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Original Article / Оригинални рад

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

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

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SUMMARY

Introduction/Objective Subtrochanteric fractures are unstable, tending to varus, antecurvatum and shortening deformities.

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

Methods The prospective study of the group of 27 patients with subtrochanteric fracture treated by the SIF (Self-dynamisable Internal Fixator with trochanteric unit) method had been done. Operation time and fluoroscopy time values from this group were compared to same parameters data from the literature for IM nail, PF-LCP, DCS and 95-angled blade plate.

Results In SIF group, operation time was 62.2 (25–140) min and fluoroscopy time was 43 (20–95) s. Average operation time from the literature data was: 102.1 (43–181) min for IM nail, 94.2 (75–129) min for PF-LCP, 105.3 (70–166) min for DCS and 221.5 (171–272) min for blade plate. Average fluoroscopy time: 109.6 (34–250) s for IM nail, 102.3 (47–180) s for PF-LCP, 238 s 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 maneuver 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; dynamization

САЖЕТАК

Увод/Циљ Суптрохантерни преломи су нестабилни преломи са тенденцијом ка варус, антекурватум 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 СИФ 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 СИФ групи просечна дужина операције је била 62.2 (25–140) *min*, а време интраоперативне флуороскопије је било 43 (20–95) *s*. Средње вредности резултата из литературе везано за време операције су биле: 102.1 (43–181) *min* за ИМ клин, 94.2 (75–129) *min* за *PF-LCP*, 105.3 (70–166) *min* за *DCS* и 221.5 (272–171) *min* за угаону плочу. Просечно трајање интраоперативне флуороскопије је према литератури било: 109,6 (34–250) *s* за ИМ клин, 102,3 (47–180) *s* за *PF-LCP* и 238 *s* за *DCS*. Време операције и интраоперативне флуороскопије је било значајно краће код СИФ 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 одређена фиксациона метода омогућава. Време трајања операције код фиксације ИМ клином некада може бити краће него код СИФ методе, што се може објаснити умешношћу хирурга да у краћем временском року изврши затворену репозицију суптрохантерног прелома адекватну за пласирање игле водиље.

Кључне речи: самодинамизирајући унутрашњи фиксатор; суптрохантерни прелом; динамизација

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 [1–3]. Subtrochanteric fractures are almost always displaced, being in antecurvatum, varus and external rotation position by the effect of muscles attached to fractured area. That is the reason for a frequent occurrence of malunion with hip contracture in non-operative treatment of these fractures, thus giving bad functional results. External fixation can provide good final results after proper postoperative treatment. Disadvantages of external fixation are postoperative discomfort for patient and risk of infection around the pins, so this fixation method is used predominately when the operative intervention is considered as a big life risk factor or for the treatment of open subtrochhanteric fractures. Internal fixation is the most used treatment method for subtrochanteric fractures today [4].

The fractures are commonly managed with intramedullary nails (IM nail) and proximal femur locking plates (PF-LCP); previous fixation methods also included dynamic condylar screws (DCS) and 95-degree-angled blade plates [5–15]. Self-dynamisable Internal Fixator (SIF) with trochanteric unit (Figure 1) is new generation implant used in the treatment of several thousand patients in many clinics including our institution [16–21].

In this paper it has been performed comparison of operation time and intraoperative fluoroscopy time between SIF method and IM nail, PF-LCP plate, DCS and blade plate.

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 Clinic for orthopaedics and traumatology in Clinical Center Niš between 01.03.2011. and 01.11.2012. We had analyzed the series of patients treated during 2011 and 2012, because at that time had been performed registration of accurate data of intraoperative fluoroscopy time on the regular bases. SIF internal fixation is method of choice in our Centre. In our and other 24 centers this method has already been applying to two thousand and five hundred patients for internal fixation of trochanteric and subtrochanteric fractures. Above parameters were calculated for 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-degrees-angled blade plate. Average parameters values for each fixation method were analyzed statistically in relation to the values of SIF group.

Above mentioned implants are classified in two groups: implants without axial dynamic fixation possibility (PF-LCP, DCS and blade plate) and implants with axial dynamic fixation possibility (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 desirable factor to provide compression and further healing of the fracture in some patients. It is still not possible to predict in advance which fracture (patient) will require dynamization in the postsurgery time. Anyway, 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 SIF method this transition happens spontaneously, without need for additional surgery, by the clamps spontaneous "unlocking" resulted from the effect of biomechanical forces on initially locked clamps (if the healing 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 SPSS 22 software, with significance for $p < 0.05$.

RESULTS

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

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

Average operative time and average fluoroscopy time from the SIF-t group were significantly shorter ($p < 0.05$) in relation to average values for IM nail, PF-LCP, DCS and 95-degrees-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 95-degrees-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 in certain angle to the previously displaced femoral shaft. This statement is supported by the fact that average intraoperative time was longer in blade plate in comparison to DCS method. Actually, blade plate is not adjustable implant and its placement requires more precise 3D orientation of the surgeon than during the use of DCS method (DCS is somewhat adjustable due to the rotation of its cylindrical part introduced in a trochanteric mass). Thus, there could be suggested that higher adjustment of the implant implies average operation time.

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

IM nail fixation requires at least partial closed reduction of the subtrochanteric fracture before introducing of 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, average operation time of IM nail method was in some papers similar in comparison to SIF group in this paper.

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

SIF implantation doesn't require the previous reduction of subtrochanteric fracture. There could be enough to introduce one lag screw parallel to the femoral neck axis. Fracture reduction is afterward performed indirectly – by leaning of the implant body to the femoral shaft; implant body position is adjusted by its rotation around the axis of implanted lag screw (Figure 3). This type of reduction and fixation could be considered as a factor for shorter average operation time. In this reduction and fixation method fluoroscopy can be needed during insertion of lag screws in the femoral neck only, contributing shorter average fluoroscopy time.

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

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, what is very common condition making subtrochanteric fractures unstable [7, 24, 25].

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

An earlier study on 49 consecutive patients with subtrochanteric fracture treated by SIF method referred about achieved bone healing in all cases, without the need for revision surgical and three patients had bone union in varus less than 10 degrees [19].

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

The fact that, according to the literature, results of subtrochanteric fractures treatment are more acceptable for DCS than for DHS method today could 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 femoral shaft axis, such as DHS and DCS, can provide this compression only by own cyclical elastic deformations in the varus direction as a result of everyday biomechanical forces in the hip region. Proximal femur undergoes the most biomechanical load in the moment of one leg standing during the walk. It had been determined that the angle of this force vector makes an angle of 159 degrees in relation to the femoral shaft [28, 29].

Due to the difference between 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 DCS method. Thus the compression force in the medial cortex of the subtrochanteric fracture is higher in DCS than in DHS method (Figure 4).

It could be considered that the absence of dynamization in femoral shaft axis in DCS and DHS method is partially "compensated" by 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.

There is an explanation of the SIF method of action, however not real mention of the risk of malunion in a system that "unlock", and allows for fracture displacement (which can often be unpredictable).

Unlocking of clamps of SIF, according to more than 4 thousand already applied implants for treatment of upper femur (2.5 thousand for trochanteric and subtrochanteric fractures), shaft and distal femur, is predictable. However there is some risk of excessive dynamization in highly comminuted fractures. To prevent such risk, we use higher moment during the screwing of clamps screws. Risk of nonunion is decreased as dynamization always provides contact between main bone fragments but it is not topic of this paper.

In the treatment of subtrochanteric fractures some surgeons sometimes use Seldynamisable Internal Fixator with condylar unit. This implant has two thick locking screws with angle of 95 degrees 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 condylar SIF implant, but only a few weeks, during initial (rigid) phase of the fixation (before spontaneous “unlocking” of clamps and consequent dynamization of implant). Higher range of cyclical varus deformation in condylar SIF implant may be considered as a factor for earlier “unlocking” of clamps initiation, in relation 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 as more desirable in some types of subtrochanteric fractures than trochanteric SIF implant.

CONCLUSION

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

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

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Table 1. Average operation time and intraoperative fluoroscopy time for different internal fixation methods in subtrochanteric fractures treatment; values for IM nail, PF-LCP, DCS and 95° blade plate were taken from the literature and it is put in the brackets.

	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)	

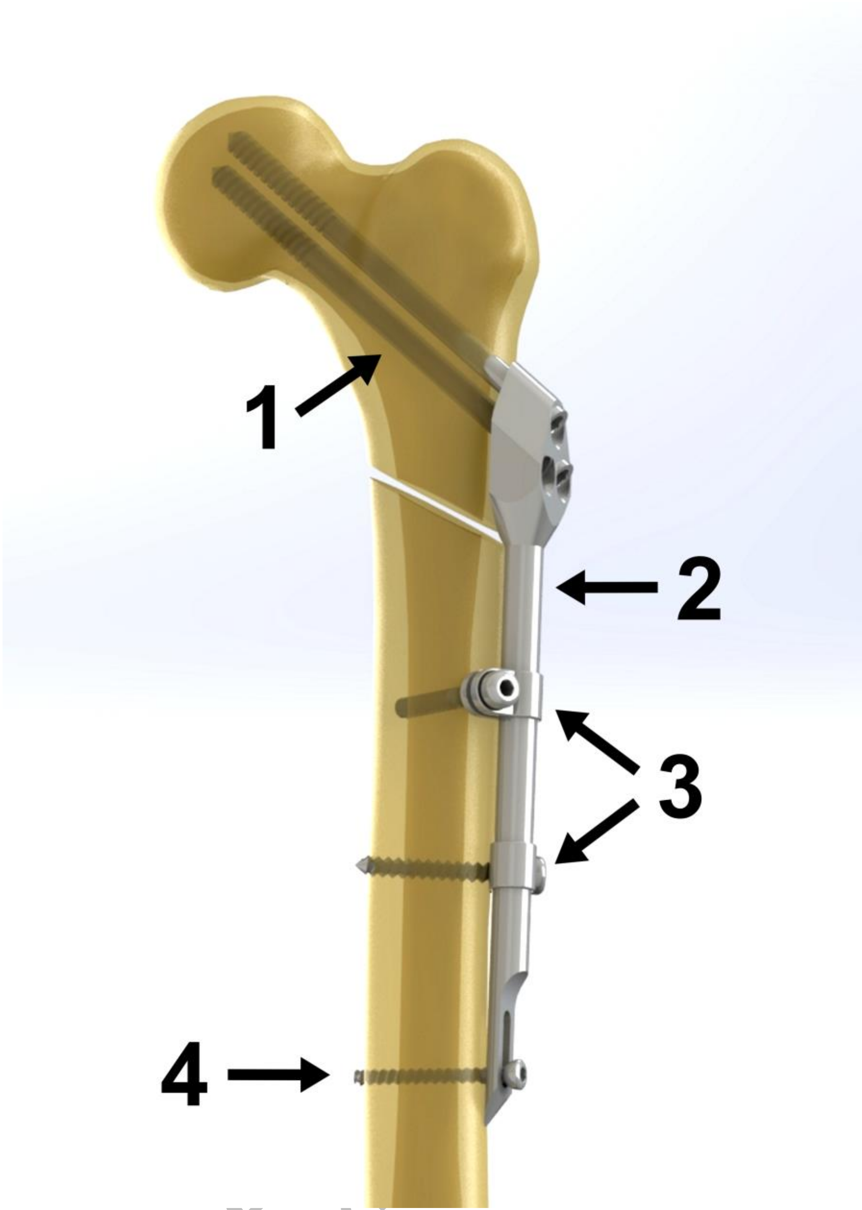

Figure 1. Selfdynamisable internal fixator (SIF) with trochanteric unit: lag screws (1), implant body (2), clamps with screws for clamps (3), dynamic antirotational screw (4); clamps are initially locked, but biomechanical forces can lead to its spontaneous unlocking (without need for additional surgery)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

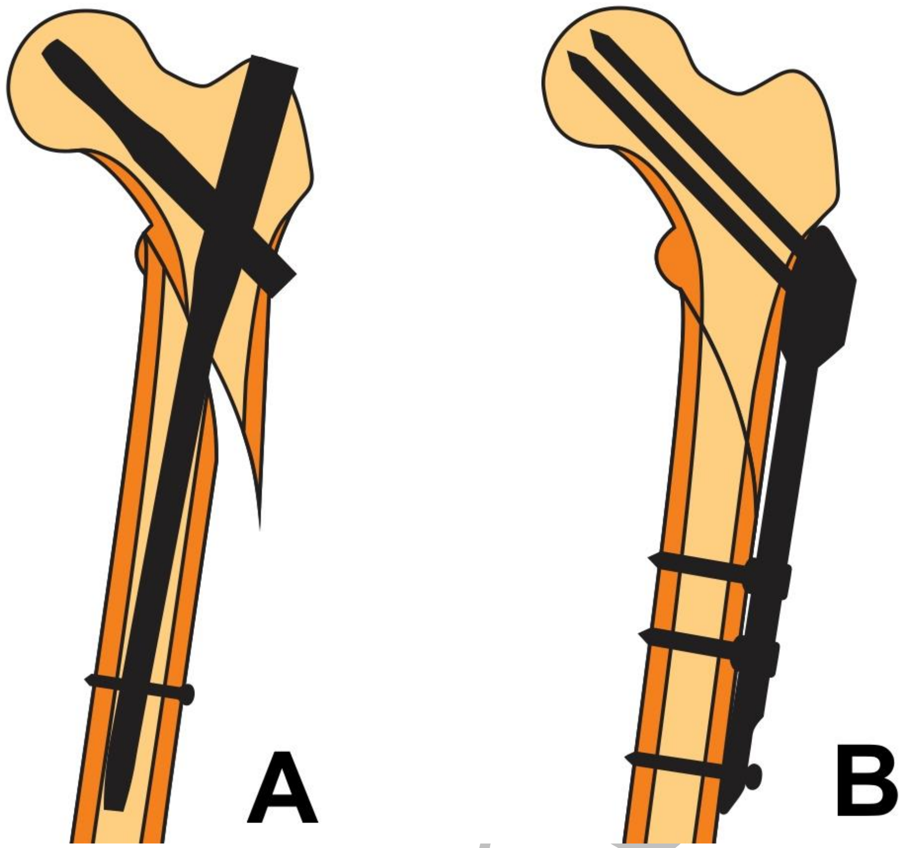

Figure 2. Possible malreduction after IM nailing of reverse subtrochanteric fracture (A); extramedullary fixation provides more accurate and reliable reduction of this fracture type (B).

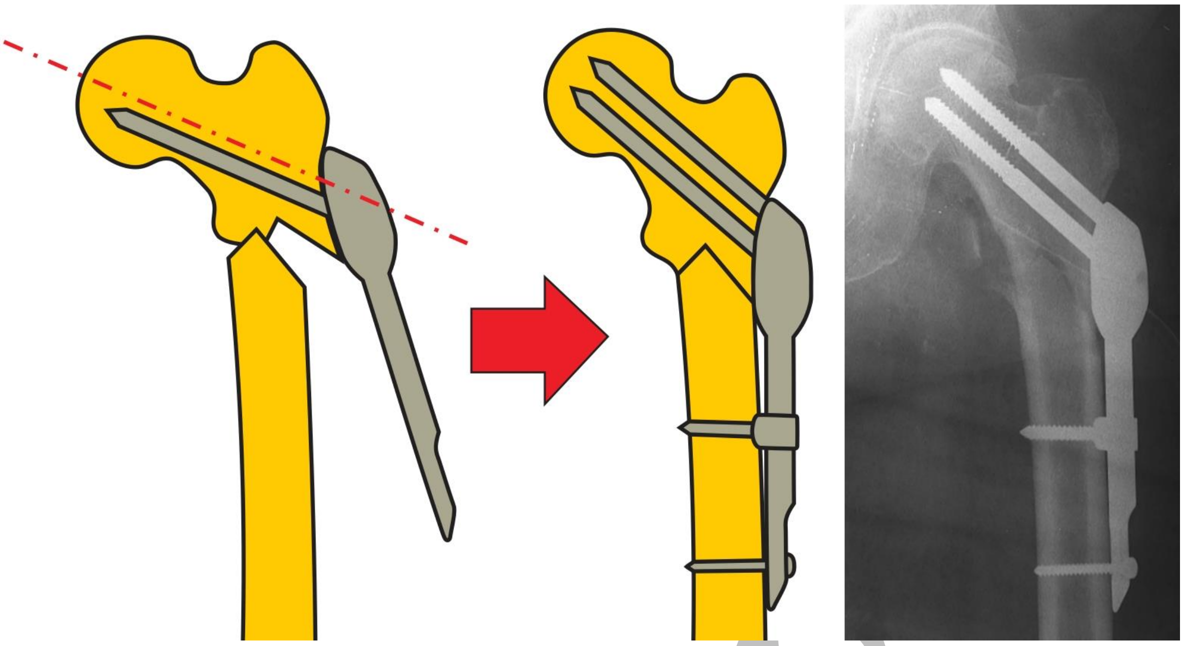

Figure 3. The scheme and X-ray of subtrochanteric fracture reduction using SIF method; first lag screw is positioned parallel to the femoral neck axis and other screws are implanted after "joystick" reduction of the fracture and adjusting of the implant body position.

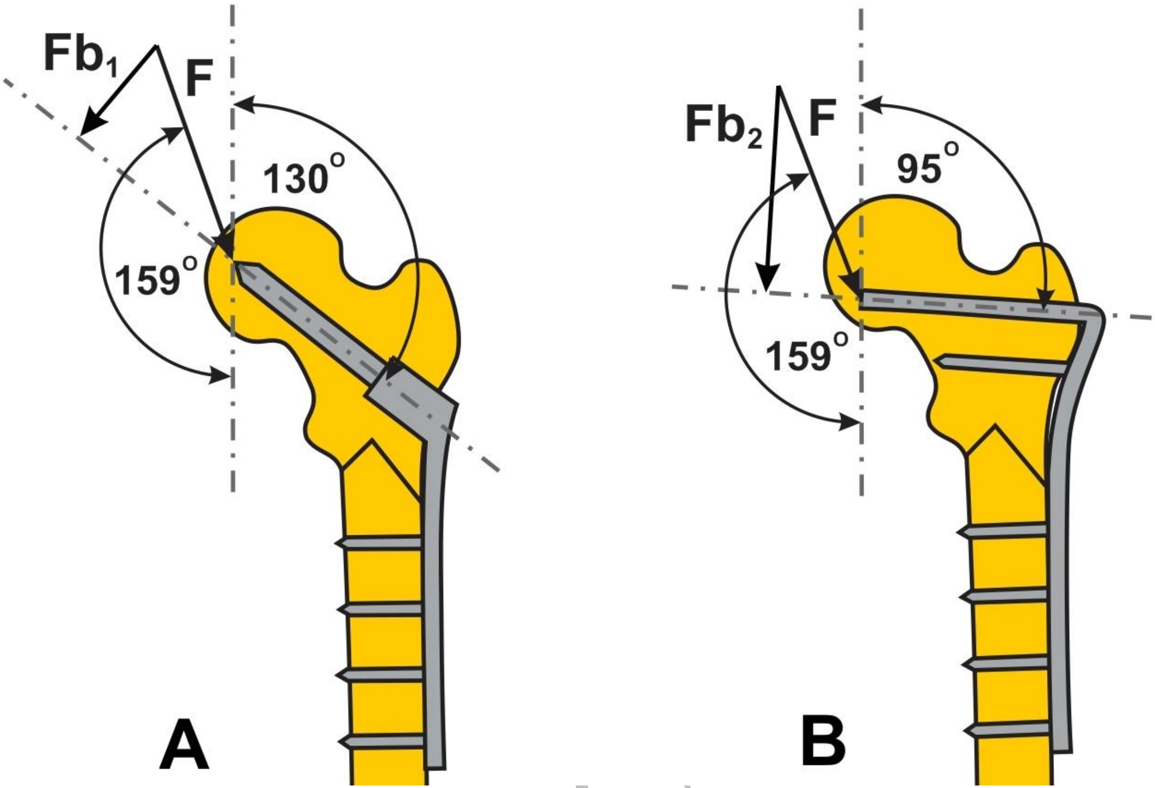

Figure 4. F – hip load force in the moment of one leg standing during the walk; Fb – bending force that induce varus cyclic elastic deformation and hence the compression in the medial cortex area; compression strength in the medial cortex area of a subtrochanteric fracture is higher in 95° blade plate (B) than in DHS method (A) due to the difference of bending force intensity.