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ORIGINAL ARTICLE / ОРИГИНАЛНИ РАД

Functional results in surgical treatment of unstable pertrochanteric fractures (AO/OTA A2) treated by TRIGEN INTERTAN and DHS methods

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SUMMARY

Introduction/Objective Intertrochanteric fractures of the femur are one of the biggest public health problems. This paper aims to determine the functional results and features of operative treatment of unstable intertrochanteric femoral fractures.

Methods This retrospective study included 67 patients who were treated surgically for AO/OTA A2 pertrochanteric fractures at the Department of Orthopedic Surgery and Traumatology of the Kosovska Mitrovica Clinical Hospital Center and at the Academician Prof. Dr. Milorad Mitković Clinic for Orthopedic Surgery and Traumatology of the Niš University Clinical Center. There were two groups of patients regarding the fixation method used – the dynamic hip screw (DHS) group and the TRIGEN INTERTAN group.

Results Patients treated using the DHS method had a statistically confirmed longer operation time, greater intraoperative blood loss, and longer hospitalization in relation to patients treated using the TRIGEN INTERTAN method ($p < 0.001$). In contrast, patients from the TRIGEN INTERTAN group spent less time in the intensive care unit and had more favorable radiological findings regarding fracture healing, as well as better functional outcomes assessed by the Harris Hip Score and Barthel index, which were also statistically significant. The peak-to-peak tip–apex distance was greater in the DHS group, with a significant difference between the techniques ($p = 0.019$). According to the Charlson Comorbidity Index, patients who were treated using the DHS method had more pronounced comorbidities ($p = 0.022$).

Conclusion Surgical treatment of unstable pertrochanteric fractures using intramedullary fixation with TRIGEN INTERTAN is very safe and effective in all patients, especially in elderly patients with comorbidities.

Keywords: unstable; pertrochanteric; fractures; hip function

INTRODUCTION

Trochanteric fractures of the femur represent a significant public health problem. They can result in disability, reduced quality of life, and increased incidence of mortality. The incidence of intertrochanteric fractures is increasing due to the growth of the elderly population as a result of improved living standards and advances in modern medicine. It is estimated that 6.25 million people worldwide will sustain trochanteric fractures by the year 2050 [1].

Trochanteric fractures belong to the group of extra-articular fractures and are one of the most common injuries in the elderly population, with approximately 90% occurring in patients over the age of 65. The treatment of trochanteric fractures is often challenging due to the complexity of the fracture, the difficulty in achieving anatomical reduction and stable fixation, and the comorbidities of the patient. Elderly patients with osteoporosis often have unstable trochanteric fractures caused by a minor external force. Conversely, in younger people, intertrochanteric fractures mostly occur as a result of high-energy force [2].

The AO/OTA classification is the most widely used classification of bone fractures, dividing the trochanteric fractures (31-A) into three main groups, which are further subdivided into nine subtypes (Figure 1). Fracture type 31-A1 includes simple two-part fractures, while 31-A2 includes a separated lesser trochanter, without (31-A2.1) or with additional comminution in the intertrochanteric region (31-A2.2 and 31-A2.3). Fractures of type 31-A3 pass through the lateral femoral wall – defined as the lateral cortex distal to the greater trochanter (distal to the femoral ridge) [3]. A1 fractures are considered stable, while A2 and A3 are considered unstable trochanteric fractures. The AO/OTA classification distinguishes between pertrochanteric (A1 and A2) and intertrochanteric fractures (A3).

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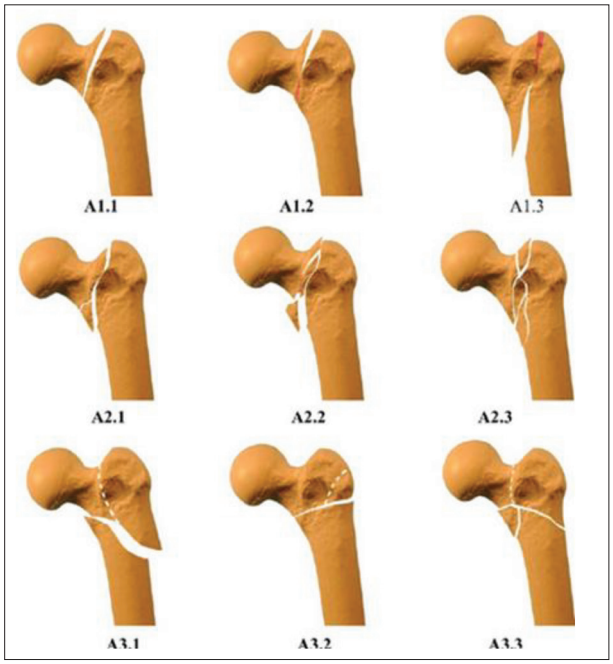


Figure 1. *Arbeitsgemeinschaft für Osteosynthesefragen* (AO) classification of intertrochanteric fractures

Internal fixation of trochanteric fractures can be extramedullary (dynamic hip screw (DHS), Selfdynamizable Internal Fixator, etc.) and intramedullary (Gamma Nail, TRIGEN INTERTAN, proximal femoral nail antirotation, etc.) [4, 5].

The aim of this paper was to determine the functional results and features of surgical treatment of unstable pertrochanteric fractures using DHS and the TRIGEN INTERTAN short cephalomedullary nail.

METHODS

The research was performed as a retrospective study and included 67 patients with unstable pertrochanteric fractures that were treated surgically 2015–2022 at the Department of Orthopedic Surgery and Traumatology of the Kosovska Mitrovica Clinical Hospital Center (CHC) and at the Academician Prof. Dr. Milorad Mitković Clinic for Orthopedic Surgery and Traumatology of the Niš University Clinical Center. There were two groups of patients regarding the fixation method used – the DHS group and the TRIGEN INTERTAN group.

The Singh osteoporosis index was used to determine the degree of osteoporosis. It consists of six groups (the main role in the gradation of the degrees of osteoporosis is played by the interruption of the main tension trabeculae): grade 6 (all trabecular groups are present), grade 5 (the main tension and main compression groups are emphasized), grade 4 (the main tension trabeculae are reduced), grade 3 (the main tension trabeculae are interrupted opposite the greater trochanter. This grade indicates definitive osteoporosis), grade 2 (the presence of only the main compression trabeculae), grade 1 (the main compression trabeculae are reduced).

Postoperative X-ray follow-up was used to assess the postoperative collodiaphyseal angle and tip–apex distance (TAD).

The Harris Hip Score (HHS), as a commonly used score to assess hip function, was measured over a period of six to 12 months to represent long-term functional outcomes. HHS is a rating scale with a total of 100 points (excellent, ≥ 90 points; very good, 80–89 points; good, 70–79 points; and poor, < 70 points). This score includes pain, movement, deformity, and function.

The Barthel scale/index is a scale that was used to measure performance in activities of daily living (ADL). Ten variables describing ADL and mobility are scored, with higher scores reflecting greater ability to function independently six months after discharge from the hospital. We have classified patients into five groups: 0–4 = complete dependence; 5–12 = severe dependence; 13–18 = moderate dependence; 19 = slight dependence.

Based on the Charlson Comorbidity Index (CCI) score, the severity of comorbidity was categorized into three grades: 1. mild (CCI scores of 1–2); 2. moderate (CCI scores of 3–4); 3. severe (CCI scores ≥ 5). It should also be noted that the callus was analyzed on the radiological image. Native X-rays were used for the analysis.

Also, it should be emphasized that intraoperative blood loss was determined by the level of aspirated fluid in the reservoir.

Statistical analysis

The data collected in the study were analyzed using IBM SPSS Statistics 20 software. Descriptive parameters were expressed as frequencies (n) and percentages (%). Comparisons were performed using the χ^2 test for categorical data, and the Mann–Whitney U test for continuous data. Statistical significance was set at $p < 0.05$.

RESULTS

Descriptive data, including general data, clinical, radiological, and functional parameters, are presented in Table 1.

Table 1. Baseline demographic and clinical characteristics among the groups

Variables		Groups		p
		TRIGEN INTERTAN [n (%)]	DHS [n (%)]	
Sex	Male	10 (22.7%)	6 (26.1%)	0.759
	Female	34 (77.3%)	17 (17.5%)	
Age	40–60 years	3 (6.8%)	0	0.382
	61–80 years	17 (38.6%)	8 (34.8%)	
	> 80 years	24 (54.5%)	15 (65.2%)	
AO/OTA fracture type	A2.1	2 (4.5%)	8 (34.8%)	< 0.001
	A2.2	26 (59.1%)	15 (65.2%)	
	A2.3	16 (36.4%)	0	

AO – *Arbeitsgemeinschaft für Osteosynthesefragen*; OTA – Orthopaedic Trauma Association

The results indicated that there was no statistically significant association between the type of surgery and patient gender, age, or the degree of osteoporosis. However, a significant difference between the surgical method groups was observed regarding blood transfusion – all transfusions were administered to patients treated with DHS, indicating greater intraoperative or postoperative blood loss in these patients. Furthermore, the type of surgical technique was significantly associated with the incidence of long-term postoperative complications. Patients treated with the TRIGEN INTERTAN method experienced a lower complication rate, whereas those who were treated by DHS had a higher rate of adverse outcomes, delayed healing, bone infections, and cut-out (Table 2).

Patients treated with the DHS technique had a statistically significantly longer duration of surgery, greater intraoperative blood loss and longer hospitalization than patients treated with the TRIGEN INTERTAN method ($p < 0.001$). In contrast, patients from the TRIGEN INTERTAN group had more favorable radiological findings regarding fracture healing, as well as better functional outcomes assessed by the HHS and Barthel index, which were also statistically significant. The peak-to-peak TAD was greater in the DHS group, with a significant difference between the techniques ($p = 0.019$) (Table 3).

According to the CCI, patients who were operated on using the DHS technique had more pronounced comorbidities ($p = 0.022$).

Examination of the relationship between the type of surgical method and AO/OTA fracture types revealed a statistically significant correlation ($p < 0.001$). The results confirm that in A2.2 and A2.3 fractures, surgeons more often perform fixation with the TRIGEN INTERTAN implant (Table 3).

Table 2. Perioperative characteristics and postoperative outcomes in all patients

Variable		n (%)
Sex	Male	16 (23.9%)
	Female	51 (76.1%)
AO/OTA	A2.1	10 (14.9%)
	A2.2	41 (61.2%)
	A2.3	16 (23.9%)
Fixation method	TRIGEN INTERTAN	44 (65.7%)
	DHS	23 (34.3%)
Blood transfusion	No transfusion	44 (65.7%)
	350 ml	17 (25.4%)
	700 ml	6 (9%)
Age	40–60 years	3 (4.5%)
	61–80 years	25 (37.13%)
	> 80 years	39 (58.2%)
ICU stay	No ICU	29 (43.3%)
	< 5 days	0
	≥ 5 days	38 (56.7%)
TAD	< 20 mm	8 (11.9%)
	21–30 mm	52 (77.6%)
	> 30 mm	7 (10.4%)
CCI	5–6	15 (22.4%)
	2–4	51 (76.1%)
	0–1	1 (1.5%)
Singh score of osteoporosis	Severe osteoporosis	0
	Moderate osteoporosis	4 (6%)
	Severe osteopenia	14 (20.9%)
	Moderate osteopenia	30 (44.8%)
	Mild osteopenia	17 (25.4%)
	Normal bone	2 (3%)
Long-term complications	Nonunion	2 (3%)
	Malunion	4 (6%)
	Bone infection	2 (3%)
	Refracture	0
	Cut-out	4 (6%)
	No complication	55 (82%)
HHS	< 70	0
	71–80	0
	81–90	18 (26.9%)
	91–100	49 (73.1%)
Operation time	< 30 min	8 (11.9%)
	31–60 min	41 (61.2%)
	61–90 min	18 (26.9%)
Dependence according to the Barthel index	Total dependence	0
	Severe dependence	8 (11.9%)
	Moderate dependence	17 (25.4%)
	Mild dependence / functional independence	42 (62.7%)
Intraoperative blood loss	< 100 ml	36 (53.7%)
	100–350 ml	31 (46.3%)
	> 350 ml	0
Radiologically visible callus at 24 weeks	Adequate mature callus visible	33 (49.3%)
	Visible immature callus	31 (46.3%)
	No visible callus	3 (4.5%)

TAD – tip–apex distance; CCI – Charlson Comorbidity Index; AO – *Arbeitsgemeinschaft für Osteosynthesefragen*; OTA – Orthopaedic Trauma Association; HHS – Harris Hip Score; ICU – intensive care unit

DISCUSSION

These findings emphasize the clinical importance of selecting an appropriate surgical technique, particularly in relation to blood transfusion requirements and the prevention of long-term complications. In contrast, factors such as gender, age, and the degree of osteoporosis did not significantly influence the choice of surgical intervention.

The mean age of all patients was 73.58 ± 15.86 years, ranging 62–97 years. A significant proportion of patients, 39 out of 67 (58.2%), were older than 80 years. The results of our study are in line with several other studies [6, 7].

In our study, female patients accounted for 76.1% of all cases. This result is consistent with Krishna et al. [8]. In our study, it was found that A2.2 pertrochanteric fractures were the most common, accounting for 61.2%, while A2.1 and A2.3 fractures were less common. These results are in line with those of Murugan et al. [9]. In older people, trochanteric fractures usually occur as a result of a fall, most often with an indirect impact on the hip. Although the traumatic force is of low intensity, most of these fractures are multi-fragmentary and complex due to osteoporotic changes in the skeletal system at various stages. Our study

Table 3. Perioperative characteristics and postoperative outcomes among the groups

Variables		Groups		p
		TRIGEN INTERTAN [n (%)]	DHS [n (%)]	
Singh score of osteoporosis	Severe osteoporosis	0	0	0.779
	Moderate osteoporosis	2 (4.5%)	2 (8.7%)	
	Severe osteopenia	10 (22.7%)	4 (17.4%)	
	Moderate osteopenia	19 (43.2%)	11 (47.8%)	
	Mild osteopenia	11 (25%)	6 (26.1%)	
	Normal bone	2 (4.5%)	0	
CCI	5–6	14 (31.8%)	1 (4.3%)	0.022
	2–4	29 (65.9%)	22 (95.7%)	
	0–1	1 (2.3%)	0	
Length of hospital stay	7–10 days	40 (90.9%)	2 (8.7%)	< 0.001
	11–15 days	4 (9.1%)	21 (91.3%)	
Operation time	≤ 30 min	8 (18.2%)	0	< 0.001
	31–60 min	36 (81.8%)	5 (21.7%)	
	61–90 min	0	18 (78.3%)	
Intraoperative blood loss	≤ 100 ml	32 (72.7%)	4 (17.4%)	< 0.001
	> 100 ml (up to 350 ml)	12 (27.3%)	19 (82.6%)	
Blood transfusion	No	44 (100%)	0	< 0.001
	350 ml	0	6 (26.1%)	
	700 ml	0	17 (73.9%)	
ICU stay	No ICU stay	26 (59.1%)	3 (13%)	< 0.001
	< 5 days	18 (40.9%)	20 (87%)	
TAD	< 20 mm	7 (15.9%)	1 (4.3%)	0.019
	20–30 mm	35 (79.5%)	17 (73.9%)	
	> 30 mm	2 (4.5%)	5 (21.7%)	
Long-term complications	Nonunion	0	2 (8.7%)	0.003
	Malunion	1 (2.3%)	3 (13%)	
	Bone infection	0	2 (8.7%)	
	Cut-out	1 (2.3%)	3 (13%)	
	No complication	42 (95.5%)	13 (56.5%)	
HHS	81–90	4 (9.1%)	14 (60.9%)	< 0.001
	91–100	40 (90.9%)	9 (39.1%)	
Barthel Index	Total dependence	0	0	< 0.001
	Severe dependence	0	8 (34.8%)	
	Moderate dependence	5 (11.4%)	12 (52.2%)	
	Mild dependence	39 (88.6%)	3 (13%)	
Radiologically visible callus at 24 weeks	Adequate mature callus visible	27 (61.4%)	6 (26.1%)	0.005
	Immature callus visible	16 (36.4%)	15 (65.2%)	
	No visible callus	1 (2.3%)	2 (8.7%)	

TAD – tip–apex distance; CCI – Charlson Comorbidity Index; HHS – Harris Hip Score; ICU – intensive care unit

also found that type A2.2 fractures were more common in female patients (45.7%), while A2.3 pertrochanteric fractures were more common in cases resulting from high-intensity force. Thus, it could be considered that A2.1 and A2.2 pertrochanteric fractures occurred more frequently in cases of low-intensity force.

In our study, we observed that 95.5% of all patients achieved fracture union. This union rate is in line with findings from other studies conducted by Yang et al. [10] and Wang et al. [11]. This high rate of union can be attributed primarily to the rich blood supply in the trochanteric area. Mature callus in the DHS group was radiologically visible in only 65.9% of the subjects. It should be noted that the formation of radiologically visible mature bone callus 24 weeks after surgery was achieved more frequently with INTERTAN than with DHS, which would support the generally faster callus maturation with the INTERTAN method.

All 23 patients in the DHS group had received blood transfusion during surgery with a mean volume of 350 ml. Patients treated with TRIGEN INTERTAN did not receive transfusions. These results are consistent with the studies of Wang et al. [11] and Kassem et al. [12].

The patients included in our study didn't have complications such as device failure or device malfunction. Regarding late complications, 56.5% of all cases had some kind of postoperative complications (deep infection, varus collapse, nonunion, malunion). The complication rate was higher in the DHS group ($p < 0.05$) and it should be emphasized that the proportion of late complications in this study was higher with DHS, probably due to the use of DHS in pertrochanteric fractures with pronounced comminution (A2.2). The large freedom of lag screw translation in DHS may be a factor for later complications in A2.2 fractures. In contrast to DHS, there are extramedullary methods that have limited lag screw translation, as well as an additional anti-rotation or additional screw (which DHS does not have), as is the case with the Selfdynamizable Internal Fixator, and it could be considered that not all extramedullary methods will produce the same results as DHS in these fractures. The immense significance of the anti-rotational screw in the Selfdynamizable Internal Fixator lies in its ability to achieve rotational stability, which serves as an excellent predictor of faster and superior fracture healing, particularly in these types of fractures that are inherently highly unstable. This finding aligns with the conclusions of studies of Ćirić et al. [13] and Mitković et al. [14]. DHS has only one lag screw and is more rotationally unstable compared to extramedullary methods that include two lag screws or one lag screw and one additional femoral neck anti-rotation pin. These results match those of Rashid et al. [15] and Shin et al. [16].

It should be noted that all patients survived the six-month postoperative period.

The quality of life after surgery for a pertrochanteric fracture depends on the degree of hip function recovery. Compared to DHS, there was no statistically significant difference between the two groups. However, in patients with a trochanteric fracture, walking ability represents an important outcome. It is widely considered that partial weight bearing during walking can begin earlier after intramedullary fixation than after fixation with DHS. In our

study, most patients in the TRIGEN INTERTAN group had an excellent score, while in the DHS group most patients had a good HHS. Such a large difference could be influenced by the larger proportion of patients with comorbidities in the DHS group. Earlier weight bearing on the operated leg reduces the risk of some complications, such as decubitus ulcers, thromboembolism, and pneumonia. Our results are in correlation with the study of Kang et al. [17], who presented that most patients (140/168) in the intramedullary group could start walking with crutches or a walker within one week after surgery.

Our study showed that weight bearing on the operated leg after fixation of a trochanteric fracture can generally be initiated earlier when using TRIGEN INTERTAN than when using DHS.

Functional independence was significantly higher in the TRIGEN INTERTAN group (88.6%) compared to the DHS group (13%). This difference could be influenced by the larger proportion of patients with comorbidities in the DHS group. So, we can safely say it is in complete correlation with published data such as those of Smith et al. [18].

The peak-to-peak TAD values were generally higher in the DHS group compared to the INTERTAN group, which is most likely why there were more cut-outs in the DHS group compared to the INTERTAN group, and thus this study confirmed the importance of better intraoperative TAD in the occurrence of cut-outs. Comparing the results with the official literature and research conducted by Luo et al. [19], we find that the results of these two studies are in correlation with each other.

Regarding mature callus visibility 24 weeks after surgery, we found that adequate mature callus was more often seen radiologically in patients from the TRIGEN INTERTAN group (61.4%) compared to the DHS group (26.1%). This finding is in accordance with Zhou et al. [20], who found adequate mature callus to be visible in 65% of patients with intramedullary fixation. Generally greater development of callus in patients in the INTERTAN group can be influenced by the rotatory stability of the proximal fragment of the pertrochanteric fracture, which is less when using DHS [20]. These results indicate a clinically relevant difference in the course and outcome of treatment depending on the chosen operative method.

CONCLUSION

In conclusion, it could be stated that the surgical treatment of unstable pertrochanteric fractures by TRIGEN INTERTAN can be followed by a lower need for blood transfusion, earlier weight bearing on the operated leg, higher hip function, and earlier radiological callus visibility, in relation to the treatment by DHS. However, it should be noted that the final outcomes may also be affected by the level of comorbidity and intraoperative TAD.

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Ethics: In order to protect patient data, all data were encrypted and processed in accordance with the ethical principles of privacy protection and based on the decisions of the Ethics Committee of the Kosovska Mitrovica CHC, No. 1039/25.02.2023 as well as the Ethics Committee of the Niš UCC, No. 7380/15.03.2023.

Conflict of interest: None declared.

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Функционални резултати хируршког лечења нестабилних пертрохантерних прелома (AO/OTA A2) методама *TRIGEN INTERTAN* и *DHS*

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САЖЕТАК

Увод/Циљ Интертрохантерни преломи фемура један су од највећих јавноздравствених проблема. Циљ овог рада био је да се утврде функционални резултати и карактеристике оперативног лечења нестабилних интертрохантерних прелома фемура.

Методе Истраживање је спроведено као ретроспективна студија која је обухватила 67 болесника оперативно лечених од 2015. године на Одељењу за ортопедску хирургију и трауматологију Клиничко-болничког центра Косовска Митровица и на Клиници за ортопедску хирургију и трауматологију „Академик проф. др Милорад Митковић" Универзитетског клиничког центра Ниш. Болесници су, према примењеној методи фиксације, били подељени у две групе – групу *DHS* (*Dynamic Hip Screw*) и групу *TRIGEN INTERTAN*.

Резултати Болесници лечени техником *DHS* имали су статистички значајно дуже трајање операције, већи интраоперативни губитак крви и дужу хоспитализацију него болесници лечени методом *TRIGEN INTERTAN* (сви $p < 0,001$). Насупрот томе, болесници из групе *TRIGEN INTERTAN* нису боравили на одељењу интензивне неге, али су имали повољније радиолошке налазе у погледу зарастања прелома, као и боље функционалне исходе процењене Харисовим скором за кук (*Harris Hip Score*) и Бартеловим индексом (*Barthel Index*), што је такође било статистички значајно. Вредност растојања врх–апекс (*tip-apex distance*) била је већа у групи *DHS*, са статистички значајном разликом између техника ($p = 0,019$). Према Чарлсоновом индексу коморбидитета (*Charlson Comorbidity Index*), болесници који су оперисани техником *DHS* имали су израженије коморбидитете ($p = 0,022$).

Закључак Оперативно лечење нестабилних интертрохантерних прелома интрамедуларном фиксацијом методом *TRIGEN INTERTAN* веома је безбедно и ефикасно код свих болесника, посебно код старијих болесника са коморбидитетима.

Кључне речи: нестабилни; пертрохантерни; преломи; функција кука