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COMPARATIVE ANALYSIS OF SURGICAL OUTCOMES IN AO-OTA 31-A2 FRACTURES: TWO-HOLE VS. FOUR-HOLE DYNAMIC HIP SCREW

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Abstract: **Background:** The choice of implant for the treatment of multifragmentary pertrochanteric fractures AO-OTA 31-A2 is complex, and the dynamic hip screw (DHS) can be used as a biomechanically safe and cost-effective option. Surgeons typically choose between DHS plates with two or four holes. The primary aim of this study was to determine whether there is a difference in surgery time, hospital stay, intraoperative blood loss, and incision length in patients with AO-OTA 31-A2 fractures treated with two-hole or four-hole DHS. The secondary aim was to compare the rate of complications, including fracture nonunion, implant breakage (DHS plate, sliding screw, compression screw, or cortical screws), cut-out, fracture collapse, and avascular necrosis.

Methods: This retrospective study included 94 patients with AO-OTA 31-A2 fractures treated with DHS implants containing either two or four holes. Patients were divided into two groups: Group A, which included 60 patients treated with a two-hole DHS plate, and Group B, which included 34 patients treated with a four-hole DHS plate.

Results: Group A had a significantly shorter surgery time (44.80 ± 8.01 minutes) compared to Group B (48.12 ± 5.43 minutes; $p < 0.05$). Group A also had a significantly smaller incision ($p < 0.05$). There were no significant differences between the two groups in terms of the remaining outcomes.

Conclusion: The absence of significant differences in complication rates supports the conclusion that both DHS types are viable options for the treatment of AO-OTA 31-A2 fractures.

Keywords: dynamic hip screw, femur, hip fractures.

INTRODUCTION

Hip fractures are a prevalent injury that continues to rise with projections suggesting that by 2050, their incidence will nearly double compared to 2018 (1). These fractures can be categorized into two primary types: intracapsular and extracapsular. Extracapsular hip fractures predominantly occur in the elderly, often resulting from low-energy mechanisms, while younger individuals may experience these fractures due to high-energy trauma (2).The AO-OTA classification system is widely utilized to classify extracapsular hip fractures, which include trochanteric fractures, which are further divided into three categories: simple pertrochanteric fractures (AO-OTA 31-A1), multi-fragmentary pertrochanteric fractures (AO-OTA 31-A2), and intertrochanteric fractures (AO-OTA 31-A3) (3).

In the management of trochanteric hip fractures, surgical intervention is the primary treatment modality, with implant selection depending on the specific fracture type. The most commonly used implants are the dynamic hip screw (DHS) and the proximal femoral nail (PFN) (4, 5, 6). Numerous studies and systematic reviews have confirmed that DHS remains the preferred implant for treating simple pertrochanteric fractures (AO-OTA 31-A1), due to favorable outcomes in terms of fracture healing, biomechanical stability, and cost-effectiveness (7, 8).

The treatment of multifragmentary pertrochanteric fractures (AO-OTA 31-A2) requires more complex decision-making, as both DHS and PFN have demonstrated satisfactory outcomes in clinical practice (8, 9). Several studies have reported good results in treating AO-OTA 31-A2 fractures with DHS (10–14). In a systematic review, Zhang et al. compared intramedullary nails and extramedullary fixation methods, concluding that both DHS and PFN can yield favorable outcomes in the treatment of unstable intertrochanteric fractures. The study emphasized that although PFN may offer advantages in terms of stability, DHS remains a reliable option, particularly in less complex cases. This underscores the importance of considering fracture morphology when selecting an implant (15).

Bone quality is another important factor in the decision-making process, as osteoporosis can adversely affect surgical outcomes (16, 17).The DHS system consists of a barrel plate, a sliding screw positioned at a fixed angle (typically 135 degrees), and a compression screw. DHS plates are available in various configurations, typically featuring two, four, or six holes for cortical screw placement. Biomechanical studies have shown that a two-hole DHS plate offers a level of safety comparable to that of four-hole plates, suggesting that fewer screws may be sufficient for effective stabilization (18-20). On the other hand, Wang et al. claimed that the length of DHS plate has a significant effect on stress on the screws and may contribute to side plate pull-out (20).

AIM

The primary aim of this study was to determine whether there is a difference in surgery time, hospital stay, intraoperative blood loss, and incision length in patients with AO-OTA 31-A2 fractures treated with either a two-hole or a four-hole dynamic hip screw (DHS).

The secondary aim was to compare the rate of complications, including fracture nonunion, implant breakage (DHS plate, sliding screw, compression screw, or cortical screws), cut-out, fracture collapse, and avascular necrosis.

MATERIALS AND METHODS

After obtaining approval from the Ethics Committee, we conducted a retrospective analysis of patients hospitalized in the Department of Orthopedic Surgery and Traumatology at Cantonal Hospital “dr. Safet Mujic” Mostar with a diagnosis of multi-fragmentary trochanteric fracture (AO-OTA 31-A2) treated with Dynamic Hip Screw Plate (Marquard, Spaichingen, Germany). We analyzed cases from January 2014 to January 2021.

For the primary outcomes, we reviewed patients’ medical histories and the hospital’s electronic database. For secondary outcomes, we used the Picture Archiving and Communication System (PACS) to review radiographic images (X-rays) obtained at the last follow-up examination, one year post-injury.

The inclusion criteria were: 1) multi-fragmentary trochanteric fracture (AO-OTA 31-A2); 2) patients treated with DHS with 2 or 4 holes; 3) complete medical history; 4) minimum follow-up of one year.

Exclusion criteria were: pathological fractures, multiple fractures, previous proximal femoral fracture, and psychiatric diagnosis.

A total of 94 patients were included in the study. Patients were divided into two groups: Group A (60 patients treated with two-hole DHS plates) and Group B (34 patients treated with four-hole DHS plates). All surgeries were performed by orthopedic surgeons with comparable levels of expertise.

All patients were placed in the supine position on a traction table after administration of general anesthesia. Closed reduction of trochanteric fracture was performed under the C-arm. In case of inadequate reduction, open reduction of fracture was done during the surgery. An incision was made at the level of the greater trochanter and extended distally. We used a muscle-splitting technique which includes a sharp incision of the fascia lata and sharp dissection between muscle fibers of the vastus lateralis muscle. A guide pin was inserted through the femoral neck to the edge of the cartilage of the femoral head with a 135° angle guide. The length of the screw was determined to be 10 mm shorter than the guide pin. We used a reamer and tap over the guide wire and after that, the screw was placed 5-10 mm beneath the surface of the femoral head cartilage. The DHS plate was placed over the screw close to the femoral surface and secured to the bone with either two or four cortical screws. The compression screw was placed and cortical screws were tightened. We retained the compression screw in order to increase construct stability (21).

Our hospital protocol for hip fracture patients includes administration of low molecular weight heparin subcutaneously on the day of admission, continued daily until discharge. After discharge, patients received Rivaroxaban 10 mg for 30 days. Two grams of Cefazolin were given as antibiotic prophylaxis. Physical therapy began on the first postoperative day, starting with sitting and bed exercises. On the second day, patients were assisted by a physiotherapist to ambulate using a walker with no weight bearing. At the first postoperative follow-up one month after surgery, radiographs were obtained, and patients were instructed to begin partial weight bearing (touching the ground). At two months, follow-up radiographs were repeated, and patients were advised to increase weight bearing to 20 kg. Full weight bearing was allowed after three months. The final follow-up examination with radiographs occurred one year after surgery.

Primary outcome data were collected from patient records and included surgery time, length of hospital stay, intraoperative blood loss, and incision length.

For secondary outcomes, radiographs from the first (one month), second (two months), third (three months), and last (one year) follow-up examinations were analyzed to identify nonunion, breakage of the DHS plate, sliding screw, compression screw, or cortical screws, cut-out, fracture collapse, and avascular necrosis.

Surgery time was defined as the interval between the initial incision and placement of the final suture. Blood loss included the sum of measured blood collected in the vertical drape pocket, blood on surgical gowns and drapes, sponges, gauzes, and suction drainage.

Nonunion was defined as a fracture persisting for at least nine months without signs of healing for three consecutive months (22). Fracture collapse was assessed by comparing radiographs from the first postoperative day and the one-year follow-up or at the time mechanical failure was detected (23). Only fracture collapse greater than 1 cm was included.

Statistical analysis was performed using GNU PSPP 2.0.1. Continuous data were presented as mean ±standard deviation (SD). Histograms were used to assess normality. Differences between normally distributed continuous variables were analyzed using independent samples t-test; for non-normally distributed variables, the Mann–Whitney U test was applied. Differences in categorical variables were analyzed using the chi-square test. A p-value < 0.05 was considered statistically significant.

RESULTS

In this study, 60 patients were treated with two-hole DHS (Group A) and 34 patients with four-hole DHS (Group B). The mean age was 73.5 ± 12.66 years in Group A and 76.26 ± 9.94 years in Group B. Group A included 18 males and 42 females, while Group B had 8 males and 26 females. There were no significant differences between the groups regarding age or sex ($p > 0.05$).

The time from injury to surgery did not differ significantly between the two groups ($p = 0.552$). However, Group A had a significantly shorter surgery time (44.80 ± 8.01 minutes) compared to Group B (48.12 ± 5.43 minutes) ($p < 0.05$).

No significant difference was observed in the length of hospital stay between the groups ($p > 0.05$). The mean intraoperative blood loss was 240.50 ± 53.22 mL in Group A and 231.18 ± 46.11 mL in Group B, with no significant difference ($p > 0.05$).

The mean incision length was significantly smaller in Group A (7.84 ± 0.52 cm) compared to Group B (9.79 ± 0.77 cm) ($p < 0.05$) (Table 1).

Regarding complication rates, Group A experienced 4 cases of nonunion, 3 cases of implant breakage, 1 case of cut-out, 12 cases of fracture collapse, and no cases of avascular necrosis. In Group B, there were 2 cases of nonunion, no implant breakages, 1 case of cut-out, 11 cases of fracture collapse, and 1 case of avascular necrosis. None of these complications showed a statistically significant difference between the two groups ($p > 0.05$) (Table 2) (Figures 1-4).

Table 1. *Comparison of primary outcomes between two groups*

	Group A (2 holes)	Group B (4 holes)	P value
Number of patients	60	34	
Mean age ± SD	73.50 ± 12.66	76.26 ± 9.94	0.276
Sex (male/female)	18/42	8/26	0.500
Time until surgery (days)	1.95 ± 0.87	1.82 ± 0.76	0.552
Surgery time (minutes)	44.80 ± 8.01	48.12 ± 5.43	**0.034***
Hospital stay (days)	12.80 ± 1.34	12.32 ± 1.12	0.086
Blood loss during surgery (mL)	240.50 ± 53.22	231.18 ± 46.11	0.395
Incision length	7.84 ± 0.52	9.79 ± 0.77	**< 0.05***

Table 2. *Comparison of number of complications in each group (secondary outcome)*

	Group A (2 holes)	Group B (4 holes)	P value
Nonunion	4	2	0.881
Implant breakage	3	0	0.185
Cut-out	1	1	0.681
Fracture collapse	12	11	0.181
Avascular necrosis	0	1	0.182

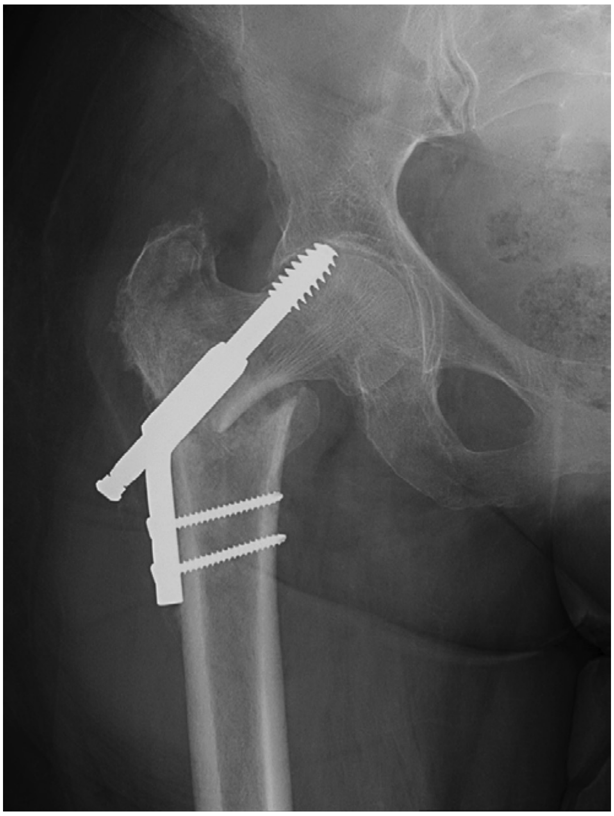

Figure 1. *X-ray showing fracture collapse and cut-out in 2-hole DHS system (from author's personal archive)*

Figure 2. *X-ray showing fracture collapse in 2-hole DHS system (from author's personal archive)*

Figure 3. *X-ray showing implant breakage (cortical screws) in 2-hole DHS system (from author's personal archive)*

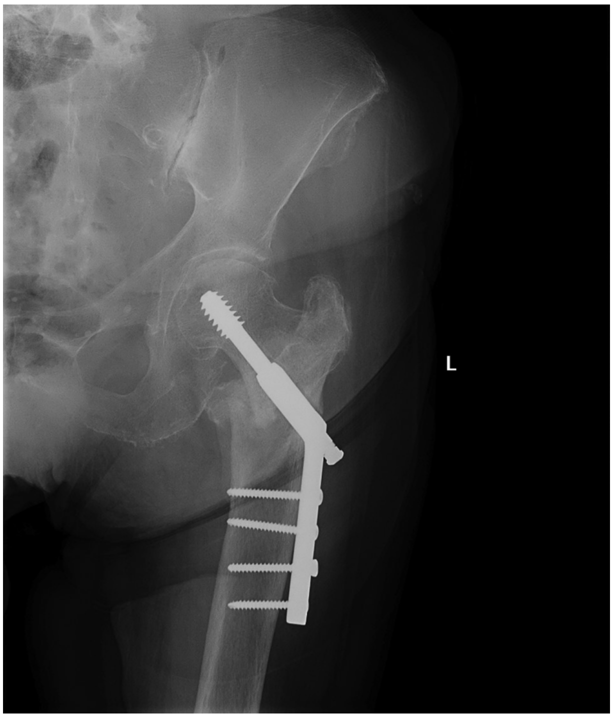

Figure 4. *X-ray showing fracture collapse in 4-hole DHS system (from author's personal archive)*

DISCUSSION

Dynamic Hip Screw (DHS) remains a key implant for treating AO-OTA 31-A2 fractures despite advances in implant technology over recent decades. Its low cost makes it particularly favored in developing countries. However, surgeons often face uncertainty when deciding the appropriate DHS plate length, with concerns mainly revolving around clinical outcomes and biomechanical stability.

Our results showed that the four-hole DHS group had less intraoperative blood loss. However, this difference was not statistically significant. This finding contrasts with most recently published studies, which report that patients treated with four-hole DHS typically experience greater blood loss due to longer incisions and more extensive soft tissue dissection (24, 25). This discrepancy may be explained by meticulous surgical technique, including careful hemostasis, gentle handling of soft tissues, and minimal muscle stripping. Additionally, we did not use surgical drains in any patient.

We found no significant difference between the two groups in terms of time until surgery or length of hospital stay. The average waiting time between hospital admission and surgery was around two days in both groups. This delay is often related to the patients' age and existing comorbidities, which frequently necessitate consultations with other specialties (internal medicine, cardiology, neurology, etc.), thus postponing surgery.

However, the two-hole DHS group had a significant advantage in terms of shorter surgical time and smaller incision length. This supports findings from previous studies suggesting that longer plates require longer incisions for proper positioning, which can influence patient outcomes (26, 27).

Although the two-hole DHS group had a higher number of complications, the difference was not statistically significant. This suggests that both DHS configurations are comparably effective in preventing adverse outcomes, consistent with literature indicating that implant design does not significantly affect complication rates (28, 29). The similar rates of complications can be attributed to the comparable biomechanical stability of both plate types. Rog et al. demonstrated that two-hole and four-hole DHS plates had similar axial and torsional stiffness and load to failure (19).

The stability provided by DHS appears adequate to promote healing and maintain femoral head integrity, thereby reducing the risk of common postoperative complications (8, 30). A study by Akinyemi et al. also found that using a four-hole DHS plate is not necessary to achieve good outcomes in both stable and unstable trochanteric fractures (31).

On the other hand, Ceynowa et al. claimed that four-hole DHS demonstrated greater strength compared to the two-hole variant, particularly in resisting rotational forces at the fracture site, which is crucial during weight-bearing activities (32). Similarly, a systematic review by Soni et al. concluded that while two-hole DHS plates offer lower biomechanical stability, other parameters such as fracture healing time, infection rates, radiation exposure, analgesic use, hospital stay, and failure rates were comparable between the two groups. They recommend the use of four-hole DHS (28).

Ultimately, achieving an optimal balance between surgical efficiency and biomechanical stability is essential for successful fracture fixation.bute to the overall success of fracture fixation.

CONCLUSION

In conclusion, although much of the literature supports the view that four-hole DHS offers greater biomechanical stability, the two-hole DHS remains a compelling option due to its advantages in surgical time and incision length. The absence of significant differences in complication rates further supports the notion that both DHS types are viable choices for the treatment of AO-OTA 31A2 fractures. The decision between using a two-hole or four-hole DHS should be based on a comprehensive assessment of the fracture pattern, the patient's overall medical condition, and the biomechanical demands on the fixation device.

Future studies should continue to investigate the long-term outcomes of these two DHS types to further refine treatment protocols and support clinical decision-making in orthopedic practice.

Abbreviations:

DHS – Dynamic hip screw

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Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki. Ethical approval was obtained by the hospital's ethical board.

Data Availability Statement: All data generated or analyzed for this report are included in the published article.

Note: Artificial intelligence was not utilized as a tool in this study.

Sažetak

KOMPARATIVNA ANALIZA HIRURŠKIH ISHODA KOD PRELOMA AO-OTA 31-A2: DINAMIČKI ZAVRTANJ ZA KUK SA DVA OTVORA U ODNOSU NA DINAMIČKI ZAVRTANJ SA ČETIRI OTVORA

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Uvod: Izbor implantata za lečenje multifragmentarnih pertrohanteričnih preloma AO-OTA 31-A2 je složen, a dinamički zavrtanj za kuk (DHS) može se koristiti kao biomehanički siguran i jeftin implantat. Hirurzi obično imaju izbor između DHS ploča sa dva ili četiri otvora. Primarni cilj ove studije bio je utvrditi postoji li razlika u vremenu operacije, dužini hospitalizacije, intraoperativnom gubitku krvi i dužini incizije kod pacijenata sa AO-OTA 31-A2 prelomima lečenih DHS-om sa dva otvora ili DHS-om sa četiri otvora. Sekundarni cilj je uporediti stopu komplikacija koje uključuju nezarastanje preloma, lom implantata (DHS ploča, klizni zavrtanj, kompresioni zavrtanj ili kortikalni zavrtnji), cut-out, kolaps preloma i avaskularnu nekrozu.

Metode: U našu retrospektivnu studiju uključili smo 94 pacijenta sa AO-OTA 31-A2 prelomima lečenih pomoću DHS-asa 2 ili 4 otvora. Pacijenti su podeljeni u dve grupe: grupu A koja je uključivala 60 pacijenata lečenih DHS pločicom sa dva otvora i grupu B koja je uključivala 34 pacijenta lečena DHS pločicom sa četiri otvora.

Rezultati: Grupa A imala je značajno kraće vreme operacije 44,80 ± 8,01 minuta u odnosu na grupu B 48,12 ± 5,43 minuta ($p < 0,05$). Grupa A je takođe imala značajno manju dužinu incizije ($p < 0,05$). Preostali ishodi nisu imali značajnu razliku između dve grupe.

Zaključak: U zaključku, odsustvo značajnih razlika u stopama komplikacija podržava ideju da su oba tipa DHS-a održive opcije za lečenje AO-OTA 31A2 preloma.

Ključne reči: dinamički zavrtanj kuka, femur, prelomi kuka.

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