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Unstable intertrochanteric fractures: How to prevent uncontrolled impaction and shortening of the femur

Nestabilni intertrohanterni prelomi: kako sprečiti nekontrolisanu impakciju i skraćenje femura

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Abstract

Background/Aim. Unstable intertrochanteric (IT) fractures, especially fractures with a reverse or transverse fracture line, have tendencies to make significant impaction on shortening of the femoral neck and lower extremity. The biomechanical complexity of the fracture, the type and the position of the implant are known to influence postoperative outcome. The aim of this study was to compare characteristics of two versions of dynamic hip implants in controlling the dynamization of unstable IT fractures of the femur. **Methods.** In the prospective study that included 1,115 patients with fractures of the proximal femur, 61 patients had IT fractures with a reverse or transverse fracture line. All the patients were treated surgically with the same implant in two versions: Dynamic Hip Screw – DHS-MB-S implant with a rigid part of standard length (40 mm) and DHS-MB-I implant, with a rigid part of the implant individualized for each patient depending on the transverse diameter of the proximal femur. The patients were under gradual radiographic and clinical control. Six months postoperatively we measured the length of the extremity and the degree of the medialization of the distal part of the femur. **Results.** All the fractures healed six months after the operation. Medialization and shortening of the extremity were significantly less in the group with fractures fixed by the DHS-MB-I implant, in which length of the rigid part of the implant was preoperatively measured individually for each patient. **Conclusion.** In order to achieve a desired functional result, the control of dynamisation in unstable IT fractures is significant in the fixation of these fractures of the femur. We presented possible methods to realize it by the contact of the rigid part of our implant with medial cortex of the proximal fragment of the femur.

Key words:
hip fractures; orthopedics; prostheses and implants; contracture; movement; prognosis.

Apstrakt

Uvod/Cilj. Nestabilni intertrohanterni (IT) prelomi, naročito frakture sa reverznom ili poprečnom frakturnom linijom, imaju tendenciju ka značajnoj impakciji i skraćenju femoralnog vrata i donjeg ekstremiteta. Kompleksnost preloma, tip i položaj implantata mogu značajno da utiču na postoperativni ishod lečenja. Cilj ove studije bio je da se uporede karakteristike dve verzije dinamičkog implantata kuka u kontroli dinamizacije nestabilnih IT preloma femura. **Metode.** U prospektivnoj studiji koja je uključila 1 115 bolesnika sa prelomom proksimalnog dela butne kosti, 61 bolesnik imao je IT prelom sa reverznom ili transverznom frakturnom linijom. Svi bolesnici lečeni su hirurški istim tipom implantata u dve verzije: *Dinamic Hip Screw* – DHS-MB-S implantat sa standardnom dužinom krutog dela (40 mm) i DHS-MB-I implantat, čiji je kruti deo prilagođen svakom bolesniku zavisno od transverzalnog prečnika proksimalnog femura. Bolesnici su kontrolisani u pravilnim vremenskim razmacima, klinički i radiografski. Šest meseci postoperativno merili smo dužinu ekstremiteta i stepen medijalizacije distalnog dela femura. **Rezultati.** Sve frakture zarasle su tokom šest meseci od operacije. Medijalizacija i skraćenje femura bili su značajno manje izraženi u grupi u kojoj su frakture fiksirane DHS-MB-I implantatom, u kojoj je dužina krutog dela implantata preoperativno merena individualno, za svakog bolesnika ponaosob. **Zaključak.** U cilju postizanja željenih funkcionalnih rezultata, kontrola dinamizacije kod nestabilnih IT preloma je značajna za fiksaciju ovih fraktura. Pokazali smo da je kontaktom krutog dela implantata sa medijalnim korteksom proksimalnog fragmenta moguće uspešno kontrolisati dinamizaciju i tako sprečiti nepoželjnu medijalizaciju i skraćenje donjeg ekstremiteta.

Ključne reči:
kuk, prelomi; ortopedija; proteze i implantati; kontraktura; pokretljivost; prognoza.

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Introduction

Fixation of unstable intertrochanteric (IT) fractures still does not completely solve the problem. Operative procedures for the reduction and fixation of IT fractures are technically challenging. Reoperation rates of 4% to 12% have been reported following the standard technique of fixation with a sliding compression hip screw [1–5].

Using fixation with dynamic characteristics leads to a significant interfragmentary transfer of the load and the decrease of postoperative complications. The deficiency of this fixation method is seen in uncontrolled impaction of main fragments and shortening of the femur neck in unstable fractures (AO/OTA 31-A3) [6] with a significant comminution of the posteromedial cortex [2, 4].

In unstable IT fractures with a reverse fracture line there is no bone barrier, which leads to uncontrolled medialisation of the distal fragment. Attempts to solve this problem with rigid implants have added lateral barriers on the implant itself, implants with biaxial dynamisation and intramedullary implants have not given a definite solution and have been followed by complications [3, 4, 7–9].

The way we deal with this problem introduces a new concept of controlled impaction and dynamisation. The concept has been realized by introducing an implant which can control the process of impaction and medialisation of the distal fragment. This process is made by the contact of the rigid part of the implant and the medial cortex of the proximal fragment.

We have not so far found in literature any other attempt to use the cortical structure of the medial cortical complex of the proximal fragment in fixation of IT fractures.

We designed a new dynamic hip implant that rigidly controls rotation of the proximal fragment of the fractured femur with two parallel head neck screws [10]. Besides that, the implant can control the level of impaction and medialisation of the distal fragment which is achieved by the contact of the rigid part of the implant and the medial cortex of the neck. Choosing different lengths of the rigid part of the implant allows individualization of the contact of the femur and the implant [11].

Methods

From 1995 to 2001 a total of 1,115 patients with a hip fracture were treated in the Orthopaedic-Trauma Ward of the General Hospital in Požarevac. There were 705 extracapsular fractures in 682 patients. In the study group, 61 fractures were classified as one out of three types of AO/OTA 31-A3. From the whole number of proximal femur fractures (1,115), 5% belonged to this type, in comparison to all IT fractures (682) which was 9%. All IT fractures were fixed by the below described implant (DHS-MB) [10].

The operation was performed on a patient in the supine position. We approached the lateral aspect of the proximal femur by a lateral incision which begins about 6 to 8 cm distally to the greater trochanter along the shaft of the femur. The incision is as long as the part of the implant that lies on the femoral shaft. Reduction of fracture and radiographic control preceded fixation.

First, we introduced a guide wire under the angle of 135º. The optimal position of the wire is in the lower third of the femoral neck and head in the antero-posterior (AP) projection and centrally in the lateral projection (Figure 1a).

The rest of the procedure was done by a pattern and was very easily carried out. Next, we did perforation of holes on the lateral cortex and application of the self-cutting canulated nail (6 mm in diameter) (Figure 1b).

On the self-cutting nail we slided a specially designed drill guide that made it possible to perforate a hole 11 mm in diameter (Figure 1c, middle). Processing the two holes resulted in a definitive oval-shaped perforation on the lateral cortex with the guide nail in the distal third (Figure 1c, right). Then, we did application of the implant. Its fixation to the femur shaft with cortical screws, application of the proximal head-neck screw and replacing of the guide nail with the distal head-neck screw we showed at Figure 1d.

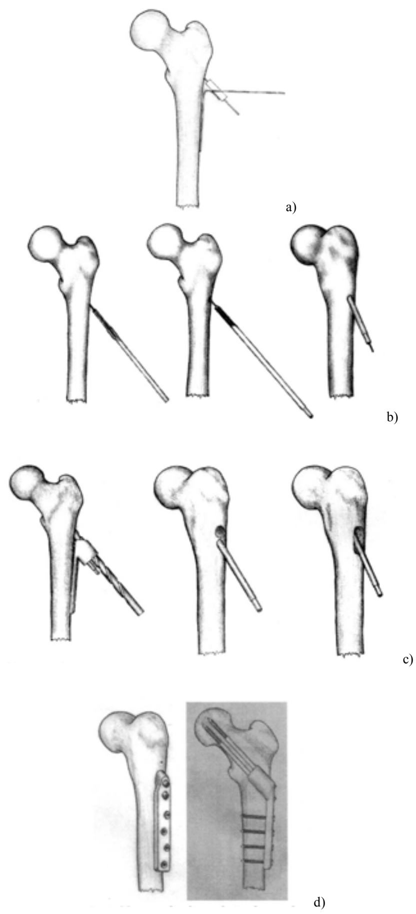


Fig. 1 – a) Introducing a guide wire; b) introducing a self cutting canullated nail; c) making a proximal perforation; d) final implant application

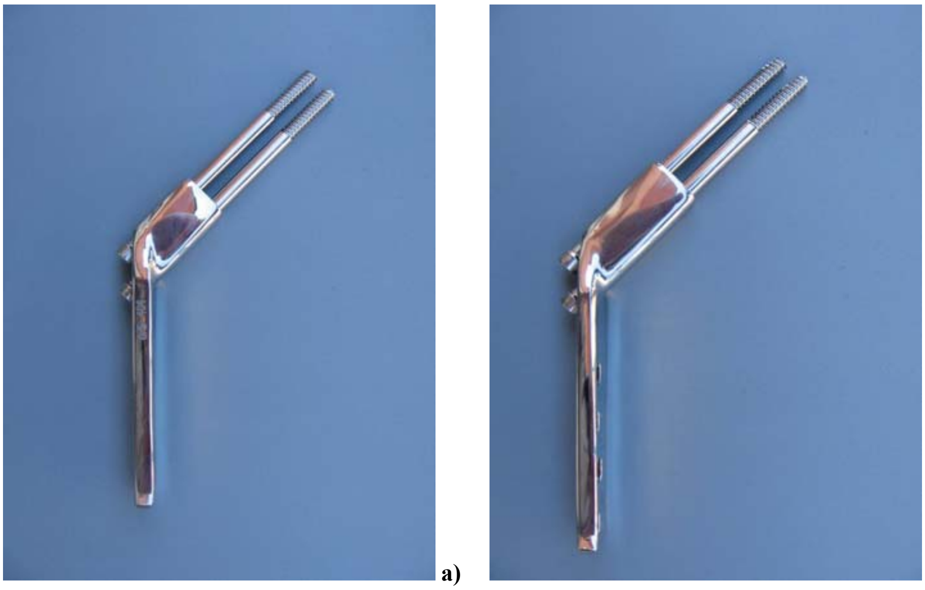
The rigid part of the implant was shaped like a wedge-plate of 135º angle. The proximal wedge was like a console that has two parallel self-cutting screws of 6 mm diameter at the distance of 4 mm. The lateral side of the plate had 2–12 perforations for cortical screws. Femoral head-neck screws were placed subchondrally. They had to control varus, anteversion, retroversion and rotation of the proximal fragment. Femoral head-neck screws have an unrestrained possibility of telescoping.

The two different versions of the implant were used: implant with a standard length of the rigid part (DHS-YU-S) of 40 mm (Figure 2a), and implant with individualised length of the rigid part (DHS-YU-I) (Figure 2b). The lenght of the implant was determined as follows. It is known that the form

We assessed the patients' mental condition [12, 13], physical status [14, 15], social status [16], and the ability to walk before surgery [17].

All the fractures were reduced by closed reduction, by traction and external or internal rotation.

We defined position of the implants in two plains by operative radiography (in the anterior – posterior view: in the upper third, centrally and in the lower third of the proximal fragment; in the lateral view: in front, centrally and back).



a) b)

Fig. 2 – Implant with standard length rigid part (DHS-YU-S) of 40 mm (a) and Implant with individualized length rigid part of the implant (DHS-YU- I) (b)

and length of the proximal wedge make contact between the rigid part of the implant and the medial cortex of the proximal fragment possible, so the implant can control medialisation of the distal fragment and impaction of major fractural fragments.

On the preoperative AP radiography of the healthy femur, we measured the diameter of the proximal femur (a) (Figure 3).

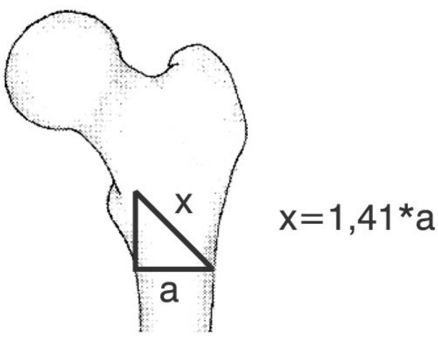


Fig. 3 – The distance (x) is calculated by using the formula
$$\mathbf{x^2 = 2 * a^2 \rightarrow \quad x = \sqrt{2} * \sqrt{a^2} \rightarrow \quad \mathit{x = 1,41 * a}}$$

On the basis of the formula:

$$x^2 = 2 * a^2 \rightarrow x = \sqrt{^2} * \sqrt{a^2} \rightarrow x = 1,41 * a$$

the distance (x) was calculated which, in fact, represents the optimal length of the rigid part of the implant that achieves contact with the medial cortex of the proximal femur and disallows unwanted impaction and dynamisation [11].

On the second postoperative day, the patients were allowed full-weight bearing (without restriction) on the operated leg.

Patients were under gradual radiographic and clinical control at the three points in time: at six weeks and then at three and six months.

Six months after the surgery, postoperative radiographs were used to measure the diameter of the proximal femur in AP projection. Its length was shown in mm. The percentage of medialisation of the distal fragment was assessed in relation to the diameter of the proximal femur [18–20]. Also, six months after the surgery, destabilization of fracture was notified and the length of the extremity was clinically measured.

The data were analyzed by the χ^2 test with the Yates correction and Student's *t*-test for small independent samples. The *p* values < 0.05 were considered to be significant.

Results

There was no statistically significant difference between the two studied groups regarding age, gender, value of the mini mental test and prefracture mobility test (Table 1).

There were no statistically significant differences in the anterior – posterior orientation of the implant between the studied groups. In the lateral view, in the patients with fractures fixed by the DHS-MB-S implant, there was a statistically significantly larger number of cases with the implant

Table 1

The data on the patients

Patients caracteristics	DHS-MB-S (n = 28)	DHS-MB-I (n = 24)	*p*
Age (years), $\bar{x} \pm SD$	71 ± 3.9	73 ± 4.8	
Sex (n)			
female	16	12	
male	12	12	
ASA [14] (n)			
I	9/28	3/24	
II	13/28	17/24	
III	4/28	4/24	
Mini mental test score [12, 13], $\bar{x} \pm SD$	11 ± 1.5	12 ± 1.3	
Type of fracture (n)			
A3.1	6/28	3/24	
A3.2	12/28	10/24	
A3.3	10/28	11/24	
Placement of the implant (n)			
AP			
up	1/28	2/24	
central	6/28	5/24	0.041†
down	21/28	17/24	
LL			
forward	0/28	0/24	
central	18/28	22/24	
back	10/28	2/24	
Mobility score [17], $\bar{x} \pm SD$ (before fracture)		8.6 ± 2.1	8.6 ± 1.9
Jensen index [16] (n)			
I	21/28	18/24	
II	6/28	6/24	
III	1/28	0/24	

***t*-test; †χ^2 test; ASA – American Society of Anesthesiology; AP – anterior-posterior projection; LL – lateral projection**

Table 2

Parameters after surgery using two modifications of implants

Parameters	DHS-YU-S (n = 28)	DHS-YU-I (n = 28)	*p*
Medialization (%)	32.29	5.18	0.127*
Length of the extremity (n)			
shortening	20/28	2/24	0.023†
without changes	8/28	19/24	
lengthening	0/28	3/24	
Mobility score [17], $\bar{x} \pm SD$ (six months after surgery)	7.0 ± 2.3	7.6 ± 1.8	

***t*-test; †χ^2 test**

oriented to the posterior, in comparison to the patients with fractures fixed by the DHS-MB-I implant.

From 1995 to 1998, fractures were stabilized with implant of standard rigid part length of 40 mm (DHS-YU-S) (Figure 3a).

In this group of the patients, 34 fractures were classified as one of three types of AO/OTA 31-A3. Six patients died within six months, the remaining 28 patients were studied.

From 1999 to 2001, we determined the length of the proximal part of the plate (console) in relation to the diameter of the proximal femur (DHS-MB-I) (Figure 3b). We classified 27 fractures as AO/OTA 31-A3 in this group. Three patients died within six months. We had the final results in 24 patients.

There was no statistically significant difference between the two studied groups in relation to the type of fracture.

There was deep infection in one patient from the DHS-YU-I implant group. The fracture was consolidated and the infection was surgically treated after removal of the implant. In one patient from the DHS-YU-I implant group, diaphyseal destabilization occurred, but without repercussion to the healing of the fracture or the function of the lower extremity within six months.

A significant average of medialization occurred in the group of fractures stabilized with the DHS-YU-S implant (32% of the proximal femur diameter), did not cause destabilization and lack of the healing process of the fracture, but this medialization caused a significant average shortening of the extremity. Also, different application in the implant in lateral view did not have an influence in the sense of destabilization and the healing process.

In the group of fractures stabilized with the DHS-YU-I implant, individualization of length of the rigid part of the implant caused a significant reduction of the average medialisation (5% diameter of the proximal femur) which produced lower levels of extremity shortening (Figures 5 a–d).

The average values of the mobility score after the surgery show that there were no statistically significant differences between the studied groups of patients.

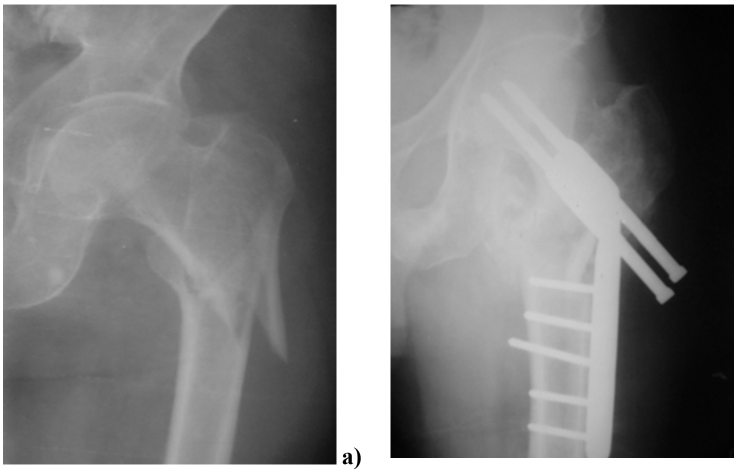


Fig. 4 – Radiography of IT fracture with reverse line: a) preoperative radiography of IT fracture with a reverse line; b) six months after the surgery (consolidation with significant medialisation)

Fig. 5 – Radiography of intratrochonteric fracture with a reverse line: a) preoperative finding; b) intraoperative finding; c) finding six month after the surgery; d) finding after the removal of the implant (consolidation without significant medialisation)

Discussion

In previously published studies, the incidence of the fracture type AO/OTA 31-A3 is comparable with our findings: Brammar et al. [18] reported 3% of the sum-total of hip fractures and 7% of the sum-total of extracapsular fractures and Haidukewych et al. [19] 5% of extracapsular fractures.

Early destabilization and pseudoarthrosis are known complications in treatment of unstable IT fractures [18–21].

Complications as destabilization and the lack of healing process of fractures did not occur in our study.

Medialization of the distal fragment was statistically significantly higher in the group of patients with the DHS-YU-S implant. In the group of patients with the DHS-YU-S implant, the percentage of patients in whom the shortening of the lower extremity occurred was statistically significantly higher than in those with the DHS-YU-I implant, too. The number of patients in the DHS-YU-I group in whom neither the shortening nor the lengthening of the lower extremity occurred six months after the operation was statistically significantly higher in comparison to the DHS-YU-S group of patients.

Rotation control of the proximal fragment is crucial in the fixation of unstable intertrochanteric fractures (AO/OTA 31-A). This control can be implemented by applying two or more parallel screws that make close contact with the femoral head. Also, it is important to control medialisation gained by the contact of the rigid part of the implant with the internal side of the medial cortex (medial, anteromedial or posteromedial). The medial cortex of the proximal femur is a very compact structure whose significance has been neglected up to now. By achieving the intimate contact of the medial cortex and the rigid part of the implant by the most favourable way under the angle of 135º, we transfer the load to the lateral cortex. The implant dynamic part allows close and continuous contact of the medial cortex and the rigid part of the implant without any danger of breaching (selfcutting) the femoral head.

In this way, all advantages of dynamization are used and the unwanted effect of medialisation of the distal fragment is prevented. According to the suggested solution, dynamization can be planned before surgery by choosing an adequate length of the rigid part of the implant and the extremity shortening can be prevented.

A parallel study that suggests fixation of IT fractures with other methods of fixation, above all with intramedullary implants, waits to be reported.

Conclusion

In order to achieve a desired functional result, the control of dynamization in unstable IT fractures is significant in the fixation of IT fractures of the femur. We presented possible methods to realize it by the contact of the rigid part of our implant with medial cortex of the proximal fragment of the femur.

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