Data-driven improvement of hip fracture care

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THE CLOCKWISE TORQUE OF SLIDING HIP SCREWS: IS THERE A RIGHT SIDE?

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Journal of Orthopaedic Trauma
2020 Nov;34:S76-S80

3

ABSTRACT

Objectives: This study evaluated whether patients with a left-sided femoral neck fracture (FNF) treated with a sliding hip screw (SHS) had a higher implant failure rate than patients treated for a right-sided FNF. This was done in order to determine the clinical relevance of the clockwise rotational torque of the femoral neck screw in a SHS, in relation to the rotational stability of left and right-sided FNFs after fixation.

Methods: Data were derived from the FAITH trial and Dutch Hip Fracture Audit (DHFA). Patients with a FNF, aged ≥50, treated with a SHS, with at least three-month follow-up data available, were included. Implant failure was analyzed in a multivariable logistic regression model adjusted for age, sex, fracture displacement, pre-fracture living setting and functional mobility, and ASA Class

Results: 1750 patients were included, of which 944 (53.9%) had a left-sided and 806 (46.1%) a right-sided FNF. Implant failure occurred in 60 cases (3.4%), of which 31 were left and 29 right-sided. No association between fracture side and implant failure was found (Odds Ratio (OR) for left versus right 0.89, 95% Confidence Interval (CI) 0.52 – 1.52). Female sex (OR 3.02, CI 1.62 – 6.10), using a mobility aid (OR 2.02, CI 1.01 – 3.96) and a displaced fracture (OR 2.51, CI 1.44 - 4.42) were associated with implant failure.

Conclusion: This study could not substantiate the hypothesis that the biomechanics of the clockwise screw rotation of the SHS contributes to an increased risk of implant failure in left-sided FNFs compared to right-sided fractures.

INTRODUCTION

Despite the fact that fixation techniques have been modernized over the years, failure rates in femoral neck fractures (FNF), especially in the displaced ones, remain as high as 20-40%. [1,2] Some of these failures can be attributed to avascular necrosis of the femoral head, whereas in others fracture collapse or true implant failure cause a breakdown of the bone-implant construct. [1–4] In many cases however, it is not clear which of the underlying factors contribute most to construct failure. It is, therefore, not without reason that the FNF is still described as the 'unsolved' fracture. [5,6]

Patient and fracture-related factors that influence failure rates have been thoroughly examined. The fracture type- or pattern seems to be one of the most critical determinants of the failure of the bone-implant construct. [7,8] Could it be, despite all the research on the topic, that we are overlooking or underestimating the influences of the biomechanics of the implant?

A study using radiostereometric analysis (RSA) showed that right-sided trochanteric fractures seemed to be more stable compared to left-sided trochanteric fractures after fixation with a sliding hip screw (SHS). [9] It was hypothesized that the clockwise rotational torque in the sagittal plane during placement of the screw may contribute to a potentially more unstable construct in left-sided trochanteric fractures compared to right-sided fractures. [10] It is during the screw insertion that clockwise rotational torque is imparted to the head-neck fragment, which in left-sided trochanteric fractures may cause flexion in the hip and extension of the fracture site, leading to a potentially unstable construct. [10] These biomechanical theories and findings suggest that the risk of implant failure is higher in left-sided trochanteric fractures fixated with a SHS compared to right-sided trochanteric fractures. A similar biomechanical theory has been described for lateral FNFs. [11] To our knowledge, no evidence or theories have yet been published to support or deny this suggestion for FNFs.

Although there are obvious biomechanical differences between trochanteric hip fractures and FNFs, we hypothesize a similar instability in the bone-implant construct in left compared to right-sided FNFs. Not only during insertion, but also during cyclic loading, eccentric forces may result in the femoral head and neck rotating around the lag screw [12,13]. As the patterns of the resulting torques at the fracture site are opposite for left and right hips, resistance to these cyclic torques by the screw thread is also opposite as the screw thread is always clockwise. A dorsocaudally applied load over the left femoral head may therefore cause micromovement with backward rotation of the femoral head and subsequent loosening of the implant from the head. [14–16] To illustrate this, a comparison could be made with the peddles on a bicycle. The left and the right peddle both move in a forward cyclic manner while cycling and, equal to walking, go through a loaded and non-loaded phase. Opposed to the right peddle with a 'normal' clockwise thread attachment, a counter-clockwise thread is used in the attachment of the left peddle to prevent loosening of the left peddle (and eventually falling off).

The primary objective of this analysis was to determine whether patients with a left-sided FNF have a higher failure rate of sliding hip screw fixation than patients with a FNF on their right side.

MATERIALS AND METHODS

Data sources

Data were derived from the FAITH trial and The Dutch Hip Fracture Audit (DHFA). [17,18] The FAITH trial was a multi-center, concealed randomized controlled trial comparing fixation of FNF with cancellous screws versus a SHS. The current study concerns a secondary analysis of patients of the SHS fixation arm of the study. The DHFA is the Dutch nationwide multidisciplinary hip fracture audit in which all patients with a hip fracture have been registered since 2016. It is part of the Dutch Institute for Clinical Auditing (DICA).

Patients

Patients aged ≥ 50 years, diagnosed with a FNF (AO/OTA 31B) treated with a SHS, and with three months follow-up data available were included in this study. [19] Excluded were patients with periprosthetic fractures or pathological fractures and patients with no pre-fracture functional mobility.

Outcome parameters

The primary outcome parameter was implant failure. In the FAITH trial, implant failure was defined as revision surgery due to loosening or breakage of the implant or other reasons (mostly screw cut-out). Implant failure in the DHFA was defined as revision surgery due to migration of the implant, loosening, or the implant breaking out.

Statistical analysis

Variables recorded as 'unknown' were recoded as missing. Missing values were assumed to be missing at random and were, therefore, left out from the analysis. The independent sample T-test was used for comparison of continuous normally distributed variables, the Mann-Whitney U test for non-normally distributed variables, and the Chi-square test for categorical variables. The odds ratio (OR) with 95% confidence interval (CI) for the risk of implant failure for left-sided fractures versus right-sided fractures was calculated using multivariable logistic regression analysis with adjustment for age, fracture displacement (displaced or undisplaced), pre-fracture living situation (institutionalized or not institutionalized), pre-fracture functional mobility (using a walking aid or able to ambulate without a walking aid), and American Society for Anesthesiologists (ASA) Class (Class 1/2 or 3/4/5). *P*-Values <0.05 were regarded as statistically significant. Statistical analysis was performed with R Studio Version 1.1.456 (R Foundation for Statistical Computing, Vienna, Austria). [20]

Table 1. Baseline characteristics of included patients, per data source

		Total	DHFA	FAITH	*p*-value*
Total		1750	1215	535	
Age, mean (SD)		70.7 (12.6)	70.2 (12.9)	71.9 (12.0)	0.02
Sex, n (%)	Male	751 (42.9)	539 (44.4)	212 (39.6)	0.07
	Female	999 (57.1)	676 (55.6)	323 (60.4)	
Prefracture living situation, n (%)	Home	1561 (94.9)	1056 (95.1)	505 (94.4)	0.60
	Institution	84 (5.1)	54 (4.9)	30 (5.6)	
Prefracture mobility, n (%)	Without aid	1347 (80.9)	931 (82.4)	416 (77.8)	0.03
	With aid	318 (19.1)	199 (17.6)	119 (22.2)	
ASA Class, n (%)	1,2	1180 (68.6)	840 (70.8)	340 (63.6)	<0.01
	3,4 and 5	541 (31.4)	346 (29.2)	195 (36.4)	
Displacement, n (%)	Undisplaced	1069 (61.1)	714 (58.8)	355 (66.4)	<0.01
	Displaced	681 (38.9)	501 (41.2)	180 (33.6)	
Fracture side, n (%)	Right	806 (46.1)	551 (45.3)	255 (47.7)	0.40
	Left	944 (53.9)	664 (54.7)	280 (52.3)	
Implant failure, n (%)	No	1690 (96.6)	1197 (98.5)	493 (92.1)	<0.01
	Yes	60 (3.4)	18 (1.5)	42 (7.9)	

* Dutch Hip Fracture Audit (DHFA) versus FAITH Trial

ASA = American Society of Anesthesiologists, OR = Odds Ratio, CI = Confidence Interval, SD, standard deviation.

RESULTS

In total, 1750 patients (1215 from the DHFA and 535 from the FAITH dataset) fulfilled the inclusion criteria and were analyzed. Baseline characteristics per data source are shown in Table 1. The fracture was left-sided in 944 (53.9%) patients, and 806 (46.1%) had a right-sided FNF. The mean age was 70.7 years (SD 12.6), 57.1% were females, who were shown to have significantly more left-sided fractures compared to men (left sided fractures (54.0% versus 46.0%, p = 0.02). Sixty-nine percent of patients were ASA Class 1 or 2. Before the fracture, 94.9% were not institutionalized and the majority of patients did not use a mobility aid (80.9%). Of all fractures, 681 were displaced (38.9%). There was a small but statistically significant difference between the datasets for most baseline-characteristics.

Implant failure within the first three months occurred in 60 patients (3.4%). The incidence of implant failure was higher in the FAITH trial than in the DHFA (7.9% versus 1.5%, p<0.01;

Table 2. Risk of implant failure of femoral neck fractures, univariable and multivariable logistic regression analysis

		Univariable Analysis		Multivariable Analysis	
		OR (95% - CI)	*p*-value	OR (95% - CI)	*p*-value
Side	Left vs right	0.91 (0.54 –1.53)	0.72	0.89 (0.52 – 1.53)	0.66
Age (mean (SD))		1.01 (0.99 – 1.02)	0.19	1.00 (0.98 – 1.02)	0.76
Sex (%)	Female vs male	2.54 (1.42 – 4.83)	<0.01	3.02 (1.52 – 6.10)	<0.01
Prefracture living situation (%)	Institution vs home	1.34 (0.40 – 3.38)	0.58	1.21 (0.34 – 3.35)	0.74
Prefracture mobility (%)	With vs without aid	2.01 (1.11 – 3.51)	0.02	2.02 (1.01 – 3.96)	0.04
ASA Class (%)	3,4 or 5 vs 1 or 2	1.18 (0.68 – 2.01)	0.54	1.04 (0.55 – 1.92)	0.89
Displacement (%)	Displaced vs undisplaced	1.97 (1.17– 3.32)	0.01	2.51 (1.44 – 4.42)	<0.01

ASA = American Society of Anesthesiologists, OR = Odds Ratio, CI = Confidence Interval

Table 1). The implant failure rates in left-sided hips (31/944 = 3.3%) and in right-sided hips (29/806 = 3.6%) were similar. Fifty-five percent of implant failures occurred in FNFs which were initially displaced.

No significant association between the fracture side and implant failure was found. The OR of implant failure in left-sided hips compared to right-sided hips was 0.91 (95% CI 0.54-1.53, p=0.72) in the univariable analysis and 0.89 (95% CI 0.52-1.53, p=0.66) in the multivariable analysis (Table 2).

Female sex (univariable analysis: OR 2.54, 95% CI 1.42-4.83, p<0.01; multivariable analysis: OR 3.02, 95% CI 1.52-6.10, p<0.01), using a mobility aid before the fracture (univariable Analysis: OR 2.01, 95% CI 1.11-3.51, p=0.02; multivariable Analysis: OR 2.02, 95% CI 1.01-3.96, p=0.04), and having a displaced fracture (univariable analysis: OR 1.97, 95% CI 1.17-3.32, p=0.01; multivariable analysis: OR 2.51, 95% CI 1.44-4.42, p<0.01) were associated with implant failure (Table 2).

DISCUSSION

To our knowledge, this is the first study that evaluates the difference in fracture fixation stability using the SHS in left and right-sided FNFs. In our combined study group of 1750 patients with a FNF treated with a SHS, 3.4% had a failure of the bone-implant construct. No association between fracture side and implant failure was found.

Two studies performed by Mohan et al. [10] and Van Embden et al. [9] mentioned a possible difference in rotational stability in left and right-sided trochanteric fractures. As a response, Pervez and Parker reviewed the incidence of screw cut-out of 1147 SHS in trochanteric fractures and did not find a difference in left and right-sided fractures. [21] Although the biomechanical theory for a potential difference in implant stability between left- and right-sided hips seems plausible, we could not find any biomechanical studies on left and right sided differences in FNF. Also, no additional evidence was found from two publications on large randomized hip fracture trials investigating implant failure of SHS, since these did not include fracture side as a confounding factor in their analyses. [17,22] From these studies we may conclude that if present, rotational instability caused by the clockwise torqued screw did not have clinical relevance in terms of increased implant failure in left-sided trochanteric fractures. Our study shows that this conclusion also seems to apply to FNF.

The implant failure rate found in this study was 3.4%. Other studies found overall complication rates of SHS varying between 5.2% -16.7%. Tsang et al. reported a surgical revision rate for mechanical causes of 2.8%. [23] The difference in implant failure rate between the FAITH trial data (7.9%) and the DHFA data (1.5%) may be explained by an underestimation of the implant failure rate due to the retrospective design of the DHFA registry, whereas the data derived from the FAITH trial were prospectively collected and thus of better quality. If implant failures were missed in the DHFA, it is likely this would have occurred equally in right- and left-sided hip fractures and would therefore not have biased the results of our study. The differences in baseline characteristics of the patients from both data sources were small and of little clinical relevance.

Factors increasing the risk of implant failure have been thoroughly studied by several investigators. Failure due to nonunion or malunion is more often seen in displaced fractures (e.g., Garden type 3 and 4) and high shear angle fractures (e.g., Pauwels type 3). [8,24–26] In our study, fracture displacement confirmed indeed a statistically significant association with implant failure.

Associations of implant failure with other previously found risk factors such as fracture pattern, bone quality [27–29], accuracy of the fracture reduction and implant positioning [8,30], body mass index, smoking, concomitant injuries and co-morbidities, and therapy compliance (in weight-bearing) of the patient [5,7] could not be substantiated in our study because these factors were not documented in both the data sources. Some of these factors were collected in one of the data sources, but not the other, or vice versa. Other factors described in the literature that may contribute to fixation failure are age and female sex. In our study, we have found that female patients and patients using a mobility aid before the fracture had a significantly higher risk of implant failure. These findings are in line with previous studies.

Strengths and limitations

A strength of this study is the large number of patients included from both a clinical trial and a national registry, so that the study group is representative of the general FNF patient population. A limitation of the combined datasets was that some information was lost because variables were classified differently. For instance, the fractures in the FAITH data were described according to the Pauwels and Garden classification but were analyzed as displaced or undisplaced to match the fracture classification used in the DHFA. Also, data of only the first three months of the available 24-month follow-up in the FAITH dataset was used, to match the length of follow-up to that in the DHFA dataset. However, implant failure of SHS mostly occurred in the first months [17], presumably when a patient starts weight-bearing. The number of implant failures occurring between 3 and 24 months in the FAITH dataset was too low to be analyzed separately. We considered the three months follow-up to be sufficient to evaluate the difference in implant failure in left- and right-sided SHS.

Due to the retrospective design of this study, only variables collected in both the FAITH trial and the DHFA registry could be used in the analysis. Thus, we could not correct for all risk factors known to be related to implant failure, such as bone density and Body Mass Index [7] . Details on the quality of the reduction, the quality and technique of the fixation (i.e., if an anti-rotation K-wire was used while inserting the screw], the Tip Apex Distance and screw position were not available, nor did the data contain details on the exact type of implant.

CONCLUSION

The results of this study could not substantiate the hypothesis that the biomechanics of the clockwise screw rotation of the SHS contributes to an increased risk of failure of the implant in left-sided FNF compared to right-sided FNF.

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