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Research Article

Intramedullary Nailing of Femur Fractures in the Obese: A Retrospective Comparison of Patients with Normal Weight versus the Obese

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Abstract

Objectives: To compare retrograde and antegrade intramedullary nailing in obese patients at a single level one trauma center relative to normal and overweight patients with respect to perioperative variables.

Design: Single center retrospective review.

Setting: University medical center (level one trauma center).

Patients/Participants: A total of 121 consecutive patients were studied (84 in the antegrade group and 37 in the retrograde group) with breakdown of 46 normal weight, 39 overweight, and 36 obese.

Intervention: Antegrade and retrograde intramedullary nailing of femoral shaft fracture.

Main Outcome Measurements: Patient and fracture characteristics, prep time, operative time, fluoroscopy time, and estimated blood loss were evaluated.

Results: Statistical differences were only in the antegrade group where increasing body mass index was related to average increase in prep time (10 minutes; P = 0.08), operative time (56 minutes; P = 0.0003), and estimated blood loss (80 mL; P = 0.08).

An increase in body mass index of 2 kg/m^2 for the antegrade group was associated with a mean increase of 1.2 minutes prep time, 5.9 minutes operative time, and 7.5 mL estimated blood loss. Retrograde group values were 1.9 minutes, 1.2 minutes, and 7.4 mL, respectively.

Conclusion: Obese patients had statistically higher operative times for antegrade intramedullary nailing while retrograde intramedullary nailing permits easier percutaneous execution and indirect reduction resulting in a decreased operative time.

Keywords: Femur; Fracture; Intramedullary; Nailing; Obese

Abbreviations

AG: Antegrade; RG: Retrograde; IMN: Intramedullary Nailing; BMI: Body Mass Index; EBL: Estimated Blood Loss; PCL: Posterior Cruciate Ligament; OTA: Orthopaedic Trauma Association; SD: Standard Deviation

Introduction

Obesity is a national epidemic with over 30% of the US adult population between the ages of 24-70 classified as obese [1]. The rate of obesity in America has increased by about 50% per decade over the past 20 years [2]. With these trends, the numbers of obese trauma patients that seek care will likely rise. Obese patients are at a higher risk for a number of postoperative complications and may exhibit a different set of injuries compared to normal weight patients [3-7].

Femoral shaft fractures are recognized as high energy, potentially life-threatening injuries that usually result from blunt force trauma. Intramedullary Nailing (IMN) is the standard of care with the nail introduced in an Antegrade (AG) or Retrograde (RG) fashion based on indications and ease in identifying the anatomical starting point [8]. AG IMN involves using a canal entry point just medial to the greater trochanter in the piriformis fossa while RG IMN involves an entry point anterior to the Posterior Cruciate Ligament (PCL) in the trochlea of the distal femur [9,10]. Tucker et al [4] conducted a prospective multicenter study to evaluate differences in operative time and functional outcome of obese and non-obese patients undergoing IMN for femur fracture. Although insertion of the intramedullary nail through an entry point in the piriformis fossa is the most commonly accepted method, their results suggest that RG IMN of femur fractures may be preferred for obese patients due to lower operative time compared to AG IMN [4]. This has also been suggested by other authors who have concluded that identifying the bony landmarks necessary for the safe and efficient placement of an AG nail through the piriformis fossa may be prohibitively difficult in the obese patient population [11-13]. This difficulty is not insignificant when compared to the ease of finding the distal femur starting point for retrograde

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nailing in the same obese population.

The purpose of this study was to evaluate the perioperative differences in caring for obese, overweight, and normal weight patients sustaining a femur fracture at a single level one trauma center. Elucidating these differences in the obese trauma patient may lead to more effective treatment modalities and algorithms to improve the outcome for this segment of our population. This study is unique in that this medical facility is the only regional trauma referral center in one of the most obese states in the country [1]. As such it allows for the unique opportunity of having a large volume of patients treated within a single institution trauma protocol (Advanced Trauma Life Support). Therefore this study represents the largest reported series of obese patients with a femur fracture treated at a single institution and aims to contribute to the discussion of antegrade versus retrograde nailing in the literature which is relatively sparse especially when considering the effect of obesity on key perioperative variables.

Materials and Methods

The study was approved by the university's institutional review board. Procedures on patients treated with terminology codes for IMN of the femur were queried. The query period included the dates between January 2005 and December 2007. During this time, 261 femur fractures were seen and evaluated. Inclusion criteria for further study included ages between 16 and 75 years, an isolated mid shaft femur fracture that could be classified as a 32 by the AO/Orthopaedic Trauma Association (OTA) comprehensive classification of fractures [14] and operative treatment of this injury using a reamed, statically locked IMN. Exclusion criteria included patients whose age was outside of the previously established age range, patients with femur fractures that were more appropriately classified as proximal (subtrochanteric or peritrochanteric [AO/OTA 31]) or distal (supracondylar [AO/OTA 33]) femur fractures, multi-trauma patients with additional injuries treated under the same anesthetic, fractures treated with plate fixation, cephalomedullary nails and intramedullary nails placed without reaming the femoral canal, and dynamically locked intramedullary nails and AG intramedullary nails that were inserted through an entry point other than the piriformis fossa.

If definitive fixation of the femur fracture in question could not be performed immediately, the patient was placed into skeletal traction until operative stabilization could be carried out. All fractures were treated with the Titanium Cannulated Retrograde/Antegrade Femoral EX nails (Synthes USA, West Chester, Pennsylvania). AG nails were inserted with a piriformis fossa starting position. RG nails were inserted using a transpatellar tendon approach and an intercondylar starting point anterior to the origin of the posterior cruciate ligament. Investigational variables were patient body mass index, prep time, operative time, fluoroscopy time, estimated blood loss (EBL), and nail insertion point. Weight classes were defined as normal weight (BMI < 25 kg/m^2), overweight (BMI ≥ 25 kg/m^2 and < 30 kg/m^2) and obese (BMI ≥ 30 kg/m^2) as defined by the Centers for Disease Control and Prevention [1]. Patient height and weight measurements were taken directly from each patient's emergency department documentation or the information contained in the preoperative evaluation. Prep time was defined as the number of minutes from the patient's entry into the operating room until surgical incision, and included the time needed to safely anesthetize a patient, place the appropriate operative monitoring devices, suitably position the patient, and sterilize the affected extremity with multiple bactericidal solutions. Operative time was defined as the number of minutes from the time of initial incision to the time at which the postoperative dressings were applied. EBL in our institution is clinically calculated by postoperatively measuring the volume of fluid in the operative suction canister and subtracting the volume of any fluids used as irrigation. These values were obtained from the anesthesia record.

Data analysis was conducted using SAS 9.1 (SAS Institute, Cary, NC). Descriptive data are presented as mean ± the standard deviation or percentage, as appropriate. Association between surgical variables and BMI was analyzed using linear regression, without and with adjustment for age and sex to reduce the variability for comparison. Group differences were analyzed using one-way ANOVA/ANCOVA, with post hoc tests of pairwise differences in group means. All P-values are two-sided, and an alpha level of 0.05 was used to judge statistical significance.

Results

A total of 121 patients met the inclusion criteria. One patient was excluded as an outlier with an excessive estimated blood loss (1,300 mL), leaving a study population of 120 patients. The average age was 30 years (SD 13.3 years, minimum of 16 years, maximum of 71 years) and 73% of the patients were male. The mean BMI was 28.1 kg/m^2 (SD 7.5 kg/m^2, minimum of 17.8 kg/m^2, maximum of 68.1 kg/m^2); 30% were obese, 32% overweight, and 38% normal weight. The obese group had a higher percentage of females (38.9% vs. 15.8% in the overweight group and 26.1% in the normal weight group) and a higher average age (33.8 years vs. 30.0 years in the overweight group and 27.2 years in the normal weight group).

The majority of the fractures (68%) were caused by blunt force trauma, usually as a result of a motor vehicle collision. Gunshot wounds (13%) and falls (10%) caused the rest. Eighty-four patients (70%) received an AG femoral nail and 36 (30%) were treated with a RG nail. In the obese group, 58.3% received an AG nail and 41.7% an RG nail, compared to 76.1% AG and 23.9% RG in the normal weight group. The breakdown in the overweight group was similar to that in the normal weight group: 73.7% received an AG nail and 26.3% an RG nail.

Overall the mean prep time was 56.2 minutes (SD 22.7 minutes, minimum of 10.0 minutes, maximum of 157.0 minutes), the mean operative time was 140.7 minutes (SD 50.2 minutes, minimum of 60.0 minutes, maximum of 345.0 minutes), and the mean EBL was 206.5 mL (SD 139.9 mL, minimum of 30.0 mL, maximum of 750.0 mL). The mean values for the surgical parameters in each weight group are shown in Table 1 (crude (unadjusted)) and Figure 1 (multivariable-adjusted for age and sex to reduce the variability for comparison).

In all weight groups (with two exceptions) the mean prep and operative times were lower, and the mean EBL was less, in the RG group than the AG group (Table 2). The exceptions were the operative times in the normal weight group and the prep time in the overweight group were both slightly higher in the RG group. The operative time exception is due to the fact that as BMI decreases, AG operative time decreases while RG operative time remains relatively constant. Thus

Table 1: Characteristics of study population by weight group.

	Normal weight		Overweight		Obese	
BMI, kg/m^2	21.9 (2.0)		27.5 (1.6)		36.7 (7.3)	
Min., max.	17.8, 24.9		25.1, 29.9		30.2, 68.1	
Age, years	27.2 (12.8)		30.0 (13.0)		33.8 (13.6)	
Females, %	26.1		15.8		38.9	
Surgical method, %						
AG IMN	76.1		73.7		58.3	
RG IMN	23.9		26.3		41.7	
Surgical parameters	Crude (unadjusted)	Adjusted for age/sex/method	Crude (unadjusted)	Adjusted for age/sex/ method	Crude (unadjusted)	Adjusted for age/sex/ method
Prep time, mins.	50.3 (20.0)	48.9	59.3 (24.6)	57.8	60.6 (23.1)	60.9
Operative time, mins.	130.2 (38.6)	123.1	127.6 (41.8)	120.4	168.1 (60.8)	165.8
Fluoroscopy time, secs.	197.5 (97.8)	186.7	168.5 (64.4)	154.6	177.9 (68.7)	170.2
EBL, mL	186.3 (113.4)	151.0	200.0 (153.8)	158.9	239.3 (152.5)	224.4

All values are mean (SD) or %, unless indicated otherwise.

Characteristics of study population by weight group, including body mass index, age, gender, and surgical method. Average crude and adjusted values for surgical parameters by weight group, including prep time, operative time, fluoroscopy time, and estimated blood loss. BMI: Body Mass Index; EBL: Estimated Blood Loss; SD: Standard Deviation

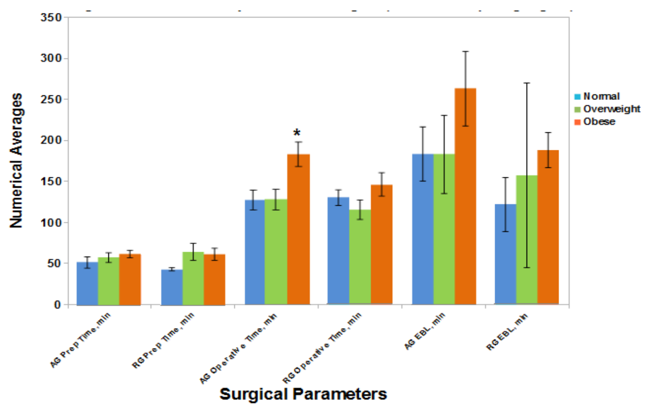

Figure 1: Multivariate-adjusted mean surgical parameters by weight group. Surgical parameters on x-axis (horizontal) with weight group means broken down by antegrade (AG) and retrograde (RG). Numerical values of means on y=axis (vertical). EBL: Estimated Blood Loss; * denotes significance.

the two times approach one another yielding negligible differences in operative times between the two approaches in the normal BMI group. Regardless of BMI, differences in prep time for both approaches are negligible because this variable is influenced very little by surgical approach. None of these differences were statistically significant.

The effect of increasing BMI on the surgical parameters differed slightly according to surgical method (Table 2). In the AG group, but not in the RG group, increasing BMI was directly related to increasing prep time (P = 0.08), operative time (P = 0.0003) and higher EBL (P = 0.08). In the AG group an increase in BMI of 2 kg/m^2 (about 13.5 pounds in an average 1.75m/80 kg man and 11.5 pounds in an average 1.60m/70kg woman) was associated with an average increase of 1.2 minutes for prep time (P = 0.08), 5.9 minutes for operative time (P = 0.0003), and 7.5 mL in EBL (P = 0.08). The corresponding values for the RG group were 1.9 minutes (P = 0.17), 1.2 minutes (P = 0.62), and 7.4 mL (P = 0.16), respectively.

In patients receiving AG nails the average increases were approximately 56 minutes for operative time, 10 minutes for prep time, and 80 mL for EBL in the obese group compared to the normal weight group. The difference in operative time was statistically significant (P = 0.0002). In patients receiving RG nails, only EBL tended to increase across weight groups. The mean EBL was approximately 64 mL higher in the obese group than in the normal weight group. However, this difference did not reach statistical significance nor is it considered clinically significant. To elucidate the comparison between AG nailing versus RG nailing in the obese weight group, the difference in operative time was 36.4 minutes showing that on average RG IMN reduces operative time.

In comparing perioperative variables for AG versus RG across weight groups, the obese group showed a decrease in operative time with RG IMN that was significant (P = 0.02) while the overweight and normal weight groups did not have statistically significant differences in operative times. There were no significant differences among the other weight groups when comparing AG IMN with RG IMN for the other perioperative variables.

Discussion

Significance of perioperative variables

The most clinically significant of the variables is operative time, which also exhibited statistical significance in our study. The importance of operative time can be appreciated when considering the expense and patient morbidity related to surgical treatment options. Surgical intervention translates into precious operating room time. There is a small yet growing body of literature specifically analyzing the effects of obesity on perioperative variables such as the ones addressed in this study. Improved surgical operations can follow from better estimates of operative time which influence surgical expense [15]. More importantly, operative time correlates with increased patient morbidity when considering the possibility of infections [16].

Effects of BMI on perioperative variables

Patients in the obese group had an average operative time that was nearly one hour longer than patients in the normal weight group.

Table 2: Surgical parameters by weight group and surgical method.

	Normal weight		Overweight		Obese		P value for trend	Post-hoc P value: Obese vs. Normal weight	P value for weight group*method interaction
	Crude (unadjusted)	Age/sex-adjusted	Crude (unadjusted)	Age/sex-adjusted	Crude (unadjusted)	Age/sex-adjusted			
Prep Time									
AG	52.0	51.0	57.9	56.5	61.0	61.0	0.08	0.28	0.50
RG	44.8	42.8	63.2	62.4	59.9	60.5	0.15	0.39	
P-value	0.30373		0.71832		0.89343				
Operative time									
AG	130.8	127.1	133.6	128.0	185.3	183.0	0.0003	0.0002	0.24
RG	128.2	131.2	110.7	115.8	144.0	146.6	0.39	0.99	
P-value	0.84545		0.06561		0.02000				
EBL									
AG	204.3	184.1	216.1	184.7	279.8	264.0	0.08	0.15	0.86
RG	129.1	120.7	155.0	155.3	182.7	184.6	0.16	0.51	
P-value	0.10537		0.75289		0.06				

Surgical parameters by weight group and surgical method, including prep time, operative time, fluoroscopy time, and estimated blood loss. Includes p-values for trend, weight group *method interaction, and post-hoc p-values for obese vs. normal weight groups. AG: Antegrade; RG: Retrograde; EBL: Estimated Blood Loss.

This increase in operative time in the obese group can be attributed to additional challenges imposed by a large body habitus, including difficulty in locating the piriformis starting point and limits imposed by the instrumentation utilized in AG IMN. In contrast, use of the more accessible starting point of the intercondylar notch in RG IMN corresponds to easier percutaneous execution and more easily managed indirect reduction techniques for midshaft and distal femur fractures. This was shown via similar operative times across all three weight groups receiving RG IMN regardless of BMI.

Discussion of other works and current standards of care

A previous study by Ostrum regarding IMN in lipomatous patients addressed the greater trochanteric insertion site [10]. The results support the greater trochanteric approach due to its effectiveness and lack of complications. Being overweight and exhibiting trochanteric lipodystrophy were indications for this insertion site.

Concordant with our results, McKee and Waddell's study followed seven morbidly obese patients (BMI > 37 kg/m^2) who underwent AG IMN. They found these patients had longer surgical times, increased blood loss, difficult starting points, and iatrogenic fractures [17]. Tucker et al also reported on IMN and obesity with 151 patients prospectively enrolled from four different level one trauma centers [4]. They found that AG IMN in the obese patient was associated with a 52% longer operative time and 79% greater radiation exposure when compared to the normal weight patient. Tucker et al also demonstrated that AG femoral nailing was associated with 40% longer operative times and three times the radiation exposure compared to RG femoral nailing in the same obese population. These authors proposed that difficulty in percutaneously finding either the piriformis fossa or the tip of the greater trochanter for AG femoral nailing was the key factor responsible for increased surgical time.

Additionally, the difficulties associated with indirect reduction techniques for proximal and midshaft femur fractures in thighs with larger girths may contribute to the increased AG operative times. Our study supports the aforementioned findings and fails to support our initial hypothesis that in obese patients there is a negligible difference between perioperative variables associated with repair of femur fractures treated with antegrade versus retrograde techniques when performed by surgeons experienced in treating and operating on obese patients.

RG IMN was initially utilized widely for the treatment of ipsilateral femoral shaft and femoral neck fractures, but has gained popularity in the treatment of distal femur fractures in a variety of clinical settings [4,17,18]. The relative indications have grown to include femur fractures of any pattern in the distal third of the femur, poly-trauma patients, patients with ipsilateral pelvic and acetabular trauma, pregnant patients, patients with "floating knee" injury patterns, periprosthetic distal femur fractures, and more recently, obese patients [3,19-21].

With the increasing use of RG IMN, the risks of postoperative anterior knee pain have become quite evident [3,20,21]. Additionally, it should be noted that there is an appreciable incidence of idiopathic knee pain in the obese population [22-25]. It may be reasonably concluded that although RG IMN may be technically easier and faster than the AG approach, especially in the obese population, this technique may potentiate the development of postoperative anterior knee pain. Therefore, when assessing the risk to benefit profile of AG vs. RG IMN, the potential for developing postoperative knee pain must be considered as a factor. In regards to patient age, there is data to support that a decrease in postoperative knee function correlates with increasing age regardless of the approach used in treatment [26].

The incidence of knee pain after IMN of femoral shaft fractures has been noted by Ricci et al [21]. In patients treated with the retrograde approach, knee pain was significantly greater. With the antegrade approach, hip pain was greater. Therefore the consideration of complications from pain should be made when evaluating the method of intervention.

Study limitations

The results of this investigation should be viewed within the context of its limitations. The variability in attending and surgical resident technique and skill also plays a role that cannot be retrospectively controlled. Several attending surgeons were involved with the surgeries. The small sample size of patients that underwent RG IMN decreases the power of the study while the higher percentage of RG IMN in patients who were obese demonstrates surgeon preference.

A power analysis conducted using the mean and standard deviation of the current study demonstrated that a total sample size of 141 patients with RG IMN would be required in order to achieve 80% power at alpha of 0.05 and to detect statistically significant differences between the three BMI groups. A power analysis was not undertaken at the beginning of this study because no data comparing the three BMI groups with respect to the perioperative variables was available at that time. However, this study presents the largest series of patients from a single institution, which increases the reliability of its data due to the uniformity of the methods utilized.

Short-term outcomes are emphasized in this study. Patients were not followed up to determine long-term effects of treatment on outcome. However, there is data to support that clinical outcomes from AG and RG treatments are similar with regard to range of motion and isokinetic knee evaluation [26].

Conclusion

Compared to the RG method, AG nailing of femur fractures in obese patients is a technically more demanding surgery whose difficulty results in greater operative time, prep time, and EBL. RG IMN, by contrast, can be performed with operative metrics that are similar across all BMI groups. Although the RG approach may represent an easier technique for the general orthopaedic surgeon, enthusiasm for this approach should be tempered by the potentially unacceptable risk of postoperative knee pain and resulting decrease in functional knee scores.

In order to facilitate surgeons making more informed procedural choices between AG and RG IMN, larger prospective investigations are needed to further evaluate postoperative functional outcomes and objective pain scores for both techniques in obese patients. The results of the current study demonstrate that trauma surgery in the obese patient generally results in greater expenditures of care and increased perioperative variables than in the normal weight patient.

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