between the 3 procedures evaluated in this analysis, the present study suggests that THA or HA can be viable index procedures in the management of IT fractures even without underlying arthritis. Future studies with longer follow-up periods and robust clinical outcome data (patient-reported outcome scores, reoperation data including reason for reoperation, etc.) should further evaluate this question.

Lee et al. found that operative time, perioperative blood loss, amount of blood transfused, and risk of iatrogenic fracture were all increased in the conversion arthroplasty cohort compared to primary arthroplasty cohort, with an average follow-up time of 3 years [21]. Challenges such as compromised bone quality, difficult surgical dissection due to scar tissue and adhesions, demanding hardware removal, and sclerotic bone may lead to these problems. Primary arthroplasty can also help the surgeon avoid IMN-specific complications such as anterior cortex perforation, lag screw cut out, varus collapse, and nonunion, which may be more likely in challenging cases such as unstable fracture patterns [27].

The reoperation rate was found to be higher for patients treated with pooled arthroplasty compared to IMN. When separating out the arthroplasty cases, the reoperation rate was higher for patients treated with HA (3.42%) when compared to IMN (1.65%) at 30 days, even after adjusting for covariates (aOR = 2.17, $P < .01$) (Table 3). Surgeon training may be one explanation for the relatively worse reoperation rate in HA when compared to THA. Fellowship-trained arthroplasty surgeons are likely to have improved outcomes when performing arthroplasty compared to nonarthroplasty surgeons [28]. It is possible that the proportion of THAs performed by fellowship-trained arthroplasty surgeons was higher than the proportion of HAs performed by fellowship-trained arthroplasty surgeons. The proportion of THA and HA performed by fellowship-trained arthroplasty surgeons is not recorded in the NSQIP database. Another potential reason could be that those treated with HA had a higher associated risk of deep SSI compared to IMN and THA. Of note, only 5 of the 51 reoperations that occurred with HA were due to deep SSI. Our findings differ from those of the meta-analysis performed by Nie et al., which found a higher reoperation rate with IMN (OR 7.06, 95% CI: 3.24-15.36, $P < .001$) vs arthroplasty across 735 IT fractures [15]. The mean follow-up of 22.2 months in their study may have captured a greater proportion of conversion arthroplasties in the IMN group that would not have been captured at 30 days.

In our study of 31,519 patients, there was a decreased need for blood transfusion in the HA group when compared to the IMN group. Furthermore, we found no difference in transfusion need between IMN and THA, and there was a decreased need in HA cohort. In a prospective study, Kim et al. compared IMN to arthroplasty in a cohort of 58 patients with unstable IT fractures, and found a greater rate of transfusion in the IMN group [27]. Conversely, in a retrospective review, Ucpunar et al. showed that patients with unstable IT fractures treated with HA were more likely to experience greater blood loss and a higher need for blood transfusion, compared to those treated with a nail [6]. In another retrospective study on 70 patients aged more than 70 years with IT fracture, Cai et al. showed that intraoperative blood loss and blood transfusions were higher in the HA cohort. They also found that overall postoperative blood loss and transfusion rates were similar between the 2 groups [29]. Although blood loss can be considerable in hip arthroplasty surgery [30], reaming is more likely to result in greater blood loss than arthroplasty [31]. In general, factors contributing to blood loss in IT fractures include higher BMI, older age, fracture type, poor baseline health, and pre-existing anemia; however, such factors were controlled in our study [32]. One

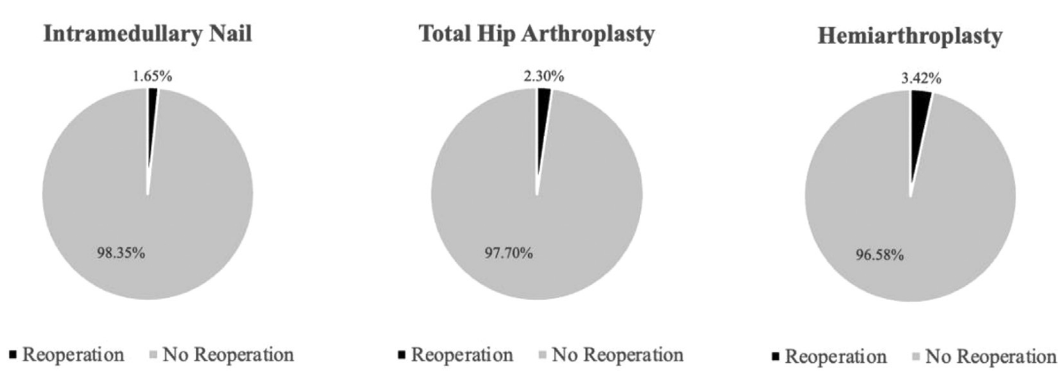

Figure 3. Reoperation rate (adjusted) by procedure.

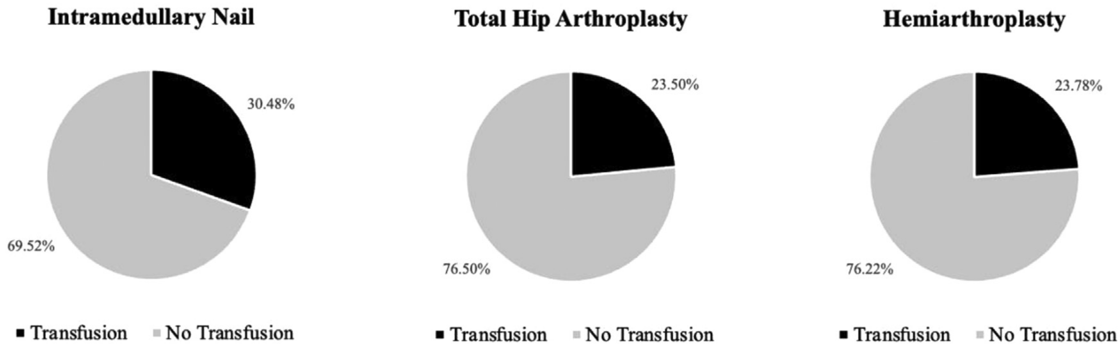

Figure 4. Need for transfusion rate (adjusted) by procedure.

explanation for our finding could be that intramedullary instrumentation with sequential reaming for IMN fixation results in greater endosteal bleeding than broaching [33]. Factors that require a greater amount of reaming, such as femurs with smaller intramedullary canal diameters, may be associated with increased bleeding [34]. In a retrospective study, Wang et al. showed there was an average of 473 mL of hidden blood loss after treatment of 122 extra-articular tibial fractures with IMN. The diameter of the medullary canal at the narrowest part of the long bone was negatively correlated to hidden blood loss, supporting the explanation that smaller medullary canals may require more reaming, influencing blood loss [34]. Although in our study we were unable to retrospectively assess the diameter of the medullary canal or the number of sequential reaming in patients treated with IMN, it is possible that this may have contributed to additional blood loss in the IMN cohort compared to HA.

Limitations

There are several limitations to this study. The subjectivity in assigning CPT codes and the plethora of possible codes to choose from can result in numerous inconsistent codes among physicians when evaluating the same cases [35,36]. Determining the correct CPT code and consistently assigning the proper code to a procedure can be challenging; thus, the NSQIP database is inherently limited due to the need for more standardization. Additionally, NSQIP coding may be subject to bias, as different reimbursements are associated with each code. Furthermore, it is impossible to determine from NSQIP whether every code was accurately input during each case. In this present analysis, the CPT code 27236 was used for HA, as it denotes HA for hip fracture and sliding hip screw for femoral neck fracture (FNF) [35,37]. Although other codes may be assigned when elective hip HA is performed, the American Medical Association guidelines state “for prosthetic replacement following fracture of the hip, use 27236” [38]. Although all FNFs were excluded from the study cohort to ensure that only 27,236 arthroplasty cases were included, it is still possible that cases including FNF or treatment with sliding hip screw were included in the analysis.

Our investigation carries the limitations of the large national database, including the absence of granularity such as implant selection, reason for reoperation, injury pattern, pre-existing arthrosis, indications for surgery, and more. Thus, findings in this study may be influenced by selection bias and potential confounding variables that were not included in the multivariate analysis. Previous studies have demonstrated that patients undergoing primary arthroplasty were more likely to have $\geq$ 3-part IT fractures, severe osteoporosis (Singer index $\geq$ 4), or loss of posteromedial cortical buttress [21], and it is possible that primary arthroplasty patients included in our analysis had similar indications.

Second, NSQIP is limited to 30 days postoperatively, thereby limiting the ability to project outcomes beyond that short timeframe. Key challenges with IMN as previously discussed are implant failure, malunion, and nonunion with resultant functional limitations. The majority of these complications may not be captured within 30 days. Likewise, key complications such as infection and instability following arthroplasty are commonly studied with at least 90-day follow-up. While variables such as operative time, LOS, readmission, and medical complications are effectively evaluated in the present analysis, longer follow-up in future analyses will improve evaluation of reoperation rate and complications.

Additionally, the NSQIP database does not distinguish prosthetic joint infections from other infections within the “deep SSI” category (ie, wound infections involving muscle or fascia). Finally, we were unable to identify which cases were performed by fellowship-trained arthroplasty surgeons, surgeons trained in other subspecialty fellowships, or nonfellowship-trained surgeons. There may be a difference in perioperative outcomes of the 3 studied treatment modalities, in proportion to surgeon type.

Conclusions

Primary HA is associated with an increased 30-day reoperation rate and decreased need for blood transfusion, but there were no other significant differences in postoperative morbidity identified among IMN, THA, and HA in the treatment of IT fractures. Given the challenges and inferior outcomes associated with conversion arthroplasty, the lack of significant difference in morbidity between the 3 groups suggests that primary arthroplasty may be a safe and viable treatment option in selected patients with IT fractures. Comparative studies with longer clinical follow-up will be necessary to establish the appropriate indications and further evaluate the clinical outcomes of primary arthroplasty in the treatment of IT fractures.

Conflicts of interest

The authors declare there are no conflicts of interest.

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CRediT authorship contribution statement

Natalia Czerwonka: Writing – review & editing, Writing – original draft, Validation, Supervision, Project administration, Investigation, Formal analysis, Data curation. **Sohil S. Desai:** Writing – review & editing, Validation, Supervision, Software, Investigation, Formal analysis. **Puneet Gupta:** Writing – review & editing, Resources, Data curation. **Roshan P. Shah:** Writing – review & editing. **Jeffrey A. Geller:** Writing – review & editing. **H. John Cooper:** Writing – review & editing. **Alexander L. Neuwirth:** Writing – review & editing, Supervision, Project administration, Methodology, Data curation, Conceptualization.

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