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Comparative analysis of operation time and intraoperative fluoroscopy time in intramedullary and extramedullary fixation of trochanteric fractures

Uporedna analiza trajanja operacije i intraoperativne fluoroskopije kod intramedularne i ekstramedularne fiksacije trohanternih preloma

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Abstract

Background/Aim. Cephalomedullary and extramedullary methods are used for the internal fixation of trochanteric fractures. The usage of the third generation Gamma Nail (GN) is a gold standard in this kind of treatments. Self-dynamisable Internal Fixator (SIF) is an extramedullary implant for trochanteric fractures' treatment. The aim of this study was to compare these two methods regarding operation time and intraoperative fluoroscopy time. **Methods.** A total of 89 patients with a surgical treatment of a trochanteric fracture were included in this study. There were two groups of patients – GN group (43 patients) and SIF group (46 patients). **Results.** Average operation times were 67.5 min (GN group) and 56.0 min (SIF group). Average intraoperative fluoroscopy times were 84.8 s (GN group) and 36.7 s (SIF group). The difference between the groups was statistically significant for both of the given parameters ($p < 0.05$). The correlation between operation time and intraoperative fluoroscopy time was confirmed in the SIF group ($p < 0.05$; r = 0.405), while it was not confirmed in the GN group ($p > 0.05$). There was a higher variability in the GN method than in the SIF method regarding the duration and type of repeated surgical maneuvers followed by X-ray checks. **Conclusion.** The number of planned surgical interventions per day could depend on the type of trochanteric fracture internal fixation (intramedullary or extramedullary). Certain additional analyses including radiation dose assessment are desirable to clarify if shorter intraoperative fluoroscopy time in the SIF method can have the influence regarding intraoperative X-ray protection clothing. If there is the need to activate dynamization in long femoral axis after initial static fixation in that axis, the SIF method provides its spontaneous activation several weeks after the surgery without the need neither for additional surgery nor for additional intraoperative fluoroscopy.

Key words:
external fixators; femoral fractures; fluoroscopy; internal fixators; intraoperative period; orthopedic procedures.

Apstrakt

Uvod/Cilj. Zbrinjavanje trohanternih preloma butne kosti se najčešće vrši metodama intramedularne i ekstramedularne unutrašnje fiksacije. Primena Gama klina (GK) treće generacije, kao intramedularne metode, se smatra zlatnim standardom u ovoj oblasti. Samodinamizirajući unutrašnji fiksator (SUF) predstavlja ekstramedularni implantat koji se, između ostalog, koristi u lečenju trohanternih preloma. Cilj rada je bio da se uporede navedene metode fiksacije u pogledu dužine trajanja operacije i intraoperativne fluoroskopije. **Metode.** Studijom je bilo obuhvaćeno 89 bolesnika sa hirurški zbrinutim trohanternim prelomom. Ispitanici su bili podeljeni u dve grupe – GK grupu (43 bolesnika) i SUF grupu (46 bolesnika). **Rezultati.** Prosečno trajanje operacije iznosilo je 67,5 min (GK grupa), odnosno 56,0 min (SUF grupa). Prosečno trajanje intraoperativne fluoroskopije iznosilo je 84,8 s (GK grupa) i 36,7 s (SUF grupa). Između grupa ispitanika je postojala značajna statistička razlika u pogledu oba navedena parametra ($p < 0,05$). Povezanost između trajanja operacije i trajanja intraoperativne fluoroskopije bila je potvrđena u SUF grupi ($p < 0,05$; r = 0,405), ali ne i u GK grupi ($p > 0,05$). GK metoda je pokazala veću varijabilnost u odnosu na SUF metodu po pitanju trajanja i vrste repetitivnih hirurških manevara koji zahtevaju rendgensku proveru. **Zaključak.** Broj planiranih operacija u jednom danu može biti određen vrstom unutrašnje fiksacije trohanternih preloma (intramedularna ili ekstramedularna). Potrebne su dodatne analize koje uključuju i procenu doze

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zračenja kako bi se proverilo da li prosečno kraća intraoperativna fluoroskopija kod SUF metode može uticati na korišćenje opreme za zaštitu od rendgenskog zračenja od strane medicinskog osoblja. Ukoliko je poželjno postoperativno aktivirati inicijalno blokiranu dinamizaciju u uzdužnoj osi butne kosti, SUF metoda omogućava da se to ostvari bez potrebe za naknadnom hirurškom intervencijom sa dodatnom intraoperativnom fluoroskopijom.

Ključne reči:
fiksatori, spoljni; femur, prelomi; fluoroskopija; fiksatori, unutrašnji; intraoperativni period; ortopedske procedure.

Introduction

Trochanteric fractures are osteoporotic fractures, mainly occurring in the elderly [1, 2]. These fractures are an important socioeconomic factor influencing life quality [3]. The relation between trochanteric and femoral neck fractures, as a type of osteoporotic hip fractures, is a variable in different parts of the world, confirming the influence of genetic and environmental factors in their incidence. Femoral neck fractures are more present in Northern Europe, while trochanteric fractures more occur in Central and Southern Europe [4]. Horii et al. [5] found that trochanteric fractures incidence rapidly grows in relation to femoral neck fractures after the eighth decade of life.

Internal fixation is the most common type of trochanteric fractures treatment. The analysis of operation time can be useful both in the daily planning of operative programs (number of operations) and in anesthesia administration. Intraoperative fluoroscopy time is important to be analyzed, primarily regarding the adequate protection of medical staff who are exposed to X-rays daily. There are different data in the bibliography about comparative analysis of intramedullary and extramedullary trochanteric fractures fixation concerning operation time and intraoperative fluoroscopy time. These data mainly refer to the comparison between cephalomedullary methods and Dynamic Hip Screw (DHS).

Gold standard in trochanteric fractures' internal fixation is the usage of the third generation of Gamma Nail (GN), as an intramedullary method with a cannulated lag screw [6–9]. Trochanteric fractures with pertrochanteric component (i.e. fracture line extending in lower-medial direction from the greater trochanter) require the use of lag screws [6, 9]. Self-dynamisable Internal Fixator (SIF) is an extramedullary implant being in routine use at many centers, predominantly for femoral fractures fixation. There are diverse types of SIF implants. The type having a "trochanteric unit" includes the use of lag screws for femoral neck and head [10–13]. The "trochanteric unit" is available in two modes – the mode with multiple thinner non-cannulated lag screws and the mode with one wider cannulated lag screw.

The aim of this study was to compare an intramedullary and an extramedullary method of pertrochanteric fractures' internal fixation – the third generation GN and SIF with two non-cannulated lag screws in terms of operation time and intraoperative fluoroscopy time.

Methods

Two groups of patients with a unilateral trochanteric fracture having a pertrochanteric component were analyzed in this study – 43 patients treated by the third generation GN (GN group) and 46 patients treated by SIF with two lag screws (SIF group). Regarding the AO Foundation/Orthopaedic Trauma Association (AO/OTA) classification based on preoperative and intraoperative X-ray analysis by the authors, all cases included 31-A1 and 31-A2 fractures, but also 31-A3 fractures accompanied by a pertrochanteric fracture line. Both groups included consecutive cases treated at the Clinic for Orthopaedics and Traumatology in Clinical Center Niš (Niš, Serbia) by all working surgeons from the Clinic after January 1st, 2012. There were 67% female and 33% male patients. The average age of the patients was 73.4 years in the GN group and 76.2 in the SIF group. The fixation method used (intramedullary or extramedullary) depended on every surgeon's preference for the method he was more familiar with.

GN used in this study was the third generation short GN. The type of SIF used had a "trochanteric unit" with three holes for non-cannulated lag screws. In all cases with this implant, the proximal fracture fragment was fixed by two lag screws. Three lag screws can be used in patients with a very wide femoral neck, but there was no such case in this study. When using just two lag screws, the triangular configuration of these holes gives an opportunity for the surgeon to make the choice for the more adequate of the two possible positions for the lower lag screw after the application of the first (upper) lag screw. Fixation of the distal fracture fragment included one screw passing the hole of the clamp and another screw (antirotation screw) passing the oblong hole in the implant body. The main role of the clamp is expressed when the lateral cortex is fractured distally to the lag screws and if the dynamisation in the long femoral axis is advisable. A fully screwed screw for the clamp initially blocks that dynamisation, while local biomechanical forces can spontaneously unlock the clamp several weeks after the surgery, thus spontaneously activating the dynamisation in the long femoral axis (Figure 1). Locking of the GN can be performed initially in dynamic or in static mode (the surgeon can sometimes assess that initially dynamic mode cannot provide sufficient initial fracture stability). If there is the need to transform the GN fixation postoperatively from the initially rigid (static) to a dynamic mode in the long femoral axis, some additional surgery of locking screw removal has to be performed.

Operation time (min) and intraoperative fluoroscopy time (s) were analyzed in patient groups. Operation time was measured as the time between the initial surgical incision and final suture. Intraoperative fluoroscopy was read on the screen of the C-arm used.

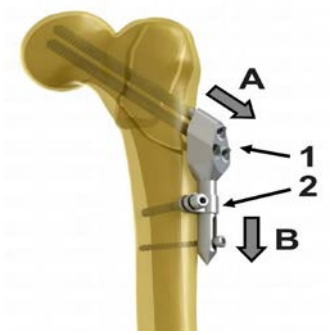

Fig. 1 – Self-dynamisable Internal Fixator (SIF) in a trochanteric fracture.
1 – trochanteric unit; 2 – clamp; A – dynamization in the femoral neck axis; B – dynamization in the long femoral axis, which is spontaneously activated after delayed unlocking of the clamp by local biomechanical forces if the contact between fracture fragments is insufficient.

The operative technique of SIF in trochanteric fractures treatment was followed by fluoroscopy in three phases of the surgery – checking the position of the K-wire for femoral neck and head, checking the first lag screw position and the final check of the fixation (Figure 2).

The GN method was succeeded by intraoperative fluoroscopy checks in all of the phases mentioned above, but also in additional phases such as checking the elastic guide-wire position and checking the vertical level of implant body before the K-wire admission to the femoral neck and head.

Statistics for average values comparing included *t*-test and Mann-Whitney *U* test. Bivariate correlation, by Spearman's correlation coefficient, was analyzed between the given parameters [14].

Results

In relation to the SIF group, average operation time and intraoperative fluoroscopy time were significantly higher in the GN group ($p < 0.05$) (Table 1).

The highest values of operation time and intraoperative fluoroscopy time (115 min; 176 s) were in the GN group, while the lowest values (20 min; 16 s) were in the SIF group.

The correlation between operation time and intraoperative fluoroscopy time was confirmed in the SIF group ($p < 0.05$) and this correlation was low positive ($0.3 < r < 0.5$). The correlation was not confirmed in the GN group ($p > 0.05$) (Table 2).

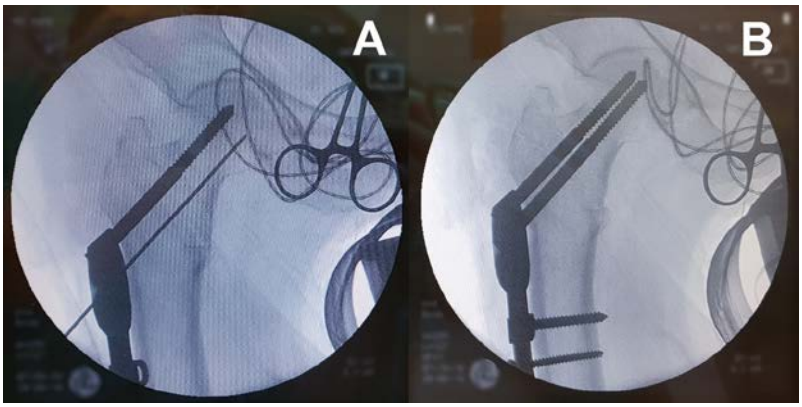

Fig. 2 – Intraoperative fluoroscopy is required in three phases of trochanteric fracture surgery by Self-dynamisable Internal Fixator (SIF): A) checking the position of just a K-wire and implant body, checking the position of the first lag screw and a K-wire with implant body; B) final check of the fixation.

Table 1

Operation time and intraoperative fluoroscopy time in trochanteric fractures' treatment by the third generation Gamma Nail (GN) and by Self-dynamisable Internal Fixator (SIF)

Parameter	GN group (mean ± SD)	SIF group (mean ± SD)	t/z	*p*
Operation time (min)	67.5 ± 17.1	56.0 ± 17.0	3.195	0.002*
Intraoperative fluoroscopy time (s)	84.8 ± 30.2	36.7 ± 19.8	-7.079	< 0.001†

*__t__-test; †Mann-Whitney *U* test; SD – standard deviation.**

Table 2

Correlations between operation time and intraoperative fluoroscopy time in trochanteric fractures' treatment by the third generation Gamma Nail (GN) and by Self-dynamisable Internal Fixator (SIF)

Statistical parameter	GN group	SIF group
Spearman's correlation coefficient (r)	0.267	0.405
Significance (*p*)	0.173	0.005

Discussion

Longer average operation time in the GN group could be explained by a more frequent need for intraoperative fluoroscopy in an intramedullary method than in an extramedullary method due to the reduced visual exposure of the implant position. Also, the fixation by GN includes more guiding instruments than the fixation by SIF. Every guiding instrument involves additional manual maneuvers of the surgeon, thus prolonging the operation time. Rimming of the medullary canal is a maneuver specific to intramedullary fixation, which is a factor for longer operation time as well.

Shorter average intraoperative fluoroscopy time in the SIF group could be explained by a more frequent need for intraoperative fluoroscopy in intramedullary methods than in extramedullary methods of fixation, as explained for the longer operation time too. Namely, as above-mentioned, the SIF method in trochanteric fractures treatment is followed by fluoroscopy in three phases of the surgery – checking the position of the K-wire for femoral neck and head, checking the first lag screw position and the final check of the fixation. The GN method is also succeeded by intraoperative fluoroscopy checks in these three phases, but also in additional phases such as checking the elastic guide-wire position, as well as checking the vertical level of implant body before the K-wire admission to the femoral neck and head.

Correlation between operation time and intraoperative fluoroscopy time was confirmed in the SIF group. The correlation was low positive, i.e. longer intraoperative fluoroscopy is expected to be followed by longer operation time and vice versa, but there was no high proportion in this relation. On the other hand, the correlation was not confirmed in the GN group. This could be explicated by the assumption that, in cephalomedullary fixation, the need for repetitive X-ray checks is variable depending on the phases of the surgery. This means that repetitive X-rays are in some cases more needed, e.g. during a K-wire setting, while in other cases they are more needed in elastic guiding wire admission, etc. Different phases of the surgery are followed by different durations of appropriate surgical maneuvers and hence by different time required for its repetitive performance. Furthermore, that additional time is sometimes not significant considering total operation time or very short duration of the maneuver. The surgical procedure of the SIF method in the trochanteric fractures treatment is followed by the requirement for repetitive X-ray checks mostly in the first phase (checking the position of the K-wire for femoral neck and head), while the second and third phases are mostly not followed by the necessity for repetitive fluoroscopy (the second phase can be followed mostly by one additional X-ray check due to the possible need for the first lag screw correction). The variation in the requirement for repetitive X-ray checks regarding surgical phases thus could be considered as lower in the SIF than in the GN method, which explains the difference in the correlations of operation time and intraoperative fluoroscopy time between the groups.

Alonso et al. [15] analyzed scatter radiation around the C-arm and they found that the lead protection is a must within 2 m of the C-arm unit. Operative technique of trochanteric fractures fixation by SIF allows the surgeon to stay at the distance of 2 meters and more from the C-arm while performing intraoperative fluoroscopy in all phases of the surgery. However, some phases of the GN method, as in other cephalomedullary methods, require the surgeon to be next to the operating table and C-arm (during entry point positioning, elastic guiding wire admission or the phases with very short repetitive maneuvers) [16, 17]. Based on the point of view above [15], we could infer that X-ray protective clothes (protective apron, thyroid shield) are not strictly to be used in trochanteric fractures fixation by the SIF implant, while it is strictly recommended during the GN fixation.

Kelly et al. [18] found that trochanteric fractures' internal fixation (including both intramedullary and extramedullary methods) was accompanied by significantly higher doses of radiation if cumulative intraoperative fluoroscopy time exceeded 50 seconds and if operation lasted longer than one hour [18]. Having obtained the results of average operation time and average intraoperative fluoroscopy time, we may assume that the average dose of radiation could be expected to be significantly higher in the GN group than in the SIF group. This statement, if accepted as true, could contribute to the deductions derived above about X-ray protective clothing. However, additional studies including the dose of radiation analysis are recommended so as to verify this statement.

Dynamisation in the femoral neck axis is important in trochanteric fractures with a pertrochanteric component, providing significant interfragmentary transfer of the load [19]. This dynamisation does not have to be blocked at the first postoperative time due to a lot of cancellous bone in the fracture area. In other trochanteric fractures, it may be beneficial to provide dynamization in the long femoral axis. When the implant with a lag screw is used, the dynamization in the long femoral axis can be achieved if the fracture has the line extending laterally below the entry point of a lag screw [20]. Furthermore, this line can sometimes be overlooked if standard X-rays are used and a comminutive trochanteric fracture can be misconsidered as just a pertrochanteric fracture (31-A1 or 31-A2) [21]. In some cases with a trochanteric fracture fixation which is primarily rigid in the long femoral axis (as in static locking of a short GN), the need to transform the fixation into longitudinally dynamic mode can be manifested in the weeks after the surgery [21]. The transformation of the GN fixation into longitudinally dynamic mode requires some additional surgery in terms of the intervention with the locking screw including additional fluoroscopy, too. When SIF is used, initially blocked longitudinal dynamisation can be activated by spontaneous partial unlocking of the clamps as the result of local biomechanical forces [22, 23], thus excluding the need for additional surgery and for additional intraoperative fluoroscopy [21, 24]. The amount of biomechanical forces' energy passing through the clamp is greater if the fracture healing is prolonged, ie. if the fracture fragments' contact is

insufficiently long. The clamp can be unlocked if this energy exceeds its specific amount, so SIF can be considered as an "intelligent implant" that "recognizes" the need for dynamization in the long femoral axis, providing its activation "by itself", thus being the only implant with this feature today [10–13, 24].

Regarding the bibliographic data about the third generation GN, Sim et al. [25] found the average operation time was 85 min, while Kelly et al. [18] found the average intraoperative fluoroscopy time was 116 s. Furthermore, Wu et al. [26], Unger et al. [27] and Arirachakaran et al. [28] found average operation times were 67 min, 56 min and 62 min, respectively, while average intraoperative fluoroscopy times were 52 s, 62 s and 109 s, respectively which implies that all these intraoperative fluoroscopies were longer than 50 s.

The similarity between DHS and SIF may be attributed to extramedullary principles in both methods. Kelly et al. [18] analyzed DHS fixation of trochanteric fractures, where intraoperative fluoroscopy time was 39 s, almost identical as in the SIF group in our study. Muller et al. [29] and Arirachakaran et al. [28] found that average operation times in DHS fixation of trochanteric fractures were 63 min and 54 min, respectively. These results are similar to the ones for SIF in our study (average operation time in the SIF group held the value between the two above mentioned average results for DHS).

Conclusion

Operation time and intraoperative fluoroscopy time are expected to be longer if the third generation GN is used as an intramedullary method in relation to the use of SIF as an extramedullary method. Operation time duration can have the influence in the number of surgical interventions per day. Additional analyses including radiation dose assessment are desirable in order to clarify if shorter intraoperative fluoroscopy time in the SIF method can influence the choice of medical staff X-ray protection clothing during the surgery of trochanteric fractures fixation.

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