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From break to breakdown: Mechanical failures in Icelandic fracture hip surgery (2013-2018)

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Abstract

This retrospective study at Landspítalinn University Hospital in Iceland investigates reoperation rates and reasons for fixation failure in hip fracture cases. In our cohort, we evaluated the effectiveness of various surgical techniques and their association with reoperations. Out of 1876 hip fracture cases analyzed between 2013 and 2018, 78 cases required reoperation due to mechanical failure. Our key findings reveal a significant risk of reoperation associated with internal fixation in displaced femoral neck fractures indicating that the use of hemiprosthesis was a more suitable treatment option in these cases. The study also detected an overreliance on dynamic hip screws for trochanteric fractures, particularly in 31. A2 fractures. Moreover, the frequent surpassing of the 25 mm threshold for Tip Apex Distance points to an opportunity for improving fixation stability. These findings emphasize the importance of surgeons adhering to established surgical guidelines and utilizing evidence-based techniques in hip fracture surgeries, aiming to optimize outcomes and reduce the incidence of fixation failure.

Keywords: Retrospective; Hospital based; Mechanical failure; Osteosynthesis failure; Fixation failure; Reoperation; Hip fractures; Femoral neck fracture; Intertrochanteric fracture.

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Introduction

Hip fractures are one of the most common traumatic injuries in the geriatric population, defined as those aged 65 years and older. Beyond the immediate implications of the injury itself, these fractures usher in heightened mortality rates, steep functional declines, and substantial economic burdens on healthcare systems and society at large [1,2]. As age advances, the occurrence of these fractures is expected to rise, mirroring the global trend where the elderly population is the fastest expanding demographic. The incidence of hip fractures in Iceland aligns closely with figures reported from other Scandinavian nations, as documented in prior research in Iceland [3]. While the emphasis in managing hip fractures is the rapid restoration of mobility, surgical interventions, the cornerstone of treatment, are not without pitfalls. The procedures intended to repair hip fractures sometimes culminate in severe complications [4-6]. Among these complications is mechanical failure or osteosynthesis failure which frequently necessitates subsequent reoperations [7,8]. Different reasons for mechanical failure have been studied extensively but most often focusing either on Femoral Neck Fracture (FNF) or the trochanteric fractures [9-14]. Moreover, there's a paucity of data specifically addressing mechanical failures post-hip surgeries in Iceland. Our study aimed to com-

prehensively document instances of mechanical failure following hip fracture surgeries at Landspítalinn University Hospital in Iceland between 2013 and 2018. Simultaneously, we sought to investigate whether specific deficiencies in the applied surgical techniques might contribute to the occurrence of mechanical failures. Thus, our research question emerged: 'Are there identifiable deficiencies in the surgical techniques applied during hip fracture surgeries at Landspítalinn University Hospital in Iceland between 2013 and 2018 that are associated with an increased risk of mechanical failure?' By delving into this question, we aim to provide valuable insights that not only enhance our understanding of hip fracture complications but also offer guidance for refining surgical practices to optimize patient outcomes.

Material and methods

Study design: This was a retrospective non-comparative cohort study conducted at the Orthopedic department in Landspítalinn University Hospital in Iceland.

Patient selection: All patients who underwent surgery after a hip fracture in the period 01.01.2013-31.12.2018 were eligible for inclusion. We excluded subjects who did not have a reoperation, had a reoperation for reasons other than mechanical failure such as wound revision or infection or had a high energy fracture.

Data collection: Clinical data were collected from electronic medical records. Pre-, post-operative and follow-up x-rays were reviewed. Information on surgical techniques and implant types were collected from surgical reports.

Radiographic analysis: Radiological analysis was done by the author in Agfa Enterprise Imaging Program. Factors as the cause of fixation failure which were classified into two primary groups based on the time of occurrence: failures that happened before 6 months and those that occurred after 6 months. If the failure occurred after 6 months, it was labeled as non-union. The specific subgroups identified in our analysis can be found in Table 1.

Table 1: Classification of fixation failure causes.

Causes	in
Aseptic Loosening	1
Axial/Valgus/Varus Collapse	12
Caput Necrosis	13
Cut Out	13
Dislocation >= 3	11
Fracture near Osteosynthesis, Non-Traumatic	1
Fracture of Osteosynthesis	4
Nonunion	6
Nonunion and Axial/Valgus/Varus Collapse	10
Nonunion and Cut Out	3
Nonunion and Fracture of Osteosynthesis	3
Rotational Instability	1

Intertrochanteric and subtrochanteric fractures were classified according to AO/OTA classification into A1, A2 and A3. Baumgartner's method, as shown in Figure 1, was employed to evaluate the Tip Apex Distance (TAD) [14] for all the fractures that were treated with Dynamic Hip Screw (DHS) or Intramedullary Nail (IMN).

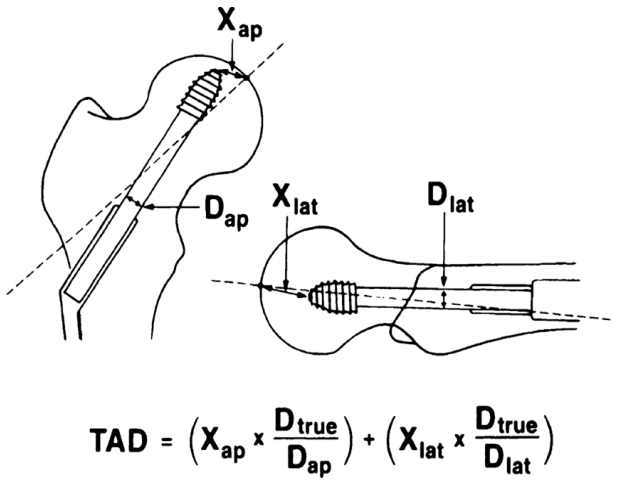

Figure 1: Baumgartners´s schematic diagram of evaluation of Tip Apex Distance.

The assessment of reduction quality was based on Baumgartner's three grade scale evaluating two criteria on Antero-Posterior (AP) and lateral views [14]. The first criterion focuses on the alignment, specifically the cervicodiaphyseal angle ranging from 120° to 135° on the AP view and an angulation of less than 20° on the lateral view. The second criterion examines the displacement, with the requirement of less than 4 mm between each fragment in both the AP and lateral views. The reduction was classified as good if both criteria were met, if only one criterion was met, the reduction was considered acceptable. However, if neither criterion was met, the reduction was categorized as poor. To estimate the position of the lag screw within the femoral head we used Parker's ratio index [15]. Femoral neck fractures were classified as displaced (Garden III and IV) and undisplaced (Garden I and II) which has shown better inter-observer reliability [16]. The Hansson pin system from Swemac is utilized for the management of undisplaced femoral neck fractures at Landspítalinn University Hospital [17]. We evaluated the quality of fracture reduction and the accuracy of pin placement by applying criteria established in prior studies conducted in Norway [18-20]. Detailed description of the criteria can be seen below. When assessing pin placement and reduction, bear in mind that the x-ray images used for the analysis weren't standardized in terms of hip rotation.

a. Fracture reduction: In the AP view, the fracture should show no varus or up to 15° valgus angulation and less than 2 mm displacement. In the lateral view, the angulation should be less than 20° ventrally or 10° dorsally, and displacement should be less than 2 mm. A score system was used, where 3 points indicated that all criteria were met, 2 points indicated that one criterion was not satisfied, and 1 point indicated that two criteria were not satisfied. Points were assigned for both AP and lateral views, with a maximum score of 6 points.

b. Pin placement: In the AP view, the caudal pin should align along the calcar, the distance between pins should be maximized within the anatomy of the femoral neck, both pins should run parallel to the femoral neck, and both pins should be inserted into the subchondral bone within 5 mm of the cartilage. In the lateral view, no pins should be positioned in the anterior third of the femoral head, and one point was deducted for each pin placed in this region. Similarly, a score system was used, with 3 points indicating that all criteria were satisfied, 2 points indicating that one criterion was not met, and 1 point indicating that two or more criteria were not fulfilled. Points

were assigned for both AP and lateral views, with a maximum score of 6 points. Displaced femoral neck fractures are treated with cemented hemi prosthesis or total hip prosthesis depending on patient factors. In this study we documented Leg Length Discrepancy (LLD), Femoral Offset, Fem-Stem Alignment (FSA) and Wibergs angle or Center-Edge Angle (CEA). A diagrammatic representation of the measurement parameters can be seen Figure 2.

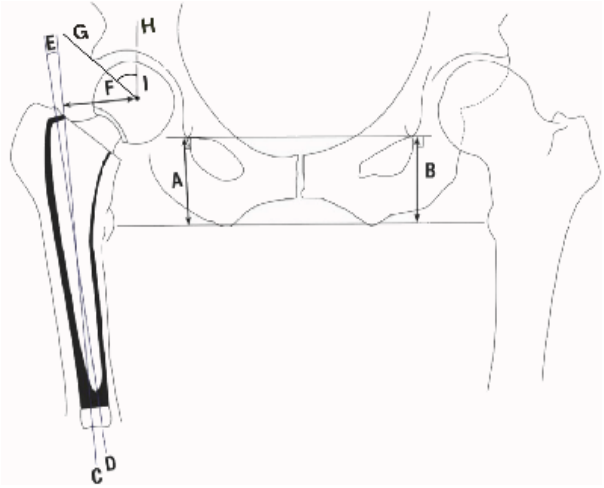

Figure 2: Diagram of the arthroplasty measurements, modified figure from [21] with CEA added. LLD: Distance A -Distance B; C: Axis of the femoral shaft; D: Axis of the femoral stem; Angle E: FSA; F: Femoral Offset; H: Vertical line from center of rotation; G: Line from center of rotation to lateral acetabular rim; Angle I: CEA.

Statistical analysis: Statistical analysis was conducted using R Studio (2023.06.0). Descriptive statistics were used to summarize patient characteristics and surgical techniques.

Ethical considerations: The study was approved by the Ethical Committee and the Scientific Research Committee of health research in the health department at Landspítali. Informed consent was waived due to the retrospective nature of the study. Patient confidentiality was maintained throughout the study by using anonymized data.

Results

A total of 1876 hip fractures were identified and reviewed. After exclusion criteria were applied (patients who did not have a reoperation, had a reoperation for reasons other than a failed internal fixation such as wound revision or infection or had a high energy fracture), 78 surgeries on 75 patients were included in the final analysis with a mean age of 76 years, ranging from 38 to 96 years old. Majority of the reoperations were done on females, or 62% (48/78). The mean ASA score before surgery was 2.5, 45% (35/72) of the patients were ASA 3, 40% (31/72) ASA 2, 5% (4/72) ASA 4, 3% (2/78) ASA 1 but in 8% (6/78) there was no ASA score recorded. The mean time between the initial surgery and reoperation was 241 days but the median was 162 days, with a minimum of 7 days and a maximum of 1264 days. The surgeries were categorized based on the original surgical procedure performed, majority were Hansson 40% (31/78), followed by DHS (Synthes) 30% (23/78), IMN (Gamma 3 Stryker and PFN Synthes) 15% (12/78), bipolar hemi prosthesis (MS30 Zimmer) 12% (9/78), and THA (Taperloc/Exceed Zimmer) 4% (3/78). The causes of fixation failure can be seen in summarized in Table 1.

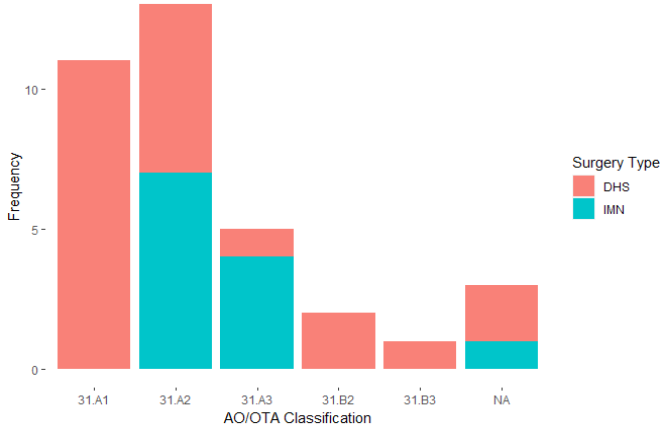

Figure 3: Distribution of surgeries for intertrochanteric and subtrochanteric fractures classified according to AO/OTA criteria 2018. NA: Not Available.

Trochanteric fractures: In Figure 3 the classification details are presented according to the surgery performed. Mean TAD was 27.7 mm, ranging from 6 to 46mm, in 60% (21/35) of the surgeries TAD was above 25mm. The assessment of reduction quality could not be carried out as intended due to the substantial number of instances where measurements on lateral fluoroscopy were unattainable due to poor image quality. The average Parkers ratio on the AP view was 53.2, with a range of 29 to 74. On the lateral view, the mean ratio was 43.6, ranging from 18 to 66. The distribution of Parkers ratio is depicted in Figure 4.

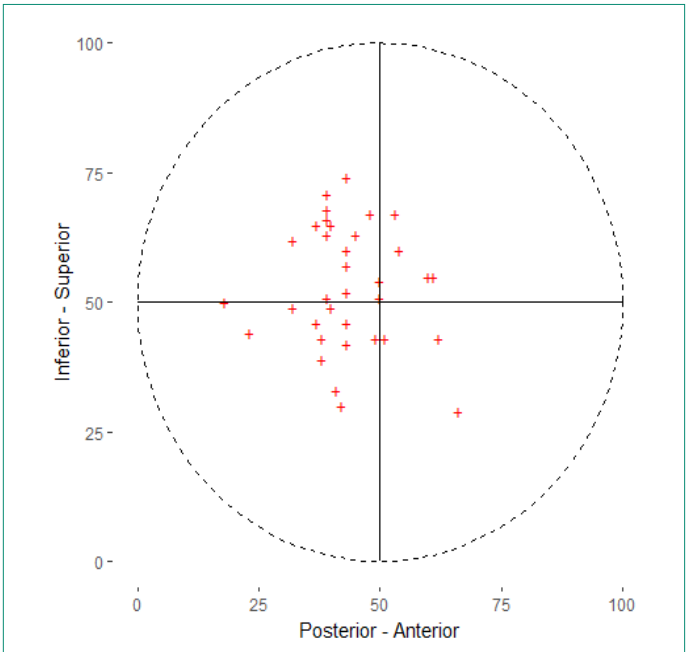

Figure 4: Distribution of the Lag Screw within the Femoral Head in Two Planes, as Measured by Parker's Ratio, for DHS and IMN Surgeries.

Femoral neck fractures: The majority of the femoral neck fractures were treated with the Hansson pin system or 72% (31/43), 21% (9/43) were treated with hemi prosthesis and 7% (3/43) were treated with total prosthesis. Of the 31 fractures who were treated with the Hansson pin system 55% (17/31) were displaced fractures, 42% (13/31) undisplaced and 1 fracture was unclassifiable due to lack of preoperative radiograph. In almost half of the cases or 42% (13/31) the reduction quality in internal fixation achieved a score of 6 points, indicating no reduction of points. Meanwhile, 26% (8/31) scored 5 points, 13%

(4/31) scored 4 points, and a minority of 16% (5/31) recorded 4 or fewer points. In total there was a reduction of 35 points. The most prevalent cause for point reduction was a 2 mm displacement observed on the AP view, accounting for 31% (11/35) of the reduced points. The next most common cause, comprising 20% (7/35) of the reductions, was a 2mm displacement seen on the lateral view. Regarding pin placement, in more than half or 61% (19/31) of the cases there is a reduction of at least one point. Scores of 6 points were seen in 39% (12/31) of cases, 5 points in 36% (11/31), and 4 points in 23% (7/31). A cumulative reduction of 25 points was observed, with 64% (16 out of 25) being due to the pin spacing not fully utilizing the anatomical breadth of the femoral neck. The second most frequent reason for reduction, accounting for 28% (7/25) of the reduced points, was the placement of one or more pins in the anterior third of the femoral head. When analyzing hip prostheses, encompassing both hemi and total prostheses, it was observed that the majority displayed varus alignment, constituting 75% (9/12) of the cases. However, only one prosthesis deviated more than 5 degrees from the neutral position, exhibiting 8.6 degrees of varus. Among the prostheses, only two had a shorter offset compared to the unaffected side, measuring -11 mm and -12 mm. The mean offset was 12 mm, with a median of 8.2 mm, ranging from -12 mm to 20 mm. In terms of CEA, the average measurement was 30 degrees, ranging from 26 to 40 degrees. Furthermore, the mean LLD was 2.3 mm, with a range from 0mm to 5 mm longer.

Discussion

In this retrospective analysis, we conducted a comprehensive review of all surgeries following femoral neck and intertrochanteric fractures. For the subset that underwent reoperation, we performed an evaluative grading of the implant positioning. We will discuss relevant outcomes for each fracture type and surgery type, starting with general factors and then each measuring factor. The average time between the initial surgery and reoperation was 264 days, with a median of 162 days. Four outlier cases were observed, ranging from 834 to 1264 days between the surgeries. Three of these cases involved caput necrosis, with patients reporting pain within two years of surgery. The remaining case had a hemi prosthesis that persistently dislocating post-surgery.

Femoral neck fractures: The conventional method of closed reduction and internal fixation for displaced femoral neck fractures has long been associated with a significant risk of reoperation [9,22-24]. A total of 31 subjects who received Hansson nails required reoperation. The fact that 42% (13/31) of the patients requiring reoperation had initially presented with a displaced fracture underlines this concern. This points towards a possible over-reliance on internal fixation in instances where arthroplasty would have been a more fitting treatment choice. In grading reduction and pin placement quality, we used previously developed criteria which can be seen in the methods above. Almost half of the cases or 42% (13/31) the reduction achieved a score of 6 points, indicating no reduction of points. However, an apparent discrepancy arises as 58% (18/31) of the fractures were initially categorized as undisplaced. This divergence results from the fact that the Garden criteria, used for classifying fractures into displaced or undisplaced, only considers the AP view, whereas our reduction criteria take both the AP and L views into account. Previous comparable studies have shown an association between quality of reduction and reoperation or failure of treatment [13,18,19,25]. In our work, we found that 58% (18/31) of reductions saw at least a one-point decrease. This underlines the critical need for precision during femoral neck fracture reduction. Alternatively, as we've suggested before, opting for arthroplasty over internal fixation in displaced femoral neck fractures. Regarding pin placement, only 39% (12/31) had no reduction of points and the most common reduction of points was due to the pin spacing not fully utilizing the anatomical breadth of the femoral neck. The influence of pin placement on treatment outcomes remains ambiguous, as highlighted by the conflicting results from previous studies [13,18,19].

Arthroplasty: In our cohort, only one arthroplasty was performed using the anterolateral approach, with the remaining utilizing the posterolateral approach, reflecting surgeon preference. The use of the anterolateral approach in Iceland has since 2018 seen a considerable increase in contemporary arthroplasty treatments for femoral neck fractures. For arthroplasties necessitating reoperation, the majority or 75% (9/12) exhibited a varus alignment, with just one hip exceeding 5 degrees in varus. The mean varus deviation from neutral was 2.5 degrees. This suggests that the femoral stem alignment in femoral neck fractures treated with arthroplasty and later requiring reoperation was generally acceptable. Past research has identified an association between reduced femoral offset, compared to the naïve hip, and dislocations [26-29] although others show no correlation [12,30]. In our study, only 17% (two hips) demonstrated a femoral offset less than the native hip (-11 mm and -12 mm), with a mean offset of 8.2 mm above the native hip. Decreased CEA has been correlated to increased risk of dislocation [12,26,27,30,31], our average CEA was 30, ranging from 26-40 degrees. Furthermore, none of the arthroplasties resulted in a negative leg length discrepancy, with an average increase of 2.3 mm and a maximum of 5 mm. From these observations, we infer that patient-related factors may have a more significant role in arthroplasty failure than surgical factors, as per the parameters we evaluated.

Trochanteric fractures: A total of 35 failures were observed in trochanteric fractures: 23 with DHS, 10 with gamma nails, and 2 with PFN nails. These fractures were classified using the AO/OTA 2018 criteria. The DHS, with the most specific indications among the three procedures, is mainly recommended for 31.A fractures (DHS surgical manual). However, it can be adapted for 31.B2/3 by incorporating an anti-rotational screw [32] and for 31.A2/3 with a trochanteric stabilization plate [33], as outlined in the DHS surgical manual. Even so, some research recommend IMN for unstable intertrochanteric fractures as Kregor showed in his review [34]. Figure 3 depicts the application of DHS and PFN for each fracture type. We noted the use of DHS + trochanteric stabilization plate for A3 fractures and DHS + anti-rotational screw for B2 and B3 fractures. Our data suggests an excessive application of DHS for A2 fractures that later required reoperation, underscoring the need for thorough preoperative planning.

TAD: The Tip Apex Distance (TAD) plays a pivotal role in predicting the outcome and stability of fixations in trochanteric fractures [14,35,36]. In our study, the average TAD observed for both the DHS and IMN stood at 27.7 mm, covering a broad range from 6 mm to a relatively high 46 mm. Notably, a significant 60% (21/35) of the surgeries demonstrated a TAD exceeding the 25mm threshold. This finding is crucial, given that numerous studies have highlighted the 25 mm mark as a critical threshold for predicting screw cut-out and post-operative complications. The prominence of TAD measurements exceeding

this threshold in our sample suggests potential areas for optimization in our surgical techniques.

Position of the lag screw: Lag screw positioning within the femoral head is important for optimal outcomes following fracture fixation. The prevailing recommendation from many studies is a central/central lag screw orientation in AP and L views [10,11,15,35], yet some studies argues an inferior placement might be preferable to the central one [37-39]. The positioning of the lag screw in our study appears to be acceptable considering these are the surgeries that went into failure, showing a minor superior bias with a Parker's ratio of 53.2 and a slight posterior alignment, evidenced by a Parker's ratio of 43.6. As mentioned in our results we set out to qualify the intraoperative reduction quality but the measurements on lateral fluoroscopy were unattainable due to poor quality. This can be prevented by making sure to include the whole osteosynthesis, caput femoris, greater trochanter and the femoral shaft on the lateral fluoroscopy.

Conclusion

Hip fractures, particularly in the geriatric population, pose significant medical and societal challenges. While surgical intervention remains the cornerstone of management to expedite mobility, its potential complications, including mechanical or osteosynthesis failures, necessitate keen clinical vigilance. Through our study of surgeries performed at Landspítalinn University Hospital in Iceland between 2013 and 2018, we aimed to shed light on the underlying reasons for reoperations, with a focus on potential deficiencies in surgical techniques. Our research aligns with the prevailing agreement in existing literature that emphasizes the preference for hemiprosthesis over ORIF in treating displaced FNF. Additionally, our findings reveal a notable propensity for employing DHS fixation in cases of 31. A2 intertrochanteric fractures during the period spanning 2013-2018. Furthermore, we observed that the TAD exceeded the critical 25 mm threshold in 60% of our cases, a significant predictor of screw cut-out. These outcomes underscore the importance of meticulous surgical techniques and a thorough understanding of the appropriate surgical interventions for specific fracture types. In the constantly evolving field of orthopedic surgery, it is crucial to continually assess and refine our techniques, ensuring optimal outcomes for patients and reducing the burden on healthcare systems.

Conflicts of interest: We have no conflicts to disclose.

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