Original Article
Clinics in Orthopedic Surgery 2023;15:560-566 • https://doi.org/10.4055/cios22325

Clinical and Radiological Characteristics of Lesser Trochanter Splitting Irreducible Intertrochanteric Fractures

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Background: The purpose of this study was to investigate the demographic factors and radiological characteristics of lesser trochanter splitting (LTS) irreducible intertrochanteric fractures and to report the clinical results of patients who underwent open reduction and internal fixation using dynamic hip screws (DHS).

Methods: Inclusion criteria were as follows: AO/Orthopedic Trauma Association type 31A1.2, a fracture line originating from the outside of the greater trochanter that passes through the lesser trochanter, and patients who were followed up for more than 1 year with a confirmed presence or absence of bone union. A total of 13 cases were identified, accounting for 3.1% (13/416 intertrochanteric fractures). Patients were classified according to posterior sagging of the distal shaft fragment relative to the head-neck fragment (posterior sagging group, 6; non-sagging group, 7). Demographic data, comorbidities, injury mechanism, type of anesthesia, operation time, blood loss, tip-apex distance, reduction quality, leg length discrepancy (> 5 mm), long lesser trochanter sign, postoperative complications, and presence of bony union were obtained by reviewing medical records and radiological findings.

Results: The mean age of the patients was 50.4 ± 10.4 years, and 12 were men. Except for 1 case (slip down), all were induced by high-energy trauma. According to the grade of reduction quality, 5 cases (38.5%) had good reduction quality and 8 cases (61.5%) had acceptable reduction quality. There were no postoperative complications, and bony union was observed in all cases. The long lesser trochanter sign was observed in 5 cases (38.5%) and leg length discrepancy greater than 5 mm was not observed. Compared with the non-sagging group, the posterior sagging group had more head-neck fragments containing more than 1/2 of the lesser trochanter length, longer operation time, and more blood loss ($p < 0.05$). Compared to the non-sagging group, the posterior sagging group had worse reduction quality and more long lesser trochanter signs ($p < 0.05$).

Conclusions: Open reduction and internal fixation using DHS for the LTS irreducible intertrochanteric fractures can achieve good clinical and radiological outcomes. However, in the posterior sagging type, reduction can be more difficult with a longer operation time and higher likelihood of blood loss.

Keywords: *Hip fractures, Treatment outcome, Complications*

Received October 7, 2022; Revised November 17, 2022; Accepted November 17, 2022

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Clinics in Orthopedic Surgery • pISSN 2005-291X eISSN 2005-4408

As the elderly population increases, the incidence of hip fractures is increasing, and intertrochanteric fractures are one of the major parts of hip fractures.[1)] These fractures are mainly associated with osteoporosis and usually occur indoors as a result of low-energy trauma such as slip down. For surgical treatment, it is common to perform rigid fixation using a cephalomedullary nail or a dynamic hip screw after adequate reduction by closed manipulation.[2)] However, sometimes these fractures can occur at a young age and can also be caused by high-energy trauma.[3)] In addition, some intertrochanteric fracture types, such as reverse oblique fracture lines, cannot be properly reduced by closed manipulation, so open reduction may be required.[1,4)]

Said et al.[5)] reported on a reduction technique for an irreducible variant of intertrochanteric fractures. The type of fracture they reported was difficult to reduce with closed manipulation because the lesser trochanter was split and attached to the head-neck fragment and distal shaft fragment and inter-positioned on the iliopsoas tendon. Therefore, there is a high probability that closed reduction will fail and open reduction will be required. Also, they explained the reduction technique in three steps, which seems to be much more difficult than the general reduction of other intertrochanteric fractures. It seems that studies reporting on the clinical results of surgical treatment for these uneasily reduced fractures are very rare.

Therefore, the purpose of this study was to investigate the demographic factors and radiological characteristics of lesser trochanter splitting (LTS) irreducible intertrochanteric fractures and to report the clinical results of patients who underwent surgical treatment using dynamic hip screws (DHS).

METHODS

The design and protocol of this retrospective study were approved by the Institutional Review Board of Daejeon Eulji Medical Center (No. 2022-07-010). Written informed consent was waived for all patients involved in this study.

The LTS irreducible intertrochanteric fracture patients included in this study were selected from a pool of 396 patients (416 intertrochanteric fractures), who were 18 years of age or older and underwent surgical treatment from January 2014 to August 2021 at our hospital. Inclusion criteria were as follows: (1) AO/Orthopedic Trauma Association (OTA) type 31A1,[2,4)] (2) a fracture line originating from the outside of the greater trochanter that passes through the lesser trochanter (Fig. 1), and (3) patients who were followed up for more than 1 year with a confirmed presence or absence of bone union. Pathological fractures were excluded. All surgical treatments were performed with open reduction on a fracture table using DHS.

Demographic data obtained by reviewing medical records and radiological findings include age, sex, medical comorbidities, injury mechanisms, type of anesthesia (general or spinal), operation time, blood loss, tip-apex

Fig. 1. Three-dimensional reconstruction image of a lesser trochanter splitting intertrochanteric fracture of a 38-year-old male patient from computed tomography.

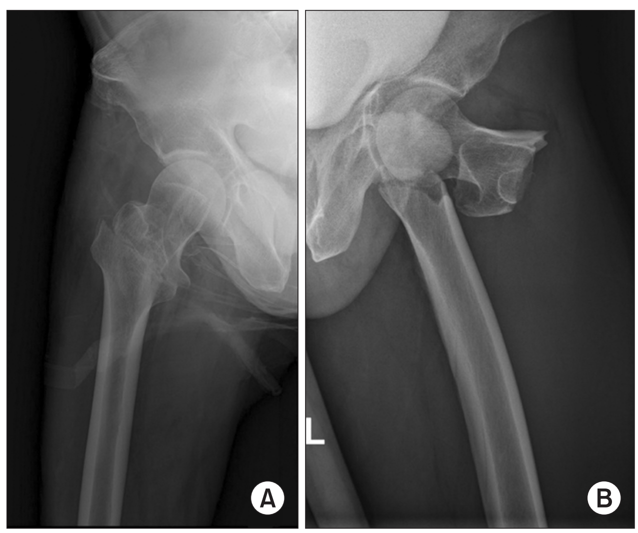

Fig. 2. (A) A translateral hip radiograph of a 65-year-old male patient. Considering the location of the head-neck fragment, the distal shaft fragment was not posteriorly translated. (B) A translateral hip radiograph of a 50-year-old male patient. The head-neck fragment was severely flexed and the distal shaft fragment was posteriorly located.

distance, reduction quality, complications such as wound infection, implant failure, and presence of bony union at postoperative 1 year. In addition, posterior sagging of the distal shaft fragment relative to the head-neck fragment in the preoperative translateral hip view (Fig. 2), the head-neck fragment containing more than 1/2 of the lesser trochanter length, and presence of the increase in length of the lesser trochanter on the postoperative anteroposterior hip radiograph (long lesser trochanter sign) were investigated (Fig. 3). We defined the long lesser trochanter sign as a condition in which the length of the injured lesser trochanter after union became more than 10% longer than that of the unaffected lesser trochanter. Finally, an increase in leg length greater than 5 mm in the scanogram view was investigated at final follow-up.

The reduction quality of alignment was evaluated based on the method proposed by Baumgaertner and Solberg,[6] which includes the following two aspects: (1) normal or slightly valgus neck-shaft angle on the anteroposterior view and (2) less than 20° of angulation on the translateral view. The reduction quality of displacement was based on the method proposed by Kim et al.,[7] which includes the following two aspects: (1) displacement less than the medial cortical thickness on the anteroposterior view and (2) displacement less than the anterior cortical thickness on the translateral view. A “good” reduction met both criteria of alignment and both criteria of displacement. An “acceptable” reduction met both criteria of alignment and only one criterion of displacement.

Statistical Analysis

Patients were classified according to posterior sagging of distal shaft fragment relative to the head-neck fragment and analyzed for clinical outcomes. We used the Fisher exact test for categorical variables and the *t*-test for numerical variables. All two-sided p-values < 0.05 were considered significant. Statistical analysis was performed using IBM SPSS statistics ver. 20.0 (IBM Corp., Armonk, NY, USA).

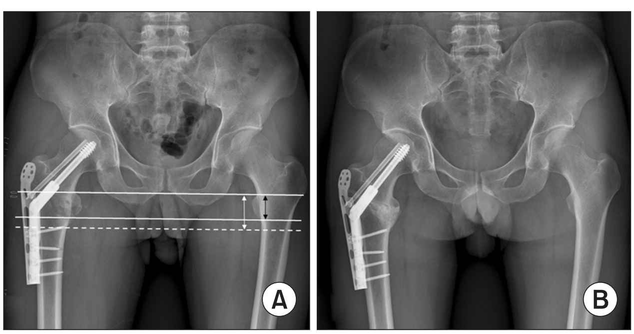

Fig. 3. Postoperative radiographs of a lesser trochanter splitting irreducible intertrochanteric fracture in a 38-year-old male patient. (A) The head-neck fragment contained more than 1/2 of the lesser trochanter length. As much as the gap of the fracture site, the length of the lesser trochanter (white arrow) was longer than that of the contralateral normal side (black arrow). (B) At 1 year postoperative, the radiograph showed complete bony union of the fracture site.

RESULTS

A total of 13 cases of LTS intertrochanteric fractures were identified, accounting for 3.1% (13/416 hips) (Table 1). The mean age of the patients was 50.4 ± 10.4 years, and there were 12 men. All but 1 case, in which the cause was a slip down, were caused by high-energy trauma. Two patients had hypertension, but the remaining patients had no underlying diseases. All fractures were fixed using DHS and 6.5 mm or 5.0 mm cannulated cancellous screws. Regarding the grade of reduction quality, 5 cases had good reduction quality (38.5%) and 8 cases had acceptable reduction quality (61.5%). There were no complications such as wound infection, pneumonia, or implant failure, and bony union was observed in all cases. Also, leg length discrepancy greater than 5 mm was not observed.

Patients were classified into a posterior sagging group (6 patients) and a non-sagging group (7 patients) according to the presence of posterior sagging on preoperative radiographs (Table 2). Compared with the non-sagging group, the posterior sagging group had more head-neck fragment containment of more than 1/2 of the lesser trochanter length, longer operation time, and more blood loss ($p < 0.05$). On the reduction quality evaluation, the reduction quality of the posterior sagging group was worse and the long lesser trochanter sign was more frequently observed than in the non-sagging group ($p < 0.05$).

DISCUSSION

A typical feature of intertrochanteric fractures in the geriatric population is that they are related to osteoporosis, are caused by low-energy trauma such as slip down, and have high mortality rates due to high comorbidity rates among patients.[8] In addition, it has been reported that if the fixation of the fracture is not rigid or accompanies severe comminution, collapse may occur at the fracture site, and as this progresses, complications such as cut out or cut through may occur.[9,10] However, the LTS irreducible intertrochanteric fractures in this study had different characteristics from the typical elderly intertrochanteric fractures. The average age of the patients was 50.4 years, and the bone mineral density was not lower than –2.0 in

Table 1. Demographics, Clinical, and Radiological Factors in Included Patients

No	Age (yr)	Sex	Right /left	Injury mechanism	Comorbidity	LT over 1/2 involvement*	Posterior sagging of distal fragment†	Type of implant	Type of anesthesia	Operation time (min)	Blood loss (mL)	TAD (mm)	Reduction quality	Complication	Bony union at postoperative 1 year	Long lesser trochanter sign	LLD over 5 mm
1	36	M	Right	Bicycle TA	No	No	No	DHS + 6.5 mm CCS	G	65	350	16	Good	No	Yes	No	No
2	38	M	Right	Pedestrian TA	No	Yes	Yes	DHS + TSP + 6.5 mm CCS	G	77	590	15	Acceptable	No	Yes	Yes	No
3	44	M	Right	Fall down	No	No	No	DHS + 6.5 mm CCS	G	46	410	12	Good	No	Yes	No	No
4	49	M	Left	Fall down	No	No	No	DHS + 6.5 mm CCS	G	58	530	16	Acceptable	No	Yes	No	No
5	50	M	Left	Driver TA	No	Yes	Yes	DHS + 6.5 mm CCS	G	66	580	14	Acceptable	No	Yes	Yes	No
6	58	M	Right	Fall down	No	No	No	DHS + 6.5 mm CCS	G	55	440	16	Good	No	Yes	No	No
7	65	F	Left	Fall down	Hypertension	No	No	DHS + TSP + 5.0 mm CCS	G	43	520	13	Good	No	Yes	No	No
8	63	M	Right	Pedestrian TA	No	No	No	DHS + 6.5 mm CCS	G	67	450	14	Acceptable	No	Yes	No	No
9	71	M	Left	Slip down	Hypertension	No	No	DHS + 6.5 mm CCS	G	49	360	16	Good	No	Yes	No	No
10	39	M	Right	Driver TA	No	Yes	Yes	DHS + 6.5 mm CCS	G	85	660	15	Acceptable	No	Yes	Yes	No
11	46	M	Right	Bicycle TA	No	Yes	Yes	DHS + 6.5 mm CCS	G	56	580	14	Acceptable	No	Yes	Yes	No
12	49	M	Left	Pedestrian TA	No	Yes	Yes	DHS + 6.5 mm CCS	G	71	670	12	Acceptable	No	Yes	No	No
13	52	M	Left	Driver TA	No	Yes	Yes	DHS + 6.5 mm CCS	G	76	630	13	Acceptable	No	Yes	Yes	No

LT: lesser trochanter, post: posterior, TAD: tip-apex distance, LLD: limb length discrepancy, TA: traffic accident, DHS: dynamic hip screw, CCS: cannulated cancellous screw, G: general anesthesia, TSP: trochanter stabilizing plate.
*Whether the head-neck fragment contained more than 1/2 of the lesser trochanter length. †Whether posterior sagging of distal shaft fragment relative to the head-neck fragment was present in the preoperative hip translateral view.

Table 2. Comparison of Clinical and Radiological Factors between Posterior Sagging Group and Non-sagging Group

Variable	Non-sagging group (n = 7)	Posterior sagging group (n = 6)	*p*-value
Age (yr)	55.1 ± 12.6	45.7 ± 5.9	0.120
Sex (male : female)	6 : 1	6 : 0	1.000
Right: left	4 : 3	3 : 3	1.000
Injury mechanism (high energy : low energy)	6 : 1	6 : 0	1.000
Comorbidity	2	0	0.462
LT over 1/2 involvement*	0	6	0.001
Operation time (min)	54.7 ± 9.3	71.8 ± 10.0	0.009
Blood loss (mL)	437.1 ± 70.6	618.3 ± 40.7	< 0.001
TAD (mm)	14.7 ± 1.7	13.8 ± 1.2	0.296
Reduction quality (good : acceptable)	5 : 2	0 : 6	0.021
Long LT sign	0	5	0.005

Values are presented as mean ± standard deviation or number.
LT: lesser trochanter, TAD: tip-apex distance.
*Whether the head-neck fragment contained more than 1/2 of the lesser trochanter length.

dual energy absorptiometry performed in the included patients over 65 years of age. In addition, only 2 patients had hypertension and none had advanced diseases. Except for 1 patient, fractures were induced by high-energy trauma. The patients included in our study had similar characteristics of young patients with high-energy intertrochanteric fractures mentioned by Amini et al.[3] They reported the clinical results of patients under the age of 65 years who underwent surgical treatment for AO type 31A1 or 31A2. The included 37 patients were in their mid-40s, with a high proportion of men. However, there was no complication in our study and all fractures were united, whereas Amini et al.[3] reported a high rate of complications such as varus collapse and nonunion. Such differences are thought to be due to differences in fracture type, reduction quality, and rigid fixation between the two studies. In the study of Amini et al.,[3] AO 31A2 type was included, so fracture instability due to comminution was higher than that of our study. Also, considering reduction quality and tip-apex distance, fixation was evaluated to be less rigid.[11] Therefore, we believe that although LTS irreducible intertrochanteric fractures have demographic and radiographic characteristics that differ from those of the typical elderly intertrochanteric fractures, good clinical results can be obtained if appropriate reduction and rigid fixation are performed.

In intertrochanteric fractures, reduction quality is a factor that can be controlled by the physician, and favorable reduction lessens complications due to early gait, as well as satisfactory clinical results.[12,13] However, in our study, for LTS irreducible intertrochanteric fractures, an acceptable reduction could not be achieved with closed manipulation, and all had to undergo open reduction. This is due to the resilient displacement force applied by soft tissues such as the iliopsoas tendon, iliofemoral ligament, pubofemoral ligament, abductors, and short external rotators attached to the proximal fragment.[12,13] In addition, if posterior sagging of the shaft fragment occurs when placed on a fracture table, it becomes more difficult to reduce. In our study, the reduction of posterior sagging group was challenging compared to that of the non-sagging group, so the operation time of the posterior sagging group was longer and more blood loss occurred in the posterior sagging group compared to the non-sagging group. In addition, postoperative reduction quality was also less favorable, and insufficient reduction appeared in the form of a lesser trochanter being longer than the contralateral normal. Even in reverse intertrochanteric fractures, posterior sagging of shaft fragment may occur, which is reported to be caused not only by gravity but also by tears in dorsal soft tissues.[4] In our study, if the length of the lesser trochanter remaining in the proximal segment was more than 1/2 of the length, the iliopsoas tendon attached to the distal fragment could not lift the distal fragment forward, so posterior sagging seemed to occur due to gravity. Therefore, various techniques may be required to reduce these fractures. Hao et al.[4] reported reduction techniques for surgical treatment of irreducible reverse intertrochanteric fractures. A periosteum elevator was used to push the head-neck fragment posteriorly, and a mallet was used to lift up the femoral shaft for reduction in the case of posterior sagging of the femoral shaft relative to the head-neck fragment. An intramedullary nail was then inserted. However, they could not obtain favorable reduction with this process alone, and precise control of the femoral shaft could not be done. Therefore, they subsequently reduced the fracture by using the joystick technique or T-handle hanging using a Schantz screw. We also tried surgical treatment in a similar way. After placing the patient on the fracture table, we properly tracted the lower limb in the distal direction at the level of the hip joint. The distal fragment was lifted to an appropriate height using an aseptic draped Mayo stand for lifting of posteriorly sagged distal shaft fragment. This allows the proximal portion of the distal fragment to be lifted without being obstructed by the image intensifier. Then, the proximal fragment was reduced by the joystick technique using Steinmann pins. The Steinmann pin is inserted in the distal portion of the proximal fragment from the anterior to the posterior direction for extension and internal rotation. Sometimes, we may need to release some traction to close the gap in the fracture site. Next, we fixed with a temporary pin and then fixed with DHS and screws. However, when a fracture table is used, it may be difficult to overcome strong displacement forces. In this situation, Said et al.[5] recommend the use of a regular operating table.

Our study has several limitations. First, there were no patients who underwent surgical treatment using intramedullary nails, so only the results of surgical treatment using DHS were reported. However, reduction using intramedullary nails is often performed with closed manipulation, and there is a problem that this fracture type cannot be reduced by closed manipulation. So, further research is needed in the future. Second, there is a risk of selection bias because the number of patients was very small. LTS irreducible intertrochanteric fractures appear to be an uncommon type of intertrochanteric fracture and further studies for analyzing clinical results are needed in more cases. Third, as a retrospective study, evaluation of the functional status such as Harris hip score was not performed. However, since we obtained an acceptable reduction and bony union in all fractures, patients were relatively healthy without underlying disease, and there was no leg length discrepancy over 5 mm in all cases, it is thought that no major functional problems were caused.

In conclusion, although LTS irreducible intertrochanteric fractures have demographic and radiographic characteristics that differ from those of typical intertrochanteric fractures, open reduction and internal fixation in surgical treatment using DHS can achieve favorable clinical outcomes. However, in the posterior sagging type, reduction is more challenging, the operation time is longer, and more blood loss is inevitable, requiring more attention of the operator in surgery.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

ACKNOWLEDGEMENTS

This research was supported by a grant of the Korea Health Technology R&D Project through the Korea Health Industry Development Institute (KHIDI), funded by the Ministry of Health & Welfare, Republic of Korea (grant no. HI22C0494).

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