

Fixation of rotationally unstable extracapsular fractures of proximal femur

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Abstract

Introduction: It was believed that the fractures of AO types A1.2 and A1.3 are rotationally stable; but, they were found to be unstable when fixed with the dynamic hip screw. Hence we hypothesize that they must be treated as rotationally unstable patterns.

Materials and Methods: dynamic hip screw with derotation screw (DHS-DRS) was done in 83 proximal femur fractures of A1, A2, and B2.1 types and followed for 24 months. Immediate assessment of reduction and fixation are found to be accurate. Collapse of fractures assessed after 6 months of surgery. Fractures were classified into 2 groups:

Inevitably unstable group (IUG) - A1.1, A2.1, A2.2, A2.3, and B2.1.

Potentially unstable group (PUG) - A1.2 and A1.3 and results were statistically analyzed.

Results: Reduction achieved in 77 patients was found to be adequate and same goes for the fixation in 71 patients. All fractures healing showed a mean time of 13.5 weeks, and the fracture collapse amounted to an average of 5.8 mm. 66 patients showed equalization of the lower limbs, and 80 patients showed healthy contralateral equalization of hip motion range. One case with AO type A1.2 needed a re-operation. Insignificant differences were found when outcome of IUG and PUG was made.

Conclusion: The use of DHS/DRS composite showed restoration and maintenance of the anatomical structure. Differences between the outcomes of IUG and PUG groups were insignificant and creates a reasonable need of classifying AO A1.2 and A1.3 as rotationally unstable types.

Keywords: Derotation screw, Proximal femoral fractures, DHS/DRS composite, Basicervical fracture, Dynamic hip screw, Rotational instability, Trochanteric fractures.

Introduction

Extracapsular proximal femoral fractures commonly occur distal to the hip joint capsule.¹ They are further subdivided into subtrochanteric, intertrochanteric, and basicervical fractures, with each having difference in management modalities and prognosis.^{2,3} Usually, successful management needs a differentiation of stable from unstable fractures. However, the current classification systems have restricted the instability only at the vertical plane.^{2,4} Recently, rotational instability has become a potential hazard affecting even a stable fracture. The use of a single cephalic screw to fix a high-angle fracture line increases the chance of rotational instability.^{3,5-7}

Many variations have been introduced on the already existing implants to achieve a stable fixation. Still, the dynamic hip screw (DHS) is considered as the standard implant for fixating intertrochanteric fractures.^{1,2} Hence, some authors have used DHS augmented with cement, and others chose proximal femoral nails (PFN).^{2,8} However, due to the complications reported with PFN,^{9,10} and proximal femoral nail antirotation was designed.¹¹ Yet, this anti-rotational device, due to its position showed early complications, and later complications like as a “Z effect.”^{5,12} Z-effect, defined as a complication results from the collapse of the proximal fracture fragment that lead to a medial migration of the superior lag screw and lateral migration of the inferior lag screw.⁵

In a prior study,³ a successful result was achieved with the use of a composite DHS with derotation screw (DHS/DRS composite) for the fixating this group of fractures, which were designated to be rotationally unstable.

The AO types A1.2 and A1.3 fractures being rotationally stable were excluded from the prior study.⁴ However, when these fractures types were fixed with the DHS alone, rotational instability was reported as a complications.

The aims of this study was two-fold: firstly, to present the results of using the DHS/DRS composite in the fixation of 83 patients with fractures with rotation instability prospectively; secondly, to investigate the feasibility of our null hypothesis using the outcomes.

Materials and Methods

From August 2016 to August 2018, 83 patients who gave consent to participate were included in a prospective study. The primary assessment done by interviewing the patients regarding their ability to walk and was classified into two categories: 1) patient able to walk without any aid independently and 2) patients able to walk with one cane independently. Fracture identification was done using x-ray, and AO classification system was used for fracture classification.¹³

Those patients who were walking and those who were using one cane, presenting with extracapsular proximal femoral fractures meeting the criteria of rotational instability were included in our studied, viz. AO types A1.1, 2, 3, A2.1, 2, 3, and B2.1 fractures were included.

The following are the criteria of rotational instability: the head-neck fragment detached from the trochanters, is detached by a high-angle fracture line, and the inferior cortical extension not long enough to hinder rotation.^{3,5} In this study, due to the lack the one criterion of rotational instability, AO types A1.2 and A1.3 fracture were also

included. In type A1.2, The head–neck fragment has a fraction of the greater trochanter, whereas in type A1.3 it has a long inferior cortical extension. Then the fractures were divided into two groups: 1) 60 patients of the AO types A1.1, A2.1, 2, 3, and B2.1 fractures were included in the IUG and 2) 23 patients of the AO types A1.2 and A1.3 fractures were included the PUG. To study the feasibility of gathering both groups within a group for the rotationally unstable fractures, results were statistically analyzed. Patients with intracapsular fractures, the AO type A3, pathological fractures, and hips with advanced arthritis were excluded.

Operative Technique

The fracture site was exposed by a linear lateral incision. Pin was inserted into the subchondral level of the femoral head with the use of the angle guide. Head–neck fragment spinning during the process of reaming and screw insertion was minimized by insertion of a K-wire parallel and proximal to the guide pin cannulated cancellous partially threaded screw inserted onto the K-wire to act as a DRS. Submuscular suction drainage system was placed, and the wound was closed in layers and sterile dressing applied.

Post Op management

Prophylactic doses of antibiotics (third generation cephalosporin) and Antithrombotics (low molecular weight heparins) were administered to the patients. The use of clutches top walk was encouraged in patients with good reduction until a good callus was observed, followed by progressive weight bearing. Delayed weight-bearing was done in cases with unsatisfactory reduction. Follow-up was carried out every other week for 16 weeks and once a month thereafter. Patients were evaluated twice yearly after first year, and outcomes was assessed postoperatively from 24 months.

Radiological Assessment

Immediate assessment of reduction done and classified as adequate when the neck–shaft angle $<10^\circ$ varus or $<15^\circ$ valgus when compared with the contralateral hip and <3 mm displacement of fracture fragments in any of the AP and lateral x-rays.³ Fixation was rated by assessing the placement of the lag screw within the femoral head using two independent classifications for its adequacy. Firstly, the nine zones classification of the femoral head was used.¹⁴ Adequate grade was given when the screw was placed inferior/central, central/central, or inferior/ posterior in AP/lateral views. But the superior and/or anterior placement of screw was considered inadequate. Secondly, the tip-apex distance of <20 mm in both AP and lateral views was considered adequate.³ The lag screw and DRS was deemed adequate, based on the parallelism between them and was used as an indicator of reduction in subsequent radiographs. Converging DHS/DRS composite was deemed inadequate.³ Time to union was calculated from the surgery date to the healing date, indicator being the trabecular extension across the fracture. Non-union was defined as absence of the

bridging bone formed at the fracture site by follow-up at six months and progressive displacements.³ Fracture collapse and sliding distance were equal, which was defined as the length of protrusion of lag screw from the lateral edge of the barrel, measured at 6th month postoperatively or when the fracture found to have healed. According to Mattsson et al.,¹⁵ the sliding distance was classified into excellent (<6 mm), good (<15 mm), and poor (at 16 mm or more).

Clinical Assessment

A goniometer was used to measure the degree of motion of the hip joint and compared with the healthy contralateral joint. Measurement and comparison of the lengths of both the lower extremities were made. The modified criteria of Kyle et al.¹⁴ was used to evaluate the functional outcomes. Patients who had a normal range of motion, who had minimum limp without pain, and who rarely used a cane (provided that they did not use a cane in the pre-fracture period) were given excellent results. Patients who had a normal range of motion, but had a noticeable limp with occasional mild pain, and who used a cane (provided that they did not use a cane in the pre-fracture period) were given good result. Patients who had a limited range of motion, a noticeable limp, moderate pain and who used two canes or a walker were given fair result. Patients who had pain on any motion and who were in a wheelchair or who were non-ambulatory were given poor result.

Results

The study considered 83 fractures in 83 patients; their mean age at surgery was 61.3 (range: 38–85 years). The preoperative details are listed in Table 1.

Radiographic Results

The reduction was graded as adequate in 77 and inadequate in 6 fractures. In four fractures, the inadequacy of reduction was related to that the neck–shaft angle exceeded the contralateral by $<15^\circ$. In one fracture, it was related to the neck–shaft angle lowered by $>10^\circ$. In 6 fractures, the displacement between the fragments was >3 mm. In five fractures, the criteria for the inadequacy of reduction were noticed together (Table 2). Upto the final assessment, measurements of the neck–shaft angles remained preserved except in one case that was re-operated upon (Fig. 1). In 71 fractures, the fixation was considered adequate and in 12 fractures, it was considered inadequate, because TAD exceeded 20 mm in 12 fractures and the lag screw was placed superior in 11 femoral heads. In 11 fractures, the criteria of the inadequacy of fixation were noticed together (Table 2). Within a mean period of 13.5 weeks (range: 10–30 weeks), all fractures were healed. The sliding distance that averaged 5.8 mm (range: 2–20 mm) was used to estimate the fracture collapse. The rating was found excellent in 59, good in 22, and poor in 2 fractures (Table 3).

Table 1: Preoperative details for patients with rotationally unstable proximal femoral fractures

Type of Fracture	Fracture Number	Age (Years)		Genders		Side		Walking Aid	
		Average	Range	Male	Female	Right	Left	No	Yes
Inevitably Unstable	60	60.5	38-85	27	33	37	23	50	10
AO type A1.1	8	66.3	50-85	5	3	5	3	5	3
AO type A2.1	12	56.6	38-70	7	5	7	5	11	1
AO type A2.2	17	59.4	44-78	5	12	13	4	15	2
AO type A2.3	14	60.8	46-79	4	10	5	9	12	2
AO type B2.1	9	61.8	42-80	6	3	7	2	7	2
Potentially Unstable	23	63.5	43-80	10	13	13	10	20	3
AO type A1.2	18	66	55-80	7	11	11	7	15	3
AO type A1.3	5	55	43-66	3	2	2	3	5	0
Total	83	61.3	38-85	37	46	50	33	70	13

Table 2: Adequacy of the reduction and fixation in immediate postoperative radiographs

	Adequacy of reduction				Adequacy of fixation							
	FNS angle (compared to other side)		Fragmentary displacement		Tip apex distance		Lag screw placement				Derotation screw parallelism	
	Equal	Unequal	< 3 mm	> 3 mm	< 20 mm	> 20 mm	C/C	I/C	I/P	S/C	Parallel	Converge
Inevitably Unstable	57	3	55	4	53	7	3	12	36	9	54	6
AO type A1.1	8	0	8	0	7	1	1	1	4	2	7	1
AO type A2.1	12	0	12	0	11	1	0	4	7	1	11	1
AO type A2.2	16	1 valgus	15	1	15	2	0	3	11	3	15	2
AO type A2.3	12	2 valgus	12	2	12	2	1	2	9	2	13	1
AO type B2.1	9	0	8	1	8	1	1	2	5	1	8	1
Potentially Unstable	21	2	21	2	18	5	0	8	13	2	19	4
AO type A1.2	17	1 valgus	17	1	15	3	0	7	10	1	15	3
AO type A1.3	4	1 valgus	4	1	3	2	0	1	3	1	4	1

FNS angle-Femoral neck shaft angle; C/C-Central/central; I/C-Inferior/central; I/P-Inferior/posterior; S/C-Superior/central.

Table 3: Outcomes of limb functions for patients treated for rotationally unstable fractures

Type of fracture	Sliding distance			Leg length		Functional outcomes			
	Excellent	Good	Poor	Equal	Unequal	Excellent	Good	Fair	Poor
Inevitably Unstable	43	16	1	48	12	51	7	2	0
AO type A1.1	6	2	0	6	2	6	2	0	0
AO type A2.1	10	2	0	10	2	12	0	0	0
AO type A2.2	12	5	0	15	2	15	1	1	0
AO type A2.3	9	4	1	11	3	11	2	1	0
AO type B2.1	6	3	0	6	3	7	2	0	0
Potentially Unstable	16	6	1	18	5	18	4	1	0
AO type A1.2	14	3	1	14	4	14	3	1	0
AO type A1.3	2	3	0	4	1	4	1	0	0

Clinical Results

The numbers of patients who used one cane increased from 13 to 18, and three of them used two walking aids instead of one, towards the final visit. In 66 patients, equalization of both lower limbs was achieved; however, in 17 patients, leg shortening that averaged 4.6 mm (range: 0–

30 mm)] was reported (Table 3). In 80 patients, Hip motion range equalized the healthy contralateral, but in 3 patients there was limitation of motion. 69 patients obtained excellent, 11 achieved good, and three achieved fair results, according to the modified criteria of Kyle et al.,¹⁴ (Table 3).

Comparison of IUG and PUG using outcomes: In IUG, reduction of 56/60 fractures were rated as adequate and inadequate in 4/60 fractures, whereas in PUG, it was adequate in 21/23 and inadequate in 2/23 fractures. The difference between both groups was statistically insignificant ($p=0.67$).

In IUG, fixation of 52/60 fractures were rated as adequate and inadequate in 8/60 fractures, whereas in PUG, it was adequate in 19/23 and inadequate in 4/23 fractures. The difference between both groups was statistically insignificant ($p=0.73$).

In IUG, the sliding distance in 43/60 fractures were rated as excellent, 16/60 as good and 1/60 as poor. In PUG, the sliding distance in 16/23 fractures were rated as

excellent, 6/23 as good, and 1/23 as poor. The difference between both groups was statistically insignificant ($p=0.77$).

In IUG, equalization of legs' lengths was achieved in 48/60 patients; though, 12/60 patients reported discrepancy. In PUG, the equalization was achieved in 18/23 with discrepancy reported in 5/23 patients. The difference between both groups was statistically insignificant ($p=0.86$).

In IUG, the functional outcome in 51/60 patients was rated as excellent, in 7/60 patients as good, and in 2/60 patients as fair. In PUG, the functional outcome in 18/23 patients was rated as excellent, in 4/23 patients as good, and in 1/23 patients as fair. The difference between both groups was statistically insignificant ($p=0.76$).

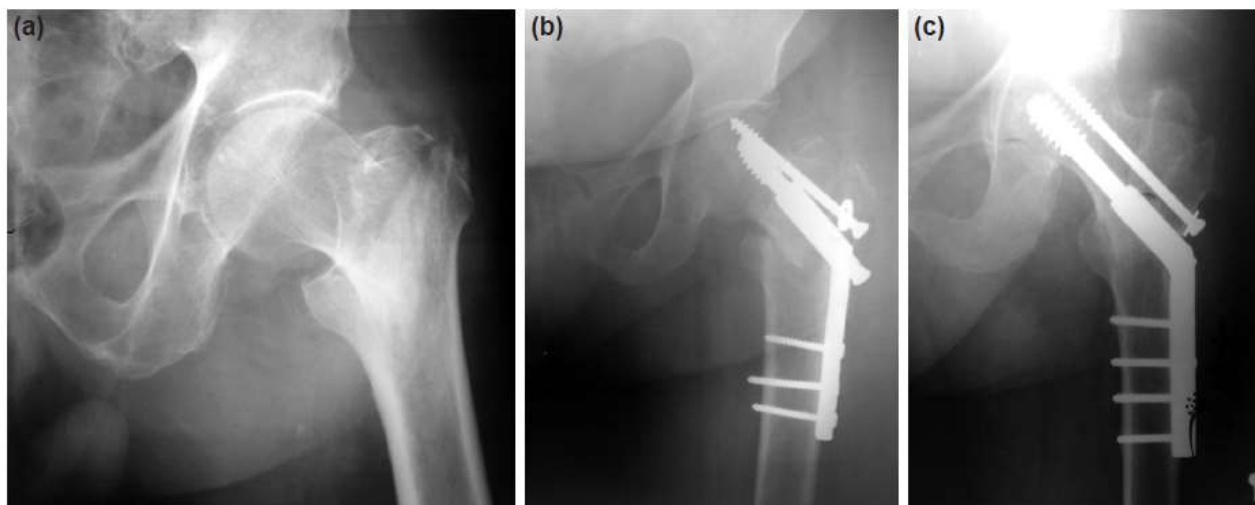


Fig. 1: (a) Preoperative AP radiograph for the right hip joint of a 69 years old female shows the AO type A1.2 trochanteric fracture. (b) AP radiograph at 2 weeks after surgery shows varus drift and excessive displacement of the head and neck fragment due to inadequate reduction and fixation. Note the placement of the DHS/DRS composite superior in the femoral head and convergence of DRS. (c) AP radiograph at 6 months after re-operation shows fracture healing, preserved neck-shaft angle, maintained parallelism between the cephalic screws of the DHS/DRS composite, and excellent sliding of the lag screw.

Complications

During the follow-up period, there were no general complications or deaths reported. However, one case with AO type A1.2 that showed excessive displacement of the proximal fragment in the postoperative radiograph due to inadequate reduction and fixation, underwent a re-operation (Fig. 1). At the postoperative 3rd week, 4 patients had superficial infection which was treated with parenteral antibiotic and daily wound dressing. 8 patients were found to have heterotopic ossification classes II and III, according to Brooker et al.¹⁶ classification, 3 of whom reported limitation of hip motion at the final visit.

Discussion

Extracapsular proximal femoral fractures are not alike in terms of rotational instability. Most of them demonstrated instability when constructed using solitary cephalic screw implant. Selecting the suitable fixation device depends on

the identification of the rotationally unstable fractures. Addition of DRS to DHS offer a compatible solution.

In a previous study, a group of rotationally unstable fractures were reported to have satisfactory results when fixed using the DHS/DRS composite.³ These fractures are the AO types A1.1, A2.1, 2, 3, and B2.1. The common factors in these fractures included loss of connection between the head-neck fragment and trochanters, separation by a high-angle fracture line, and loss of distal extension that can hinder the rotation.^{3,5}

The AO types A1.2 and A1.3 fractures upon fixation using DHS alone exhibited rotation of the proximal fragment around the lag screw during its insertion as well as loss of reduction during postoperative period. The head-neck fragment in the AO types A1.2 and A1.3 fractures is separated by a high-angle fracture line, which can generate a shear force and rotational instability.^{6,7}

Although the AO types A1.1, 2, and 3 fractures are equivalent to the stable fractures in Jensen classification,⁴ when used an implant with a single cephalic screw, reported

varus displacement in 11 of the stable fractures group, in another study by Jensen et al.¹⁷ Jensen could relate the instability to the separation of the head–neck fragment from the trochanters; though he could not explain how it occurred.⁴ The hip joint being a ball-and-socket joint have completely rotational motions.¹⁸ Rotation will not occur when the single cephalic implant is placed in the theoretical center of the femoral head, according to a study by Lenich et al.¹⁹ Implantation of a single cephalic screw was believed to lead to cutout according to the author.¹⁹

The adequacy of reduction and fixation can be measured by the immediate postoperative radiography (Table 2) which suggested that the inefficiency of the DHS/DRS composite to control rotation caused the differences in outcomes. In this study, inadequacy of reduction and/or fixation primarily correlated to the changes in the neck–shaft angle, re-displacement, excessive sliding, and limb shortening, rather than the implanted composite, and hence satisfactory outcomes can be achieved with adequately reduced and fixed fractures (Tables 2, 3).

Bone collapse, varus drift, or distal migration of the proximal fragment can cause shortening of the femoral neck and/or limb.^{8,15,19} Fracture collapse of 6.1 mm (range 0–30 mm) and a mean shortening of the limb of 4.7 mm (range 0–25 mm) was reported by Pajarinen et al.⁸ in a group of patients (n=41) treated with DHS. The outcomes of using DHS without and with resorbable cement augmentation in the fixation of trochanteric fractures were compared by Mattsson et al.¹⁵ Mean sliding distances of 15.9 mm with DHS alone and 13.5 mm when augmented, was reported by them. Moreover, they pointed out that limb mobility was not affected with a sliding distance of <6.7 mm; hence, they have correlated reduction of limb mobility with the sliding distance.¹⁵

A mean fracture collapse of 5.8 mm (range: 2–20 mm) and a mean limb shortening of 4.6 mm (range: 0–30 mm) were observed, in the present study. Fracture collapse and limb shortening were also consistently noticed together (Table 2). It has been reported that the high-angle fracture line displace the head–neck fragment distally and hence contributes to limb shortening.^{3,7} Accordingly, in control of the shear force, we appreciate the role of DRS, which is fastened as a rafter between the lateral femoral cortex and subchondral bone of the femoral head.

In the present study, the phenomenon of a rotational instability has been resurfaced to the light and presented as a potential hazard which could be avoided and identified in a group of fractures that has a susceptibility for rotation, albeit clinically. Published biomechanical and clinical studies supports the hypothesis and outcomes. However, being a case series study including a small number of patients and lacking biomechanical evaluation of its hypothesis, pose limitations of this study. Therefore, to demonstrate the merits of the present technique compared with other techniques, a power, multicenter, and randomized control study is required, coinciding with the biomechanical studies to provide more evidence for the assumptions.

Conclusion

During the follow-up period, the anatomical features of the proximal femoral end for the treated fractures as well as restoration the limbs' functions were maintained by the DHS/DRS composite. Addition of the AO types A1.2 and A1.3 fractures to the rotationally unstable fractures seems reasonable due to the similarity in the anatomical features of the head–neck fragment and the insignificant differences between the outcomes of the inevitable and potential rotationally unstable groups.

Conflict of Interest: None.

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