

## ORIGINAL ARTICLE / ОРИГИНАЛНИ РАД

# Operation time and intraoperative fluoroscopy time in different internal fixation methods for subtrochanteric fractures treatment

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## SUMMARY

**Introduction/Objective** Subtrochanteric fractures are unstable, tending to a varus, antecurvatum, and shortening deformity.

The aim of this paper was to compare operation time and fluoroscopy time between different internal fixation methods in the treatment of subtrochanteric fractures.

**Method** The prospective study of the group of 27 patients with a subtrochanteric fracture treated by the SIF (selfdynamisable internal fixator with a trochanteric unit) method had been done. Operation time and fluoroscopy time values from this group were compared to the same parameters data from the literature for intramedullary (IM) nails, proximal femur locking plates (PF-LCP), dynamic condylar screws (DCS), and the 95°-angled blade plate.

**Results** In the SIF group, operation time was 62.2 (25–140) minutes and fluoroscopy time was 43 (20–95) s. Average operation time from the literature data was: 102.1 (43–181) minutes for IM nail, 94.2 (75–129) minutes for PF-LCP, 105.3 (70–166) minutes for DCS and 221.5 (171–272) minutes for blade plate. Average fluoroscopy time from the literature data was: 109.6 (34–250) seconds for IM nail, 102.3 (47–180) seconds for PF-LCP, 238 seconds for DCS. Operation time and intraoperative fluoroscopy time were higher in IM nail, PF-LCP, DCS and blade plate comparing to SIF method ( $p < 0.05$ ).

**Conclusion** The above mentioned difference could be explained by a degree of required accuracy in the initial operative technique maneuvers, by used number of screws and by the type of the fracture reduction performance in different fixation methods. Operation time during IM nailing of subtrochanteric fractures sometimes can be shorter than average operation time in SIF method, what could be explained by the skill of the surgeon to perform as fast closed reduction for insertion of guide wire.

**Keywords:** selfdynamisable internal fixator; subtrochanteric fractures; dynamisation

## INTRODUCTION

Subtrochanteric fractures occur in 3.2/100,000 population per year and are often pathological in nature [1]. They are more common in females and in patients who have been taking bisphosphonates. They are defined as extending from the lesser trochanter to 3–5 cm distally although there are other definitions [1, 2, 3]. Subtrochanteric fractures are almost always displaced, being in antecurvatum, varus, and external rotation position by the effect of muscles attached to the fractured area. That is the reason for a frequent occurrence of malunion with hip contracture in non-operative treatment of these fractures, thus giving poor functional results. External fixation can provide good final results after proper postoperative treatment. Disadvantages of external fixation are postoperative discomfort for the patient and a risk of infection around the pins; hence, this fixation method is used predominately when the operative intervention is considered a big life risk factor or for the treatment of open subtrochanteric fractures. Internal fixation is

the most used treatment method for subtrochanteric fractures today [4].

These fractures are commonly managed with intramedullary (IM) nails, proximal femur locking plates (PF-LCP), dynamic condylar screws (DCS), and 95°-angled blade plates [5–15]. Selfdynamisable internal fixator (SIF) with a trochanteric unit (Figure 1) is a new-generation implant used in the treatment of several thousand patients in many clinics including our institution [16–21].

In this paper, operation time and intraoperative fluoroscopy time between the SIF method and IM nail, PF-LCP plate, DCS, and blade plate have been compared.

## METHODS

Operation time and intraoperative fluoroscopy time were analyzed in the group of 27 consecutive cases with SIF internal fixation of a subtrochanteric fracture. These surgical interventions were performed at the Clinic for Orthopaedics and Traumatology of the Clinical Center of Niš

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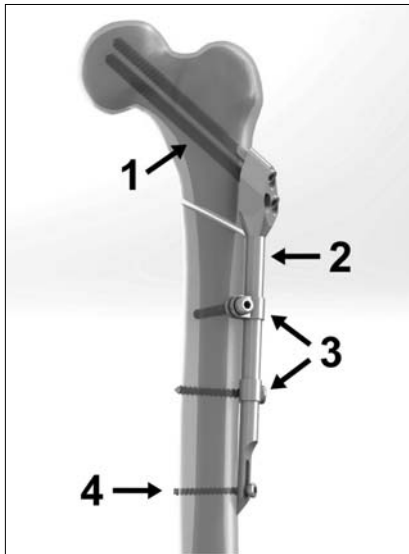
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**Figure 1.** Selfdynamisable internal fixator with a trochanteric unit: (1) lag screws; (2) implant body; (3) clamps with screws for clamps; (4) dynamic antirotational screw; clamps are initially locked, but biomechanical forces can lead to their spontaneous unlocking (without the need for additional surgery) if the union is delayed or absent

between March 1, 2011 and November 1, 2012. We had analyzed the series of patients treated during 2011 and 2012 because the registration of accurate data of intraoperative fluoroscopy time was being performed on the regular bases at that time. SIF internal fixation is the method of choice at our center. In our and other 24 centers, this method has already been applied to 2,500 patients for the internal fixation of trochanteric and subtrochanteric fractures. Aforementioned parameters were calculated for the average values and evaluated for linear correlation.

Operation time and intraoperative fluoroscopy time were also evaluated for values taken from other published papers regarding internal fixation of subtrochanteric fractures with IM nail, PF-LCP, DCS, and 95°-angled blade plate. Average parameters values for each fixation method were analyzed statistically in relation to the values of the SIF group.

Above-mentioned implants are classified into two groups: implants without axial dynamic fixation feature (PF-LCP, DCS, and blade plate) and implants with axial dynamic fixation feature (IM nail and SIF). Axial dynamic fixation of subtrochanteric fractures includes the possibility of controlled fractured fragments sliding along the long axis of the femur, which is a desirable factor to provide compression and further healing of the fracture in some patients. It is still not possible to predict which fracture (patient) will require dynamization in the post-surgery time. Nevertheless, fixation has to be rigid in the initial after-surgery time and the dynamization could be needed later, after several weeks. IM nail method provides the transition from initially rigid to dynamic fixation mode by additional later surgery (interlocking screw removal). In the SIF method, this transition happens spontaneously, without any need for additional surgery, by the clamps spontaneous “unlocking” resulted from the effect of biomechanical forces on initially locked clamps (if the heal-

ing process is slow or absent, resulting in longer implant load-bearing time) [16–22].

Statistical analysis was performed by the use of Student's t-test and linear correlation analysis in IBM SPSS Statistics, Version 22.0 (IBM Corp., Armonk, NY, USA) with the significance level set at  $p < 0.05$ .

## RESULTS

Average operation time was 62.2 (25–140) minutes, and average intraoperative fluoroscopy time was 43.9 (21–95) seconds in the group of patients with subtrochanteric fracture treated by the SIF method.

Averages of values taken from the literature for subtrochanteric fracture fixation regarding operation time were as follows: 102.1 (43–181) minutes for IM nail, 94.2 (75–129) minutes for PF-LCP, 105.3 (70–166) minutes for DCS, and 221.5 (272–171) minutes for 95°-angled blade plate. Average values from the literature regarding fluoroscopy time were as follows: 109.3 (34–250) seconds for IM nail, 102.3 (47–180) seconds for PF-LCP, and 238 seconds for DCS. No values were found for fluoroscopy time in subtrochanteric fracture fixation using the 95°-angled blade plate (Table 1) [5–15].

**Table 1.** Average operation time and intraoperative fluoroscopy time for different internal fixation methods in subtrochanteric fractures treatment; the values for the intramedullary nail, proximal femur locking plates, dynamic condylar screws and 95°-angled blade plate were taken from the literature and are placed inside the parentheses

Method	Operation time (minutes)	Fluoroscopy time (seconds)
SIF (trochanteric)	62.2	43.9
IM nail	102.1 (181, 166, 93, 82, 48, 43)	109.6 (250, 45, 34)
PF-LCP	94.2 (129, 91, 82, 75)	102.3 (180, 80, 47)
DCS	105.3 (166, 80, 70)	238 (238)
95° blade plate	221.5 (272, 171)	

IM – intramedullary nails; PF-LCP – proximal femur locking plates; DCS – dynamic condylar screws

The average operative time and average fluoroscopy time from the SIF group were significantly shorter ( $p < 0.05$ ) in relation to the average values for IM nail, PF-LCP, DCS, and 95°-angled blade plate calculated by the use of data taken from the literature.

Pearson correlation coefficient for correlation between operative time and fluoroscopy time in the SIF group was  $r = 0.482$ .

The results of this study can however be compared as a reference statement, rather than a real indication that the SIF is better.

## DISCUSSION

Longer intraoperative time in subtrochanteric fractures treatment using the 95°-angled blade plate and DCS could be explained by the need for achieving reduction before the implant placement procedure. This is required due to

the necessity for proximal part of the implant to be at a certain angle to the previously displaced femoral shaft. This statement is supported by the fact that the average intraoperative time was longer in the blade plate in comparison to the DCS method. Actually, the blade plate is not an adjustable implant and its placement requires more precise 3D orientation of the surgeon than the use of the DCS method (DCS is somewhat adjustable due to the rotation of its cylindrical part introduced in a trochanteric mass). Thus, it could be suggested that higher adjustability of the implant impacts the average operation time.

In addition to the aforementioned reasons, longer operative time in PF-LCP in relation to the SIF method of subtrochanteric fractures treatment could be explained by the higher number of screws in the PF-LCP method. Higher number of screws affects both the operation time and the fluoroscopy time. Longer fluoroscopy time is here primarily caused by the implantation of screws for the proximal femoral fragment, as it is important for the hip screws not to pass behind the medial cortex or into the hip joint.

IM nail fixation requires at least partially closed reduction of the subtrochanteric fracture before introducing a guide-wire into the distal fragment medullary canal. Because of the type of subtrochanteric fracture displacement, closed reduction is often hard to be performed, resulting in repeated fracture reduction and guide-wire introduction maneuvers, and hence in longer operation time and longer fluoroscopy time. However, in some papers, the average operation time of the IM nail method is similar to the SIF group in this paper.

It should be kept in mind that the introduction of the IM nail in the distal medullary canal does not always provide the correct reduction of some forms of the subtrochanteric fracture. There are some papers presenting the subtrochanteric fracture with a varus reduction after the IM nail fixation and with good final results after a switch to an extramedullary fixation (Figure 2) [23].

The SIF implantation does not require previous reduction of a subtrochanteric fracture. It could be enough to

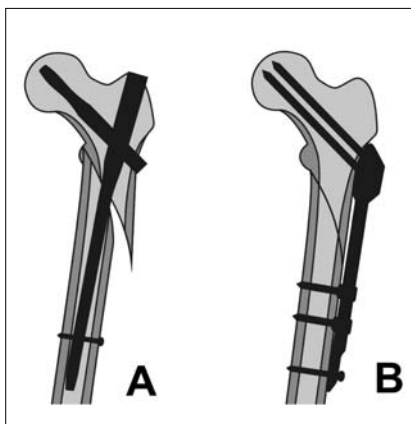
introduce one lag screw parallel to the femoral neck axis. Afterwards, fracture reduction is performed indirectly – by leaning of the implant body to the femoral shaft; the implant body position is adjusted by its rotation around the axis of the implanted lag screw (Figure 3). This type of reduction and fixation could be considered as a factor for a shorter average operation time. In this reduction and fixation method, fluoroscopy can be needed during the insertion of lag screws in the femoral neck only, contributing to a shorter average fluoroscopy time.

Pearson's coefficient was  $> 0.3$ , supporting the statement that there is a correlation between the operative time and the fluoroscopy time in the SIF group (longer operation time is followed by longer fluoroscopy time). However, the coefficient of  $< 0.8$  rejected this correlation as a strong one, and this is supported by the fact that some of the highest values for the fluoroscopy time were in the cases with almost average values of the operation time. This could be explained by the occasional need for repeated K-wire insertions in the femoral neck before taking a good position for the lag screw, requiring more intraoperative fluoroscopy in a not too long operative time.

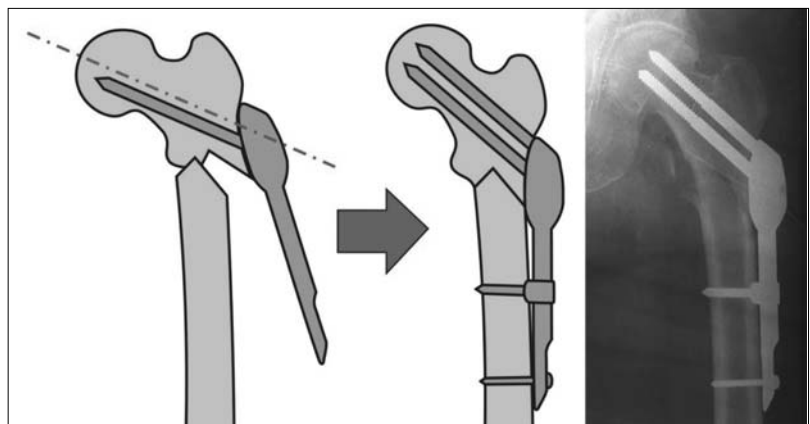
Dynamic hip screw (DHS) was not suggested in this paper as one of the most used methods in the treatment of subtrochanteric fractures, due to already confirmed higher frequency of postoperative complications in relation to other methods of internal fixation. Results of earlier studies referred that these complications were almost always associated with medial cortex comminution, which is a very common condition, making subtrochanteric fractures unstable [7, 24, 25].

Excessive sliding of a lag screw in unstable subtrochanteric fractures treated by the DHS can result in medialization of the femoral shaft. Medialization of more than one third of the femoral shaft diameter is followed by a seven times more likely fixation failure, including implant breakage [26, 27].

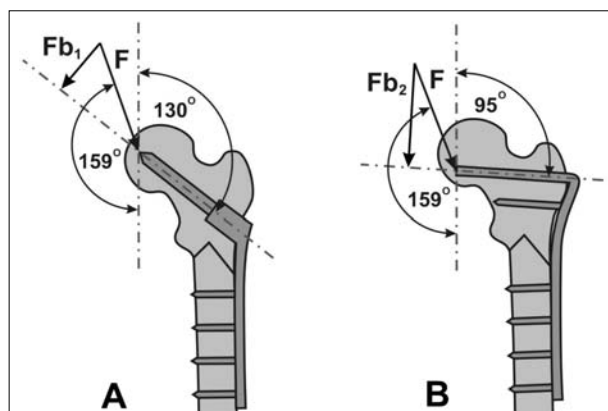
In an earlier study on 49 consecutive patients with a subtrochanteric fracture treated by the SIF method it was



**Figure 2.** (A) Possible malreduction after intramedullary nailing of a reverse subtrochanteric fracture; (B) extramedullary fixation provides a more accurate and reliable reduction of this fracture type



**Figure 3.** A scheme and an X-ray of subtrochanteric fracture reduction using the self-dynamisable internal fixator method; the first lag screw is positioned parallel to the femoral neck axis, and other screws are implanted after "joystick" reduction of the fracture and adjusting of the implant body position



**Figure 4.** Compression strength in the medial cortex area of a subtrochanteric fracture is higher in a 95°-angled blade plate (B) than in the dynamic hip screw method (A) due to the difference of bending force intensity;  $F$  – hip load force at the moment of one leg standing during walking;  $F_b$  – bending force that induces a varus cyclic elastic deformation and hence the compression in the medial cortex area

stated that bone healing was achieved in all cases, without the need for surgical revision, and three patients had bone union in varus angulation of less than 10° [19].

The difference in after-surgery complications rate between the DHS and SIF implants can be explained by the fact that the DHS method provides dynamization in just one axis (femoral neck axis) and the SIF implant provides dynamization in two axes (both femoral neck axis and femoral shaft axis). Stabilization of an unstable subtrochanteric fracture after SIF surgery is achieved by the dynamization more in the femoral shaft axis and less in the femoral neck axis. Thus, the excessive medialization of the femoral shaft is rarely obtained in the SIF in comparison to the DHS method in subtrochanteric fractures treatment. Biaxial dynamization could also be the reason for the lower rate of complications in the IM gamma nail method (surgery is performed after the interlocking screw removal) in relation to the DHS method, for subtrochanteric fractures.

The fact that, according to the literature, results of subtrochanteric fractures treatment are more acceptable for the DCS than for the DHS method could today be explained by the need for these fractures to have compression in the area of the medial cortex. Actually, implants without the feature for dynamization in the femoral shaft axis, such as DHS and DCS, can provide this compression only by their own cyclical elastic deformations in the varus direction as a result of everyday biomechanical forces in the hip region. Most of the biomechanical load is transferred to the proximal femur when one leg is standing during walking. It had been determined that the angle of this force vector makes an angle of 159° in relation to the femoral shaft [28, 29].

Due to the difference between the DCS and DHS implants' body angles, force-inducing varus bending elastic

deformation (component of the hip load force) has different values between these two fixation types, higher in the DCS method. Thus, the compression force in the medial cortex of the subtrochanteric fracture is higher in the DCS than in the DHS method (Figure 4).

It could be considered that the absence of dynamization in the femoral shaft axis in the DCS and DHS methods is partially "compensated" by the above-mentioned cyclic elastic deformations of the implant. However, cyclic bending forces are relatively high risk for implant fatigue breakage, especially in patients with delayed bone union.

In the treatment of subtrochanteric fractures, some surgeons sometimes use the SIF with the condylar unit. This implant has two thick locking screws with an angle of 95° to the body of the implant. The principle of cyclical elastic deformations, described above for DCS, can be regarded as a risk for fatigue breakage of the condylar SIF implant, but only for a few weeks, during the initial (rigid) phase of the fixation (before spontaneous "unlocking" of the clamps and consequent dynamization of the implant). Higher range of the cyclical varus deformation in the condylar SIF implant may be considered as a factor for earlier "unlocking" of the clamps' initiation, in relation to when trochanteric SIF implant is used. This would be a hypothesis in some further studies.

Entry-point for condylar SIF locking screws in this way is located more proximally than entry-point for trochanteric SIF lag screws. This feature can make condylar SIF more desirable in some types of subtrochanteric fractures than the trochanteric SIF implant.

## CONCLUSION

Operative time and fluoroscopy time in internal fixation of subtrochanteric fractures using a trochanteric SIF implant have in average lower values than in the use of DCS, PFLCP, IM gamma nail, or a 95°-angled blade plate.

It was observed that the operation time in subtrochanteric fractures treatment can be similar between the trochanteric SIF and IM gamma nail fixation. Despite relatively short operation time and minimally invasive surgery in the IM nail method, one should have in mind that extramedullary fixation can provide more accurate reduction and fixation in some shapes of subtrochanteric fractures.

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## Време операције и интраоперативне флуороскопије код различитих метода унутрашње фиксације суптрохантерних прелома

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### САЖЕТАК

**Увод/Циљ** Суптрохантерни преломи су нестабилни преломи са тенденцијом ка варусу, антекурватуму и деформитету скраћења.

Циљ овог рада је упоређивање дужине операције и времена интраоперативне флуороскопије између различитих метода унутрашње фиксације суптрохантерних прелома.

**Методе** Анализирана је група од 27 болесника са суптрохантерним преломом, који су лечени унутрашњом фиксацијом СУФ методом (самодинамизирајући унутрашњи фиксатор са трохантерном јединицом). Ове вредности су потом упоређиване са вредностима истих параметара из литературе за ИМ клин (интрамедуларни клин), *PF-LCP*, *DCS* и угаону плочу од 95°.

**Резултати** У СУФ групи просечна дужина операције је била 62,2 (25–140) минута, а време интраоперативне флуороскопије је било 43 (20–95) секунде. Средње вредности резултата из литературе у вези са временом операције су биле: 102,1 (43–181) минута за ИМ клин, 94,2 (75–129) минута за *PF-LCP*,

105,3 (70–166) минута за *DCS* и 221,5 (171–272) минута за угаону плочу. Просечно трајање интраоперативне флуороскопије, према литератури, било је: 109,6 (34–250) секунди за ИМ клин, 102,3 (47–180) секунде за *PF-LCP* и 238 секунди за *DCS*. Време операције и интраоперативне флуороскопије је било значајно краће код СУФ групе у односу на резултате осталих наведених метода из литературе ( $p < 0,05$ ).

**Закључак** Наведена разлика у трајању операције и интраоперативне флуороскопије би могла да се објасни потребним степеном прецизности у почетној фази имплантације фиксационог материјала, коришћеним бројем фиксационих завртњева, као и начином репозиције прелома који одређује фиксациона метода омогућава. Време трајања операције код фиксације ИМ клином некада може бити краће него код СУФ методе, што се може објаснити умешношћу хирурга да у краћем року изврши затворену репозицију суптрохантерног прелома адекватну за пласирање игле водиле.

**Кључне речи:** самодинамизирајући унутрашњи фиксатор; суптрохантерни прелом; динамизација