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# Trocantheric Femoral Fractures

- a retrospective cohort study comparing reoperation rates before and after implementation of new treatment protocol

Version 2

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## Abstract

**Introduction:** Hip fractures are very common in Sweden. Keeping reoperation rates as low as possible is critical. One factor correlated to mechanical complications and thereby reoperation rates is the tip-apex distance. In April of 2017 the Orthopedic clinic at Karlstad's Central Hospital in Sweden implemented new routines for the choice of treatment method of pertrocantheric and subtrocantheric femoral fractures.

**Aim:** The primary aim of this study was to compare reoperation rates of pertrocantheric and subtrocantheric femoral fractures before and after implementation of new routines. Secondly, we wanted to study the association between the tip-apex distance and reoperation rates for pertrocantheric femoral fractures treated at Karlstad's Central Hospital.

**Method:** This was an internal quality control designed as a retrospective cohort study. Data on patients treated for pertrocantheric or subtrocantheric femoral fractures were retrieved from the Swedish Fracture Registry. Tip-apex distances were measured on patients' radiographic images. P-values for comparison of the two study periods were created using the chi2 test. Association between the tip-apex distance and reoperation rate was presented as odds ratio.

**Result:** The reoperation rates were the same for both time periods. The reoperation rates of unstable fractures were lower for the study period after implementation of new routines. Neither of these results were statistically significant. There was also no statistically significant association between the tip-apex distance and reoperation rates.

**Conclusion:** No statistically significant decrease in reoperation rates was seen after implementation of new routines. There was no association between the tip-apex distance and reoperation rates.

***Keywords:*** Pertrocantheric femoral fracture, subtrocantheric femoral fracture, tip-apex distance, Swedish Fracture Registry, reoperation.

**Abbreviations**

AO classification - Arbeitsgemeinschaft für Osteosynthesefragen
CSK - Karlstad's Central Hospital
IM - Intramedullary Nail
OR – Odds Ratio
PTFF - Pertrocantheric Femoral Fracture
SFR - Swedish Fracture Registry
SHS - Sliding Hip Screw
STFF - Subtrocantheric Femoral Fracture
TAD - Tip-Apex Distance
TH - Twin-Hook

## Introduction

Hip fractures are very common in Sweden with 16,000 cases annualy [1,2]. Because of the aging population the world-wide annual incidence of hip fractures is growing and it has been estimated the annual incidence will reach 2.6 million by 2025 and as high as 6.3 million by 2050 [3,4]. The majority of patients who suffer hip fractures are women (67%) [5]. Due to their large impact on day to day function and quality of life, hip fractures pose a great demand, both from a socioeconomic standpoint as well as from a health care standpoint [6].

Based on anatomy, hip fractures can be divided into three groups; cervical hip fractures, which are the most common in Sweden, pertrocantheric femoral fractures (PTFF) and subtrocantheric femoral fractures (STFF). PTFFs and STFFs can further be divided into nine different categories based on AO classification (Arbeitsgemeinschaft für Osteosynthesefragen), consisting of three different groups with three subgroups each (figure 1). The three groups are 31-A1, 31-A2 or 31-A3 [7]. In Sweden, 31-A2 fractures are the most common, followed by 31-A1 fractures and then 31-A3 fractures [8]. Pertrocantheric two-part fractures are classified as 31-A1. Fractures beginning in the greater trocanther with more than two fragments are classified as 31-A2. STFFs are classified as 31-A3. Fracture patterns 31-A1.1 to 31-A2.1 are usually stable while 31-A2.2 through 31-A3 usually are considered unstable [7,9].

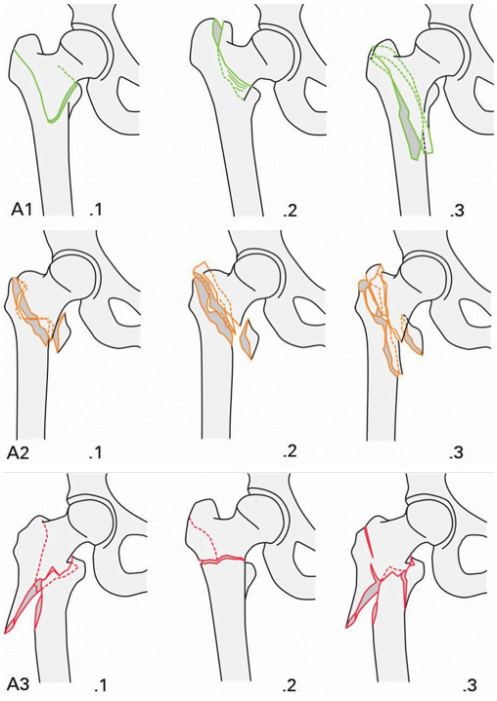



Figure 1. Fracture classifications according to the AO classification system. Copyright The AO Foundation, Switzerland.

PTFFs and STFFs are most commonly treated surgically with either an extramedullary device, such as the sliding hip screw (SHS) or the twin-hook (TH), or an intramedullary device, such as the intramedullary nail (IM) [2]. Which method is superior remains open to debate. One randomized trial including 1000 patients with trocantheric hip fractures who were treated with either the SHS or IM showed no statistically significant difference in reoperation rates [10]. Another study by Miedel et. al found a lower rate of reoperations in both PTFFs and STFFs treated with IM compared to those treated with SHS [11]. Several studies have shown a greater rate of postoperative complications for STFFs treated with extramedullary devices [12,13]. Although there is no consensus, it has been proposed that extramedullary devices are best for treating stable fractures while the IM is more suited for treating unstable fractures [9,14]. Between the years 2009 and 2018 the use of IM in treating STFFs increased from 72% to 85% [5]. In the end, choice of method depends on the appearance and stability of the fracture, the experience of the surgeon and on the clinic's routines [2].

A common underlying mechanism of failure is the cutout, which is "the collapse of the neck-shaft angle into varus, leading to extrusion, or so-called cutout, of the screw from the femoral head" [15]. It has been proposed that the tip-apex distance (TAD) is an important factor in determining the risk of cutout and other mechanical complications that require reoperation. TAD was first described by Baumgaertner et al. In their study from 1995 they studied several factors believed to contribute to the risk of cutout for patients treated with the SHS. While age, fracture instability and other factors contributed to the risk of reoperation, TAD was the strongest predictor of cutout. A TAD greater than 25 millimeters was defined as an increased risk of cut out [15]. Other studies have supported TAD as a predictor of mechanical complications in patients treated with extramedullary devices as well as those treated with the IM [16].

Previously Karlstad's Central Hospital in Sweden (Centralsjukhuset i Karlstad - CSK) had used an extramedullary device, the TH, in a larger percentage of their PTFF and STFF surgeries compared to other hospitals in Sweden [17]. On April 1, 2017 a new treatment protocol was implemented at CSK, increasing the use of the IM. Prior to implementation of the new treatment protocol, an internal quality control was done comparing results of PTFFs and STFFs being treated with either TH or IM at CSK with the results at other hospitals in Sweden [18]. Though the reoperation rates during this time period were higher at CSK for

both fracture types and treatment methods, no statistically significant difference was found in reoperation rates compared to other hospitals [18].

## Aim

The primary aim was to compare reoperation rates of PTFFs and STFFs treated at CSK before and after implementation of new routines. The secondary aim was to evaluate TAD as a predictor of mechanical complications in PTFF surgeries conducted at CSK since implementation of new routines.

## Material and methods

### Study design and population

This project served as an internal quality control, designed as a retrospective cohort study. The study included PTFFs and STFFs treated at CSK. For the primary aim, all PTFFs and STFFs in patients 18 years or older that had been treated with TH or IM at CSK between January 1, 2013 and December 31, 2015 or between April 1, 2017 and August 31, 2019 were included [17]. For the secondary aim only PTFFs from the latter time period were included.

### Data collection

Data on age, fracture classification, original treatment, and reoperations were retrieved from the SFR. Upon diagnosis treating physicians are supposed to register all fractures and treatments in the SFR. It is known, however, that occasionally physicians forget to make the registrations. Therefore, data from the SFR was compared to Provisio, the electronic booking system for operations used at CSK, to ensure that no reoperations were missed. There were no reoperations registered Provisio that were not registered in SFR. Reoperations were defined as additional surgery due to complications within six months of primary surgery.

### Tip-Apex Distance

Radiographic images were accessed through Sectra (Sectra Workstation IDS7, version 19.3, Linköping, Sweden). Measurements were made on the anteroposterior (figure 2) and the lateral intraoperative radiographic images. The distance between the tip of the lag screw or TH and the apex of the femoral head was measured in both images. Magnification was adjusted for by measuring the diameter of the lag screw, known to be 9 millimeters in the TH-devices and 11 millimeters on the IM-devices.

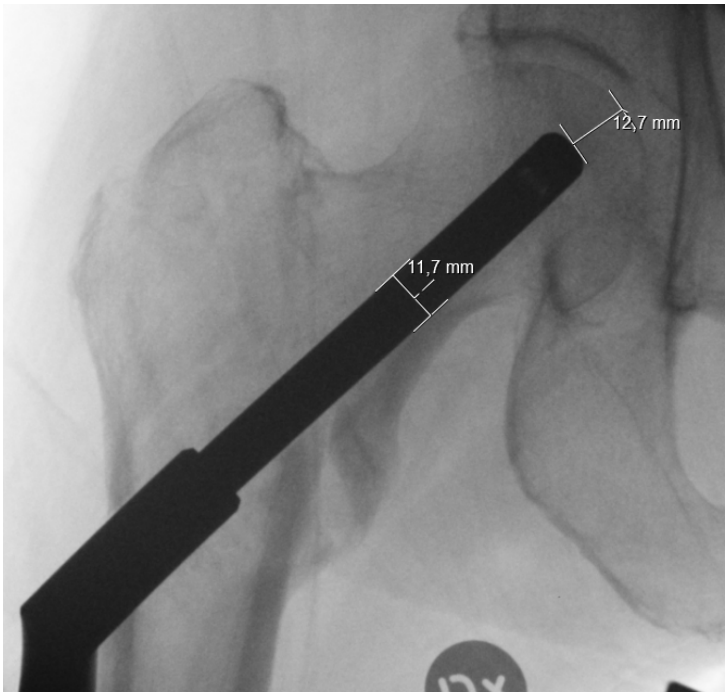
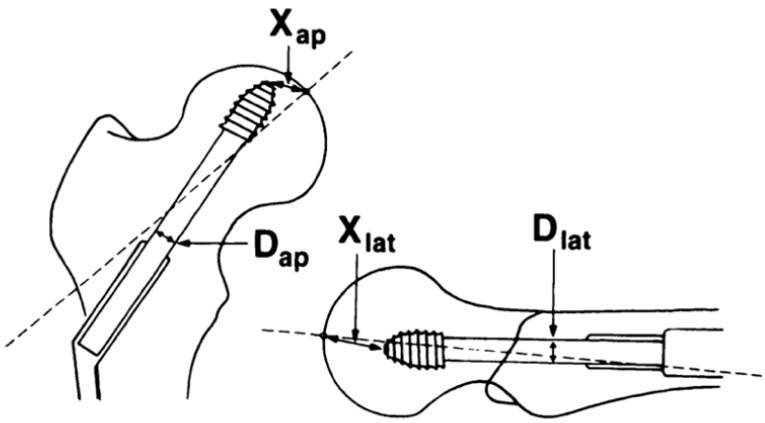



Figure 2. Anteroposterior radiographic image with tip-apex distance measurements.

TAD was calculated using the formula first described by Baumgaertner et al. (figure 3) [15]. All measurements were made by the same observer. Based on the measurements the population was divided into two groups, one group with fractures that had TADs greater than 25 millimeters and one with fractures that had TADs less than or equal to 25 millimeters.




$$TAD = \left(X_{ap} \times \frac{D_{true}}{D_{ap}}\right) + \left(X_{lat} \times \frac{D_{true}}{D_{lat}}\right)$$

Figure 3. Illustration of measurements and formula for calculating the tip-apex distance (TAD). Xap is the distance from the tip of the lag screw or TH to the apex of the femoral head on the anteroposterior radiographic image. Dap is the measured diameter of the lag screw or TH in the anteroposterior image. Xlat is the distance between the tip of the lag screw or TH and apex of the femoral head. Dlat is the measured diameter of the lag screw or TH in the lateral image. Dtrue is the known diameters of the lag screw or TH. Copyright Baumgaertner et al.

### Statistical analysis

For the primary aim, the Chi2 test was used to compare results before and after implementation of new routines. Statistical significance was set to $p<0.05$. For analyzing the association between TAD and reoperation rates, logistic regression was performed. Odds ratios (OR) were calculated with a 95% confidence interval (CI). Statistical analysis was done using SPSS (IBM SPSS Statistics, version 26, Armonk, NY, USA). Tables and figures were created in Excel (Microsoft®, version 2019, Redmond, WA, USA).

### Ethical considerations

Since this was an internal quality control approved by the head of the clinic, no ethical approval was required, neither was the approval of the included patients. Furthermore, we believe the possible benefits of this study outweigh the risks. To minimize the breach of privacy, all data was collected from the SFR where very limited information about patients is available, ensuring that only the information needed for the study was accessed by the author. Additionally, radiographic images were accessed directly through Sectra. This way the patients' digital charts were only viewed through Cambio COSMIC® in the few cases where the necessary data was missing in the SFR.

## Results

### Baseline charateristics

At baseline 1040 fractures were included in the study, 568 treated between January 1, 2013 and December 31, 2015 (group A), and 472 treated between April 1, 2017 and August 31, 2019 (group B) (table 1). PTFFs were more common than STFFs in both groups. The most common fracture type in both groups were 31-A2. The mean age was 82 in group A and 81 in group B. The majority of the patients included were females, 64% group A and 67% in group B.

Table 1. Patient demographics.

| | Group A | Group B |
|---|---|---|
| Number of fractures | 568 | 472 |
| Male | 206 (36%) | 154 (33%) |
| Female | 362 (64%) | 318 (67%) |
| Mean age (SD[a]) | 82 (11) | 81 (11) |
| Fracture classification | | |
| 31-A1 | 176 | 119 |
| 31-A2 | 256 | 247 |
| 31-A3 | 136 | 106 |

[a] Standard deviation

## Treatment methods

In group A, 432 of 568 fractures were classified as PTFFs, three treated with IM and 429 with TH. Of the 136 STFFs seven were treated with IM and 129 were treated with TH. In group B 366 had suffered a PTFF, 324 treated with TH and 42 with IM. Of the 106 STFFs 26 were treated with TH and 80 with IM.

Table 2. Treatment method divided by type of fracture.

| | Group A | | Group B | |
|---|---|---|---|---|
| | **Twin-hook** | **Intramedullary nail** | **Twin-hook** | **Intramedullary nail** |
| Pertrocantheric | 429 | 3 | 324 | 42 |
| Subtrocantheric | 129 | 7 | 26 | 80 |

## Reoperation rates

No difference was found in reoperation rates comparing group A and B, 13 of 568 (2.3%) and 11 of 472 (2.3%) respectively (p=0.96). The reoperation rate at was lower in group A for the 31-A2 fractures as well as for the 31-A3 fractures. The 31-A2 had a reoperation rate of 2.7% in group A and 2.4% group B (p=0.83). The reoperation rate for the 31-A3 fractures was 4.4% in group A and 2.8% in group B (p=0.52). Comparison of reoperation rates are shown in figure 4.

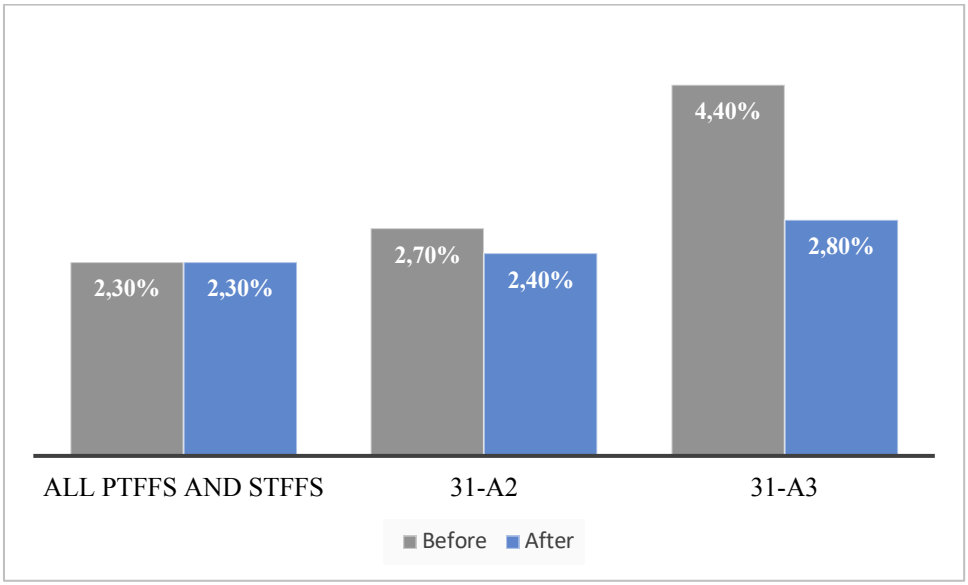



Figure 4. Reoperation rates before and after change in treatment protocol.

**Tip-apex distance**

All PTFFs from group B were included, totaling 366 at baseline. A total of 76 were excluded due to death before six months follow-up. Another 14 were excluded due to poor radiographic image quality. This left 276 fractures, 201 in women and 75 in men, to be studied. The median age of the population was 82.

Of the 276 fractures, 244 had been treated with TH and 32 had been treated with IM. 181 of 276 fractures were classified as stable (31-A1-31-A2.1) and 95 of 276 fractures as unstable (31-A2.2-31-A2.3). The TH-device was the most common treatment method for all classifications except 31-A2.3.

Five fractures suffered mechanical complications requiring reoperation at six months follow-up. Three of these had been treated with TH and two had been treated with IM. The average TAD of the three fractures treated with TH that required reoperation was 29.1 millimeters. The average TAD of those not requiring reoperation was 21.6 millimeters. For the fractures treated with IM, the average TAD of those requiring reoperation was 20.5 millimeters compared to 19.7 millimeters in those not requiring reoperation.

In total, 198 treated fractures had a TAD of 25 millimeters or less. Three of these (1.5%) suffered a mechanical complication requiring reoperation. Of the 78 fractures with a TAD

greater than 25 millimeters two (2.6%) needed reoperation due to mechanical complications. The risk of reoperation was higher in TAD>25 mm, OR 1.71, (95% CI 0.280-10.4). Analyzing TAD as a continuous variable showed no statistically significant increase in risk of reoperation with increasing TAD, OR 1.04 (95% CI 0.96-1.1).

## Discussion

Before the change in treatment protocol an internal quality control was done comparing results of PTFF and STFF surgeries at CSK to the rest of Sweden. Our study, however, is the first to compare results before and after the change in treatment protocol. No difference was found in reoperation rates before and after this change. Since the new routines mainly meant an increase in the use of IM for unstable fractures, we also analyzed 31-A2 and 31-A3 fractures separately. Reoperation rates were lower in the study period after the change in routines for both of these fractures, which might speak in favor the new treatment protocol for treating these patients. The differences, however, were not statistically significant. Since the number of reoperations were low, the lack of statistical significance might indicate a type 2 error.

Our data showed a higher reoperation rate for PTFFs with a TAD greater than 25 millimeters in our studied time period. When analyzed as a continuous variable, no statistically significant association between TAD and reoperation rates was found. Since the TAD was first introduced, in 1995, as a predictor of complications in PTFFs treated with the SHS, many studies have shown a correlation between TAD and reoperation rates in both PTFFs and STFFs treated with extramedullary devices as well as intramedullary devices [15,16,19,20]. Consistent with the original study by Baumgaertner et al. our study period had a higher reoperation rate for PTFFs with a TAD greater than 25 millimeters. Though our study population was fairly large, our results were not statistically significant.

After change in treatment protocol, we found lower reoperation rates for 31-A2 and 31-A3 fractures. Although our results were nonsignificant, previous studies support the use of IM over TH in unstable PTFFs and STFFs [11–13]. Analyzing the results for strictly unstable fractures was limited by the fact that prior to the change in treatment protocol all PTFFs were classified in the SFR as either 31-A1 or 31-A2, not specifying subgroups. Almost half of all 31-A2 fractures are actually stable (31-A2.1) and the main increase in the use of the IM was

seen in the 31-A2.2 through 31-A3 fractures. Therefore, it would have been more interesting to compare the results of the treatment of the unstable fractures as a group before and after the change in treatment protocol. Reclassification of the fractures in group A would require reviewing the original radiographic images.

Many of the studies mentioned above had smaller study populations than our study, but still produced statistically significant results supporting the theory that TAD is correlated to complication rates. One possible reason for this could, once again, be the low number of reoperations. During our study period, only five of 276 patients treated for PTFF required reoperation, within six months, due to mechanical failure. In comparison, previous studies had complication rates ranging from 5.1% to 15% [15,19,21,22]. Several factors may have played a role in our lower observed complication rates, such as: shorter follow-up time, fewer unstable fractures, and lower TADs compared to the other studies.

Because the new treatment protocol was implemented approximately two years prior to this study, the later study period was rather short. This, combined with the fact that patients in both groups could only be followed for six months, resulted in a low number of reoperations. We believe this may have been an important factor in the lack of statistical significance, as our study population of 1040 fractures was rather large. Because of this it is fair to say that this study was most likely conducted too early. Many complications occur within the first few months after initial treatment, but many also occur several years later. In our early study period 12 reoperations had occurred later than six months after initial treatment. A study conducted in a few years would have a larger population to study to begin with and could also follow the patients for a longer time period, thereby including more complications that occur later than six months after initial treatment. This would give a truer image of reoperation rates.

The fact that the TAD-measurements were all made by one observer can be viewed as both a strength and a limitation of the study. The fact that the author had very limited experience of studying radiographic images and no experience of measuring the TAD may result in slightly inaccurate measurements. This could have an effect when comparing the reoperation rates of surgeries with a TAD greater than 25 millimeters to those with a TAD less than 25 millimeters. To minimize this error, measurements on the more difficult radiographic images were confirmed by the supervisor. A possible strength of all measurements being made by

one observer is that they were consistent. This could be viewed as a strength when viewing TAD as a continuous variable.

## Conclusion

No difference in reoperation rates was found after implementation of the new treatment protocol. There was no association between a TAD greater than 25 millimeters and risk of reoperation due to mechanical complication. The low number of reoperations in this study indicates the need for a larger study or longer follow-up time in evaluating the effect of the new treatment protocol.

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