Osteosynthesis of Non-displaced Femoral Neck Fractures in the Elderly Population Using the Femoral Neck System (FNS): Short-term Clinical and Radiological Outcomes

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Research Article

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Title: Osteosynthesis of non-displaced femoral neck fractures in the elderly population using the Femoral Neck System (FNS): short-term clinical and radiological outcomes

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Abstract

Background: Femoral neck fractures (FNF) are frequent in the elderly population and surgical management is indicated in the vast majority of cases. Osteosynthesis is an alternative to arthroplasty for non-displaced FNF. Triple screw construct (TS) and the Dynamic Hip Screw system (DHS) are considered gold standards for osteosynthesis. The newly available Femoral Neck System (FNS) currently lacks evidence as to whether it is a valid alternative to TS and DHS. The purpose of this study was to evaluate short-term clinical and radiological outcomes after non-displaced (Garden I and II) FNF osteosynthesis using TS, DHS, and FNS.

Methods: All the patients of the author's institution aged ≥ 75y with a non-displaced (Garden I and II) FNF eligible to osteosynthesis between November 2015 and December 2019 were included in this single-center retrospective non-randomized study. Patients were treated with either TS, DHS, or FNS depending on surgeon's preference. Clinical data (age, gender, duration of surgery, need for blood transfusion and number of packed red blood cells transfused, surgical site complications, length of stay, discharge location, postoperative medical complications, and readmission within 30 days, and mortality within 3 months) were extracted from patients' charts. Radiological analysis assessed fracture classification, fracture impaction, and proximal femur shortening at 3 and 6 months using the institutional imaging software.

Results: The TS (n=32), DHS (n=16), and FNS (n=15) groups were similar with respect to age (mean 85y) and gender (female: male ratio 4:1). There were no significant differences across groups for need for blood transfusion, surgical site complications, length of stay, postoperative medical complications, and readmission within 30 days, discharge location and mortality within 3 months. Duration of surgery was significantly lower in the FNS group (43.3 vs 68.8 min; p < 0.001). Radiological assessment found
similar impaction (5.2 mm ± 4.8) and shortening (8.6 mm ± 8.2) in all groups that did not seem to progress after 3 months.

**Conclusion:** The FNS appears to be a valid alternative implant for FNF osteosynthesis and is associated with shorter operative time than TS and DHS. Short-term clinical and radiological outcomes of FNS are similar to TS and DHS implants. Further long-term multi-center randomized studies are however necessary to confirm these first results.

**Disclosure of interest**

The authors declare that they have no conflict of interest.

**Key words**

Femoral neck fracture; elderly population; osteosynthesis; orthogeriatrics; FNS; Femoral Neck System; DHS; Dynamic Hip Screw; triple screws
**Background**

Femoral neck fractures (FNF) are common in the elderly population and are associated with significant morbidity and mortality [1]. Advanced age and comorbidities are associated with muscle weakness and osteoporosis, increasing the likelihood of falls and fractures [2]. It is estimated that at the age of 80, the risk of developing a fracture of the proximal femur is approximately 20% for women and 10% for men [3]. Optimal management of FNF in the elderly population involves multidisciplinary comanaged care itineraries, as well as a proper surgical indication in order to provide these patients with the best chances of favorable outcomes [4]. Surgical management of FNF is indicated in the vast majority of elderly patients and the indication to fix or to replace the fracture depends on fracture displacement and patient selection [5]. Elderly patients presenting with non-displaced (Garden I-II) FNF with a posterior tilt of >20° and those presenting with displaced (Garden III and IV) FNF will preferentially benefit from hip arthroplasty [6, 7, 8]. Stable non-displaced (Garden I and II) FNF may be managed with either hip arthroplasty or osteosynthesis [9] and the optimal treatment for such fractures is still subject to debate, depending on several parameters, including the amount of posterior tilt on the axial view [8], [10]. Osteosynthesis is associated with higher complication rates than arthroplasty, such as non-union (20 to 35%) [11], avascular necrosis of the femoral head (23%) [12], fracture impaction and consecutive abductor insufficiency (27%) [13]. This results in revision rates up to 3 times higher than with arthroplasty ranging from 10% to 49% [14, 15]. However, osteosynthesis has several advantages in this population, including a shorter operative time, less physiological stress [16], reduced blood loss and risk of infection [17]. Immediate full-weightbearing is usually allowed and low revision rates have been reported after FNF fixation. The most commonly used implants for non-displaced FNF fixation are the
triple screw construct (TS) and the Dynamic Hip Screw system (DHS) [18]. The TS technique consists in placing 3 cannulated screws in an inverted triangle configuration in the femoral neck, across the fracture site [19]. This construct provides good torsional stability, preserves blood flow to the femoral head and can be performed through a minimally invasive approach [20]. This technique, however, provides limited resistance to vertical shear forces at the fracture site [21]. The DHS is a 2-or more hole lateral buttress plate with a barrel angle between 130-150° and a sliding cervico-cephalic screw, which may be associated with a free anti-rotation screw, if needed [22]. Its design provides better resistance to vertical shear forces, but requires a larger incision for implantation and bears a higher risk of avascular necrosis of the femoral head [23]. A large international, multicenter, randomized controlled trial failed to show any difference in terms of outcomes between TS and DHS [24].

The Femoral Neck System (FNS) is a novel device available since 2018 [25]. This system combines a short lateral plate that holds one or 2 locking screws with a fixed-angle tunnel allowing a diverging blade and screw construct to recoil through the plate. Biomechanical studies of this novel implant report high resistance to shear, torsion and compression forces [26]. However, there is no in-vivo literature available to date regarding this new device. Therefore, the aim of the present study was to assess short term radiological and clinical outcomes after non-displaced (Garden I and II) FNF using the FNS, in comparison to TS and DHS.

**Methods**

All patients >75y admitted between November 2015 and December 2019 with a non-displaced FNF (Garden I and II, posterior tilt < 20°) and eligible for fixation were included in this retrospective single-center non-randomized study. Patients are cared
for by a multidisciplinary comanaged clinical pathway and no major changes were brought to this setup during the study period, besides rotation of team's members within the division. Surgery was performed by four residents supervised by a consultant, and by 7 staff surgeons mitigating the effect of advanced trauma surgeon experience on operative time. All data were collected in the fracture registry available in our institution. All patients were allowed to fully bear weight with crutches or a walking frame after surgery. The following clinical data were extracted from patients' charts: age, gender, duration of surgery, need for blood transfusion and number of packed red blood cells transfused, surgical site complications (local or implant infection, peri-implant fracture, scar dehiscence), length of stay (LOS), discharge location, postoperative medical complications and readmission within 30 days and mortality within 3 months. Standardized radiographic images were obtained pre-operatively, post-operatively, and at 3 and 6 months after surgery, as per standard institutional protocol. Radiological analysis of proximal femur shortening was assessed according to Zhang et al [27] and Felton et al [13] (Fig. 2). Impaction was calculated by analysis of the displacement of the screw normalized to the length of the barrel for DHS and FNS (Fig. 3-4), and by measurement of the recoil of the screws normalized to screw length for TS (Fig. 5). All measurements were performed using a dedicated web-based open-source PACS workstation DICOM viewer (Weasis medical viewer, available on https://nroduit.github.io/en/). All data were anonymized and stored in a computerized database.

Categorical variables were expressed as proportion, and for continuous variables, mean, standard deviations and ranges were reported. Patients' characteristics and outcomes were compared between groups (TS, DHS, FNS) using chi-square test or Fisher exact test for qualitative parameters, and linear regression model for quantitative parameters,
except length of stay, which was compared between groups using a Kruskal-Wallis test.

Finally, the overall effect of surgery on radiographic outcomes was assessed using mixed
effects linear regression models with random effect on patients and fixed effects on surgery and time, with no interaction term between fixed effects (i.e we hypothesized that the effect of surgery, if any, was the same at 3 and 6 months). Statistical significance was assessed at the two-sided 0.05 level for all analyses. All analyses were performed using R version 4.0.2. This study was carried out in accordance with the Chart of Helsinki. This study followed the recommendations of STROBE guidelines.

Results

Clinical outcomes:

We analyzed 681 patients with FNF, of which 576 were displaced and 105 were non-
displaced. Among non-displaced FNF, 42 were candidates to arthroplasty due to a posterior tilt > 20°, and 63 to osteosynthesis (Figure 1). The latter were classified as Garden I and II in 54 and 9 cases, respectively. Fracture fixation was performed with TS, DHS and FNS in 32, 16 and 15 patients respectively. The 3 groups were comparable for age, gender, and Garden classification. The mean age for TS, DHS and FNS groups was 85.0, 83.4 and 86.1, respectively (Table 1). The male-female ratio was 1 to 4. Average operative time for TS, DHS and FNS was 66.9, 70.7 and 43.3 minutes, respectively. The FNS group showed significant shorter intraoperative time than TS and DHS (p<0.001) (Table 2). The average LOS for TS, DHS and FNS was 12.2 days (range 5-30), 12.4 (range 8-27), and 10.3 (range 5-25), respectively. The shorter LOS in the FNS group did not reach statistical significance. At least one blood transfusion was necessary in 3 patients in the TS group, none in the DHS group and 1 in the FNS group. One single 30-day surgical postoperative complication was noted in the TS group warranting revision for
infection. No early surgical revisions due to technical error or failure of the implant were noted. Thirty-seven percent of all patients developed at least one medical complication within 30 days after surgery. These were noted in 14 (43%), 4 (24%) and 5 (26%) patients of the TS, DHS and FNS groups respectively, without reaching statistical significance. Overall, patient discharge was possible to a rehabilitation center, nursing facility and home in 63%, 25% and 11% cases, respectively. Transfer to a rehabilitation center was noted in 20, 11 and 9 patients in the TS, DHS and FNS groups, respectively. One case from the FNS group required hospital readmission at 30 days, due to an acute onset pulmonary edema. Overall three-months mortality was 8%, divided in 3 patients for the TS group, 2 patients for the DHS group and 0 patients for the FNS group.

Radiographic outcomes:

In our study population, 15 patients (24%) did not have any documented radiological follow-up, 13 (20%) had one 3 months x-ray and 35 (56%) had both 3- and 6-months x-ray. Reasons for incomplete radiological follow up were due to living abroad (4), death (5), refusal (1) and inability (18) to attend postoperative consultations. Radiographic analysis showed an average 5.2 ± 4.8 mm fracture impaction at 3 months when compared to immediate postoperative x-rays. The TS, DHS and FNS groups showed a similar mean impaction of 5.0 ± 4.5, 5.4 ± 6 and 5.5mm ± 4.4, respectively. In mixed linear regression model, the type of surgery had no statistically significant effect on impaction (p=0.872) and impaction was not statistically significantly different between 3 and 6 months (p=0.979). Analysis of proximal femur shortening at 3 months showed an average 8.6mm ascension of the trochanter with respect to the acetabular roof. The TS, DHS and FNS groups had an 8.4 ± 7.0, 8.3 ± 11.9 and 9.3mm ± 6.0 shortening, respectively. In mixed linear regression model, the type of surgery had no
Discussion

Fixation options for non-displaced FNF in the elderly population are associated with several advantages such as reduction in operative time and reduced blood loss in comparison to hip replacement surgery. To date, no implant has been proven superior to another for FNF osteosynthesis [28, 29]. The FNS is a novel implant designed to address the low resistance to shearing-forces of TS and allow better rotational stability than the DHS. To the best of the authors’ knowledge, no studies to date have evaluated the clinical and radiological outcomes of the FNS.

Operative time is an important factor when considering surgery in frail patients. Longer surgeries are associated with higher blood loss, longer anesthesia, higher infection rates and overall higher postoperative complication rates [30]. Our study found a significantly shorter operative time in the FNS group, with an average of 43.3 min (vs. 66.9 min). Eleven different surgeons (seven staff surgeons and four residents under supervision) have implanted the FNS and none had experience with this implant before the start of the study. Also, none of them has implanted the FNS more than 2 times. This finding highlights the relative simplicity of the FNS technique, despite a theoretical learning curve for this novel implant.

Anemia is a negative predictive factor for survival after hip fracture surgery [31]. As for TS and to a lesser extent the DHS, the FNS is designed to be implanted through a minimally invasive approach using a single lateral small-sized 2-3cm incision. Our study failed to identify any significant postoperative differences in the need for transfusion between groups, despite a theoretical larger incision and soft tissue trauma associated
with DHS. Moreover, it is possible that preoperative bleeding from the fracture site,
regardless of time to surgery, may be a confounding factor in the occurrence of
postoperative anemia. Our study did however not directly assess absolute hemoglobin
values pre and postoperatively.

In the light of the budgetary constraints and the economic burden of fragility fractures,
LOS is a much looked upon variable to measure quality of care and efficiency. The
average in-hospital stay in the study's population was 11.8 days. This is less than the
LOS of patients with arthroplasties for FNF (12.8 days, authors' institutional Elderly
Proximal Femoral Fracture Register, unpublished data). Our study suggests a trend
toward a shorter stay in the FNS group (10.4 days) without reaching statistical
significance. This potential shorter stay associated with FNS may be beneficial in terms
of resources available on the wards and lowering the burden on healthcare
professionals in charge of this highly dependent patient population.

Femoral neck fractures frequently result in an important loss of function despite
appropriate rehabilitation. One of the reasons for this is the occurrence of a limp, with or
without leg length discrepancy. Functional shortening of the femoral neck due to
fracture impaction, may result in the loss of the abductors moment of force on the
greater trochanter, resulting in weakness, pain and patient dissatisfaction [13]. In this
study, TS, DHS and FNS were associated with some degree of radiologic femoral neck
impaction and proximal femur shortening during follow-up. However, none of the
implants were significantly more prone to do so. From that perspective, despite our
small group of patients, the FNS seems to be at least as effective as other implants in
maintaining a stable fracture reduction. It is also important to acknowledge that, in
contrast to TS and DHS, some technical inaccuracies in choice of size and positioning of
the implants due to a lack of experience with this new implant may have negatively
influenced our outcomes. Despite this, no patient in the FNS group needed revision surgery due to technical error. This study has several limitations. First, it may be subject to methodological bias due to its retrospective and observational design. Secondly, clinical and radiological outcomes were reported with a low number of patients. This is due to the fact that non-displaced FNF are fairly uncommon as they represent 15% of all FNF (authors’ institutional Elderly Proximal Femoral Fracture Register, unpublished data). A larger scale study, possibly multi-center would be desirable to confirm our preliminary results. Also, the FNS has only been recently made available in the authors’ institution, providing less cases than TS or DHS to include in the analysis. Third, 24% of the patients were lost to follow-up in the current series, but this is in the range of most studies on FNFs in elderly patients. In a multicenter randomized trial on 201 patients comparing cemented and uncremented hemiarthroplasty, Moerman and al. found a 24% rate of loss to follow-up, which was mainly due to a high number of patients with cognitive disorders and high age of the participators who were unable to adhere to postoperative follow-up visits [32]. Fourth, our study was focused on short term outcomes, and hypothesized that most adverse events correlated with the use of the device (FNS, DHS or triple screws), would occur within 6 months after surgery. A long-term follow-up would be useful in detecting delayed complications such as AVN, as well as trochanteric pain. Fifth, we acknowledge that fracture healing evaluation with a CT-scan would have been more accurate to detect nonunion, but this is not performed routinely in our department, neither in most studies published on this topic. In a recent study evaluating the outcomes of intra-capsular non-displaced FNFs in 244 patients treated with cannulated screws, mechanical failure of fixation was identified on standard X-Rays, which is considered as the standard of care in this elderly population [33]. Lastly, this study was
not designed to evaluate the clinical correlation between secondary displacement of the
fracture and clinical or gait abnormalities.

Conclusion

To the best of the authors' knowledge, this is the first study to evaluate clinical and
radiological outcomes of the FNS. In comparison to TS and DHS, use of the FNS is
potentially associated with a significant shorter operative time, a non-significant shorter
LOS and appears to be as effective as TS and DHS in preventing early secondary fracture
displacement. The FNS appears to be a valid alternative to other FNF fixation techniques
in non-displaced FNF in the elderly population. Further high-quality, large volume, long-
term multi-center randomized studies are necessary to confirm these first results.
Declarations

Availability of data and materials:
The detailed datasets and materials of this study are available from the corresponding author through emails on reasonable request.

Ethics approval and consent to participate
The study was conducted in conformity with the local ethics committee (Commission Cantonale d’Ethique de la Recherche sur l’être humain du canton de Genève – CCER). Given the retrospective design of the study, patient consent was not required

Consent for publication:
Not applicable.

Competing interests:
The authors declare that they have no competing interests.

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Authors’ contributions:
OV carried out the conception and design of the study, was the major contributor for the acquisition and interpretation of data and drafted and critically revised the manuscript.
AG critically revised the manuscript.
DH critically revised the manuscript.
WB carried out the conception and design of the study, contributed to the interpretation of data and critically revised the manuscript.

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### Table 1: Characteristics of patients included

| Characteristics          | Modality | All (n=63) | TS (n=32) | DHS (n=16) | FNS (n=15) | pval |
|--------------------------|----------|------------|-----------|------------|------------|------|
| Age (y)                  | mean (sd)| 84.9 (6.4) | 85 (6.6)  | 83.4 (7.3) | 86.1 (4.6) | 0.48 |
|                          | median (IQR)| 85 (79 - 90) | 85 (79.8 - 90) | 81 (77.8 - 88.8) | 87 (85 - 88.5) | 0.48 |
|                          | range     | 75 to 100  | 75 to 100 | 76 to 98   | 75 to 92   | 0.48 |
|                          | missing   | 0          | 0         | 0          | 0          | 0.48 |
| Gender                   | Female (n(%)) | 50 (82) | 27 (84)  | 10 (62) | 13 (86) | 0.128 |
|                          | Male (n(%)) | 12 (19)   | 4 (12)   | 6 (36)   | 2 (13)   | 0.128 |
|                          | Missing   | 1          | 1         | -         | -         | 0.128 |
| Garden classification    | Garden I (n(%)) | 54 (86) | 30 (94)  | 10 (63) | 14 (93) | 0.021 |
|                          | Garden II (n(%)) | 9 (14)   | 2 (6)    | 6 (34)   | 1 (7)    | 0.021 |

Garden I: femoral neck fracture type incomplete subcapital impacted in valgus; Garden II: femoral neck fracture type complete subcapital without displacement.

TS: triple screw; DHS: Dynamic Hip Screw system; FNS: femoral neck system

### Table 2: Clinical outcomes for TS, DHS and FNS

| Characteristics          | Modality | All (n=63) | TS (n=32) | DHS (n=16) | FNS (n=15) | pval |
|--------------------------|----------|------------|-----------|------------|------------|------|
| Length of surgery (min)  | mean (sd)| 62.2 (23.6) | 66.9 (25.4) | 70.7 (20) | 43.3 (10.1) | <0.001 |
|                          | median (IQR)| 55 (46 - 76) | 63.5 (50 - 80) | 66 (53 - 83) | 42 (37.5 - 52.5) | <0.001 |
|                          | range     | 20 to 128  | 20 to 128 | 50 to 114  | 28 to 63   | <0.001 |
|                          | missing   | 0          | 0         | 0          | 0          | <0.001 |
| Blood transfusion (n(%)) | 0        | 59 (94)    | 29 (90)   | 16 (100)   | 14 (93)    | 0.466 |
|                          | 1        | 2 (3.2)    | 2 (6.3)   | -          | -          | 0.466 |
|                          | 2        | 2 (3.2)    | 1 (3.1)   | -          | 1 (6.7)    | 0.466 |
| Surgical site complications (n(%)) | 0 | 62 (98)    | 31 (97)   | 16 (100)   | 15 (100)   | 1.000 |
|                          | 1        | 1 (1.6)    | 1 (3.1)   | -          | -          | 1.000 |
| Length of stay (days)    | mean (sd)| 11.8 (5.9) | 12.2 (6.2) | 12.4 (5.3) | 10.3 (6)   | 0.001 |
|                          | median (IQR)| 10 (8 - 13.5) | 10 (8 - 15) | 10.5 (9 - 13.2) | 8 (6 - 10.5) | 0.131 |
|                          | range     | 5 to 30    | 5 to 30   | 8 to 27    | 5 to 25    | 0.131 |
|                          | missing   | 0          | 0         | 0          | 0          | 0.131 |
| Discharge location (n(%))| Rehabilitation | 40 (63) | 20 (63)  | 11 (69) | 9 (60) | 0.509 |
|                          | Home      | 7 (11)     | 2 (6)     | 3 (19)    | 2 (13)     | 0.509 |
|                          | Nursing home | 16 (2) | 10 (31)  | 2 (13)    | 4 (27)     | 0.509 |
| Medical complication (30 days) (n(%)) | 0 | 40 (63) | 18 (56) | 12 (75) | 10 (67) | 0.441 |
|                          | 1        | 7 (11)     | 4 (13)    | 1 (6)     | 2 (13)     | 0.441 |
|                          | 2        | 11 (17)    | 7 (22)    | 2 (13)    | 2 (13)     | 0.441 |
|                          | 3        | 2 (3)      | 1 (3)     | 1 (6)     | -          | 0.441 |
|                          | 4        | 2 (3)      | 1 (3)     | -         | 1 (6.7)    | 0.441 |
|                          | 5        | 1 (2)      | 1 (3)     | -         | -          | 0.441 |
### Table 3: Measure of impaction and shortening at 3 months and 6 months for TS, DHS, FNS

| Caracteristics | Modality | All (n=63) | TS (n=32) | DHS (n=16) | FNS (n=15) | pval |
|----------------|----------|------------|-----------|------------|------------|------|
| **Impaction**  |          |            |           |            |            |      |
| 3 months       | mean (sd) | 5.2 (4.8)  | 5 (4.5)   | 5.4 (6)    | 5.5 (4.4)  |      |
|                | median (IQR) | 4.9 (1.7 - 7.2) | 4.9 (2.5 - 6.6) | 2.6 (1.4 - 7.7) | 5.4 (1.8 - 9.4) |      |
|                | range     | 0 to 21.1  | 0 to 18   | 0.2 to 21.1 | 0.2 to 13.1 |      |
|                | missing   | 15         | 10        | 3           | 2          |      |
| 6 months       | mean (sd) | 5.4 (5.2)  | 5.4 (4.8) | 5.6 (5.9)  | 5 (6.7)    |      |
|                | median (IQR) | 4.7 (2.6 - 6.9) | 4.7 (3.2 - 5.9) | 4.5 (2 - 8.1) | 7.3 (3.4 - 8.9) |      |
|                | range     | -4.8 to 19.6 | 0 to 19.6 | -2.9 to 18.7 | -4.8 to 10.1 |      |
|                | missing   | 30         | 13        | 6           | 11         |      |
| Global         |          |            |           |            |            | 0.872|
| Δ 3-6 months   |          |            |           |            |            | 0.979|
| **Shortening** |          |            |           |            |            |      |
| 3 months       | mean (sd) | 8.6 (8.2)  | 8.4 (7.0) | 8.3 (11.9) | 9.3 (6.0)  |      |
|                | median (IQR) | 8.3 (2.4 - 12.1) | 8.6 (4.3 - 12.6) | 8.4 (0.3 - 11.4) | 8.3 (5.7 - 13.3) |      |
|                | range     | -6.2 to 42 | -6.2 to 22.3 | -4.1 to 42 | 1.1 to 22 |      |
|                | Missing   | 15         | 10        | 3           | 2          |      |
| 6 months       | mean (sd) | 7.0 (9.0)  | 8.1 (10.3) | 4.9 (7.9)  | 6.7 (4.0)  |      |
|                | median (IQR) | 6 (1.2 - 10.5) | 5 (2.5 - 11.4) | 6.7 (-2.3 - 12.4) | 7.8 (4.9 - 9.6) |      |
|                | range     | -5.8 to 38.9 | -3.9 to 38.9 | -5.8 to 13.6 | 1.2 to 10.1 |      |
|                | missing   | 30         | 13        | 6           | 11         |      |
| Global         |          |            |           |            |            | 0.982|
| Δ 3-6 months   |          |            |           |            |            | 0.218|

Surgical site complications include local or implant infection, peri-implant fracture, scar dehiscence.

Medical complications include heart failure, respiratory failure, urinary tract infection, pulmonary embolism.

TS: Triple screw; DHS: Dynamic Hip Screw system; FNS: femoral neck system

TS: Triple screw; DHS: Dynamic Hip Screw system; FNS: femoral neck system
Fig 1: Flow chart showing the distribution of fractures by implants.
Fig 2: Calculation of proximal femur shortening with DHS, TS and FNS. Postoperative and 3 months X-ray.

Shortening (mm) = \((D0 \times \frac{L3}{L0}) - D3\)
Fig 3: Calculation of impaction with DHS implant. Postoperative and 3 months X-ray.

\[ \text{Impaction DHS (mm)} = (L_0/X_0-L_3) \times L_3 \]
Fig 4: Calculation of impaction with FNS implant. Postoperative and 3 months X-Ray

Impaction FNS (mm) = (L0/X0-L3/X3)* L3
Fig 5: Calculation of impaction with TS implant. Postoperative and 3 months X-ray.

Impaction TS (mm) = D0/D3 * R3
Figures

Figure 1

Flow chart showing the distribution of fractures by implants.
Figure 2

Calculation of proximal femur shortening with DHS, TS and FNS. Postoperative and 3 months X-ray

\[ \text{Shortening (mm)} = (D_0 \times \frac{L_3}{L_0}) - D_3 \]
Impaction DHS (mm) = (L0/X0-L3)*L3

Figure 3

Calculation of impaction with DHS implant. Postoperative and 3 months X-ray.
Impaction FNS (mm) = (L0/X0-L3/X3) * L3

Figure 4

Calculation of impaction with FNS implant. Postoperative and 3 months X-Ray.
Figure 5

Calculation of impaction with TS implant. Postoperative and 3 months X-ray.

Impaction TS (mm) = \( \frac{D0}{D3} \times R3 \)