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Brief Report

Influence of Bone Cement Augmentation on Complications in Cephalomedullary Nail Fixation of Geriatric Intertrochanteric Hip Fractures

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ABSTRACT

Introduction. The purpose of this study was to determine if augmentation of the helical blade with polymethylmethacrylate bone cement decreases the rates of varus cut-out and medial perforation in geriatric intertrochanteric hip fracture fixation.

Methods. This was a retrospective comparative cohort study at two urban Level I trauma centers. Patients with an intertrochanteric hip fracture (classified as AO 31A1-3) who were treated with the TFN-Advanced Proximal Femoral Nailing System (TFNA) from 2018 to 2021 were eligible for the study. Medical records and post-operative radiographs were reviewed to determine procedure complications and reoperations.

Results. Of the 179 patients studied, cement augmentation (CA) was used in 93 patients (52%) and no cement augmentation (NCA) was used in 86 (48%). There were no significant differences between group demographics and fracture reduction grades. Varus cut-out occurred three times in the CA group and five times in the NCA group ($p = 0.48$). Medial perforation occurred three times, all in the NCA group ($p = 0.11$). The most frequent complication was symptomatic blade lateralization from fracture collapse, with eight occurrences in the CA group compared with two in the NCA group ($p = 0.10$). There were 10 reoperations in the CA group and 9 in the NCA group ($p = 0.99$). The most common reason for reoperation was varus cut-out and the most common revision procedure was hip arthroplasty.

Conclusions. Intertrochanteric hip fractures treated with the TFNA fixation system with and without cement augmentation have similar complication profiles and reoperation rates.

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INTRODUCTION

A well-known but uncommon surgical complication of cephalomedullary nail (CMN) fixation of low impact geriatric intertrochanteric (IT) proximal femur fractures is collapse of the femoral head/neck with varus cut-out of the lag screw or helical blade.[1-5] The helical blade was designed to achieve superior stability over traditional lag screws in CMN fixation through impaction of the cancellous bone within the femoral head.[6] However, some studies have indicated that there may be an increased rate of cut-out with helical blades as compared to lag screws.[2,3] Moreover, a complication unique to the helical blade is perforation of the medial femoral head without loss of fracture reduction.[1]

To decrease the rates of varus cut-out and other major complications, augmentation of the helical blade with cement injected through the blade into the cancellous bone of the femoral head has been proposed. Although biomechanical[7,8] and clinical[9-11] studies have demonstrated promising results with this technique, the issue as to whether cement augmentation significantly decreases surgical complication or failure rates is unsettled.[12,13] The aim of this study was to identify major (requiring operative intervention) and minor (not requiring surgery) complications in elderly patients who underwent CMN fixation of IT femur fractures, comparing the complication and reoperation rates of those who had cement augmentation (CA) with those who had no cement augmentation (NCA).

METHODS

We designed a retrospective comparative cohort study involving patients at two Level I trauma centers. Using Current Procedural Terminology code 27245, we identified all patients who underwent CMN fixation of IT femur fractures from 2018 to 2021. Operative reports and intraoperative flouroscopy images were reviewed to confirm the TFN-Advanced Proximal Femoral Nailing System (TFNA) manufactured by DePuy Synthes (West Chester, PA) was used for fixation. The fractures were classified based on preoperative radiographs and/or computed tomography according to the Arbeitsgemeinschaft für Osteosynthesefragen (AO) and Orthopaedic Trauma Association (OTA) system as AO/OTA 31-A type fractures.

Fracture fixation proceeded according to standard surgical technique. The decision to use polymethylmethacrylate (PMMA) bone cement augmentation was based on surgeon preference, considering the fracture reduction and the patient's bone quality at the time of surgery. No objective measures of bone mineral density were used in the decision-making process. Injected cement volume varied from 1 mL to 8 mL of PMMA and was determined by fluoroscopic evaluation of cement spread during injection. Intraoperative fluoroscopy was used to measure the tip-apex distance, the quality of fracture reduction,[14] cement spread, and cement extrusion.

Post-operatively, patients were allowed to weight bear as tolerated without hip precautions. Clinic records and post-operative anteroposterior and cross-table lateral radiographs of the hip were reviewed to identify complications and determine how these complications were addressed. Patients were included if they had a minimum follow-up of 10 weeks or if hip radiographs were performed 10 weeks or more after surgery.

Our primary outcome measures were the rates of varus cut-out and medial perforation of the helical blade. Varus cut-out was defined as any collapse of the fracture into varus resulting in blade migration

within the femoral head necessitating revision surgery or any varus collapse in which the blade penetrated the intra-articular space. Medial perforation was defined as medial migration of the blade without loss of fracture reduction or collapse of the helical blade, causing penetration of the articular surface. Secondary outcome measures included other complications such as implant failure, periprosthetic fracture, nonunion, malunion, avascular necrosis, fracture collapse resulting in a symptomatic prominent lateral blade, superficial wound infection, or deep wound infection.

Study data were collected and managed using the Research Electronic Data Capture (REDCap) system.[15,16] Descriptive statistics were used to summarize all data. Continuous variables were assessed for normality and reported as means and standard deviations or medians and interquartile ranges. Categorical data were reported as frequencies and percentages. Patient demographics and baseline characteristics of participants were compared by group using t-tests. Fisher's exact tests were employed to examine the association between categorical variables using a 2x2 cross-tabulation. All analyses were conducted using two-sided tests with alpha level of .05 in IBM SPSS Statistics version 29.

RESULTS

There were 179 cases meeting inclusion criteria for the study, 93 (52%) in the CA group and 86 (48%) in the NCA cohort. No statistically significant differences were found between the groups in terms of age at time of surgery, body mass index (BMI), biologic sex, smoking status, American Society of Anesthesiologists (ASA) scores, comorbidities, or mechanism of fracture (Table 1). The most often reported ASA score was 3.

Table 1. Patient demographics and clinical characteristics as a function of cement augmentation.

	Cement Augmentation Used?				
	Yes = CA		No = NCA		
Demographics	**n = 93**	**52%**	**n = 86**	**48%**	**p**
Mean, standard deviation (sd)	*mean (sd)*		*mean (sd)*		
Age at time of surgery, yr	82.4 (8.2)		82.1 (7.9)		0.821
Height, cm	165.3 (10.7)		165.9 (11.2)		0.738
Weight, kg	67.0 (15.0)		72.0 (17.0)		0.068
BMI, range 16.1 to 41.0	24.5 (4.9)		25.9 (5.0)		0.064
Frequency and percentage	*n*	*%*	*n*	*%*	
Biological sex					0.422
Female	67	72.0	57	66.3	
Male	26	28.0	29	33.7	
Smoking status					0.216
Smoker	12	12.9	8	9.3	
Nonsmoker	56	60.2	42	48.8	
Former smoker	19	20.4	27	31.4	
unknown	6	6.5	9	10.5	
ASA score					0.188
One	0	0	1	1.2	
Two	16	17.2	11	12.8	
Three	64	68.8	68	79.1	
Four	13	14	6	7	
Co-morbidities					
Diabetes mellitus	22	23.7	27	31.4	0.314
Osteoporosis	14	15.1	13	15.1	0.999
Prior fragility fracture	6	6.5	6	7.0	0.999
Mechanism of fracture					0.109
Low energy (fall from standing)	93	100	83	96.5	
High energy (MVC)	0	0	3	3.5	

Note: Continuous data were evaluated by group using t-tests for equality of means. Categorical data were evaluated by group using Fisher's Exact tests.

There were no significant differences in hip laterality, fracture classification, fracture reduction grades, and tip-apex distance (Table 2). CMN length differed significantly between groups with the most common length reported as intermediate. Cement extrusion was rare, occurring only twice, once through the femoral head and once through the fracture site.

Table 2. Hip laterality, pre- and post-operative radiographic findings as a function of cement augmentation.

	Cement Augmentation Used?				
	Yes = CA		No = NCA		
Description	**n = 93**	**52%**	**n = 86**	**48%**	**p**
Frequencies and percentages	*n*	*%*	*n*	*%*	
Hip laterality					0.456
Left	41	44.1	43	50.0	
Right	52	55.9	43	50.0	
Fracture classification					0.309
AO 31A1	32	34.4	35	40.7	
AO 31A2	44	47.3	42	48.8	
AO 31A3	17	18.3	9	10.5	
Nail length					<0.001
Short	11	11.8	28	32.6	
Intermediate	77	82.8	58	67.4	
Long	5	5.4	0	0.0	
Fracture reduction grade					0.554
Good	75	80.6	73	84.9	
Acceptable	18	19.4	13	15.1	
Mean, standard deviation (sd)	*mean (sd)*		*mean (sd)*		
Tip-apex distance	23.6 (5.4)		22.1 (5.6)		0.075

AO31A1: simple peritrochanteric, lateral wall >20.5mm
AO31A2: multifragmentary peritrochanteric, lateral wall incompetent < 20.5mm
AO31A3: intertrochanteric with reverse obliquity
Categorical data were evaluated by group using Fisher's Exact tests.
Continuous data were evaluated by group using t-tests for equality of means.

Procedure complications and reoperations did not differ significantly between the cohorts (Table 3). Fifteen patients in the CA group experienced 19 complications, whereas for the NCA group, 16 patients had 16 complications.

Table 3. Procedure complications and reoperations as a function of cement augmentation.

	Cement Augmentation Used?				
	Yes = CA		No = NCA		
Description	**n = 93**	**52%**	**n = 86**	**48%**	**p**
Complications	*n*	*%*	*n*	*%*	
Varus cut-out	3	3.2	5	5.8	0.484
Medial perforation	0	0.0	3	3.5	0.109
Implant failure	0	0.0	1	1.2	0.480
Periprosthetic fracture	1	1.1	0	0.0	0.990
Nonunion	1	1.1	1	1.2	0.990
Malunion	1	1.1	3	3.5	0.352
Avascular necrosis	3	3.2	0	0.0	0.247
Symptomatic blade lateralization	8	8.6	2	2.3	0.102
Deep wound infection	2	2.2	1	1.2	0.990
Reoperations	*n*	*%*	*n*	*%*	
Arthroplasty	4	4.3	4	4.7	0.990
Revision nail	0	0.0	2	2.3	0.229
Revision of blade only	4	4.3	2	2.3	0.684
Irrigation and debridement	2	2.2	1	1.2	0.990

More than one type of complication may have occurred in each patient. Results shown compared those who reported "yes" to a specific complication type against those who reported "no" and were tested using Fisher's exact test.

Regarding the primary outcome measures, there were eight cases of varus cut-out, three in the CA group and five in the NCA group. Medial perforation occurred three times, all in the NCA cohort. The most frequently reported complication was a symptomatic lateralized blade from fracture collapse; eight cases in the CA group and two cases in the NCA group.

There were 19 reoperations; 10 in the CA group and 9 in the NCA group. The most common reoperation was revision of the CMN to total hip arthroplasty.

DISCUSSION

In our study of geriatric IT fractures treated with CMN fixation, we were unable to demonstrate any statistically significant difference in post-operative complication rate or reoperation rate between the CA and NCA cohorts. We did not examine other outcome metrics.

Some clinical studies have demonstrated good results with CA. For example, at an average follow-up of four months, Kammerlander et al.[10] reported no cases of varus cut-out, medial blade perforation, unexpected blade migration, implant loosening or breakage in a series of 59 patients who underwent PMMA augmentation of Proximal Femoral Nail Antirotation CMN fixation. This group of researchers also reviewed the same patient cohort at 15 months, reporting a complication rate of 3% with none of the complications being related to CA.[9] However, both studies lacked a control group without CA for comparison.

In a retrospective review of patients who underwent CMN fixation with and without CA, Goodnough et al.[12] noted a 6% rate of cut-out and a 9% reoperation rate in their cohort with all adverse outcomes occurring in the non-cemented group. However, the study was limited by small sample size (11 cemented, 33 non-cemented), and the investigators were unable to demonstrate a significant difference between the groups. In a similar study of 76 patients (47 cemented, 29 non-cemented) at minimum six month follow-up, Yee et al.[11] showed a significantly lower rate of fixation failure and no instances of varus cut-out in the CA group. There were three cases of varus cut-out and one case of medial perforation in their non-cemented group, while none were noted in the cemented group.

In a randomized control trial of 253 patients, Kammerlander et al.[13] reported that no patient in the CA group suffered mechanical failure, but six failures were noted in the non-augmented group. Although this difference failed to achieve statistical significance, the study suggested that CA may prevent reoperations due to mechanical failure by creating a stronger osteosynthesis construct. We agree with their recommendation for a large-scale randomized controlled clinical trial to further investigate the utility of CA in CMN fixation.[13]

Limitations. Our study had limitations, including its retrospective design and relatively short follow-up duration. Additionally, the decision to use CA was not standardized but left to the surgeon's discretion based on intraoperative assessment of bone density and fracture reduction. Consequently, there was a strong bias towards using bone cement augmentation in patients with osteoporotic bone. This limitation could be addressed in a future study on CA by incorporating objective measures of bone mineral density.

CONCLUSIONS

This retrospective comparative cohort study of geriatric intertrochanteric hip fractures treated with the DePuy Synthes TFNA fixation system found no significant differences in complications or reoperations between cases with CA and those without. The traumatologists in this study continue to use CA in osteoporotic bone settings, as PMMA may help reduce CMN fixation failure, but they await more definitive studies.

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