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Original article

Is rigid fixation of the greater trochanter necessary for arthroplasty of intertrochanteric fractures?

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ABSTRACT

Introduction: Stable fixation of the greater trochanter fracture fragments is necessary in arthroplasty of intertrochanteric hip fractures, as nonunion of the greater trochanter fracture comminution may result in impaired function or dysfunction of the abductor lever arm.
Hypothesis: The ethibond suture technique is an efficient method for fixation of the greater trochanter fracture fragments.
Materials and methods: A total of 47 cases were studied. The mean age of the patients was 80.6 years, and the minimum follow-up was 6 months. Radiologic evaluation was done by examination of greater trochanter healing and measurement of migration of the greater trochanter fragment. Functional evaluation was done by comparison of pre-injury and postoperative ambulation status.
Results: The mean migration of the greater trochanter fragment with ethibond sutures was 5.98 mm. Union was achieved in 76.6%, and the nonunion rate was 23.4%. 86.9% of patients had no difference in ambulation or had a difference of only 1 level by the Koval score after treatment compared to their pre-injury status.
Discussion: The ethibond suture technique provides good fixation of the greater trochanter fragments in arthroplasty of intertrochanteric hip fractures.
Level of evidence: IV, Case series.

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1. Introduction

As the world population grows older, the incidence of hip fractures is increasing. Approximately 280,000 hip fractures occur every year in the United States, which is estimated to be doubled in the next half century [1]. Intertrochanteric hip fractures account for 45% of all hip fractures. Comminuted fractures of the greater trochanter exist in 30 to 45% of intertrochanteric hip fractures [2]. These patients are susceptible to many complications such as pneumonia and pulmonary embolism etc., therefore operative treatment is the mainstay of treatment to promote early mobilization and return to prefracture status [3]. Internal fixation is an excellent option, but bipolar hemiarthroplasty can be a suitable alternative for elderly patients to provide early full weightbearing and rapid rehabilitation [4]. Bonnevialle et al. suggest that arthroplasty is a better option for unstable trochanteric fracture patients over 75 year old [5].

In many cases, the greater trochanter fracture fragment must be stably fixed during arthroplasty of intertrochanteric hip fractures. Nonunion of the greater trochanter fracture comminution may result in impaired function or dysfunction of the abductor lever arm, causing pain and Trendelenburg gait pattern [6]. Various techniques have been developed for fixation of the greater trochanter fragments, such as cerclage wiring, tension band wiring, K-wire insertion & grip plate fixation [7–17]. These implants may help preserve the abductor lever arm, but increase the operation time, may be expensive and cause irritation of the adjacent tissue causing chronic pain.

In this study, the short-term results of osteosynthesis of the greater trochanter fragments by nonabsorbable ethibond sutures was investigated. The hypothesis was that the ethibond suture technique is an efficient method for fixation of the greater trochanter fragments in arthroplasty of intertrochanteric hip fractures.

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2. Materials and methods

2.1. Patient population

Between 2010 and 2016, there were 578 intertrochanteric hip fracture cases at our institute. 128 hips were treated by bipolar hemiarthroplasty, and only 45 patients (1 male, 44 females) were followed up for at least 6 months. A total of 47 hips were studied as 1 male and 1 female had both hip fractures. The average age of the patients was 80.6 years (range 65–97 years). (Fig. 1) (Table 1).

According to the AO classification system, there were 13 cases of type A1.2 trochanteric fractures, 1 case of type A1.3 trochanteric fracture, 15 cases of A2.1 trochanteric fractures, 10 cases of type A2.2 trochanteric fractures, 7 cases of type A2.3 trochanteric fractures, 1 case of type A3.2 trochanteric fracture. We divided the cases into 2 groups based on the location and shape of the fracture line at the greater trochanter, with relation to the insertion of the gluteus medius muscle and the gluteus minimus muscle. The abductor muscles: gluteus medius muscle and gluteus minimus muscle originate from the outer surface of the pelvis and insert at the lateral and anterior facet of the greater trochanter respectively [18]. The gluteus medius insertional footprint is located on the lateral aspect of the greater trochanter; from the posterior tip of the greater trochanter to the anteroinferior corner of the lateral facet. The gluteus minimus insertional footprint is located at the anterior facet of the greater trochanter; from the anterior tip of the greater trochanter to the anteroinferior vastus tubercle [18]. Type A was defined as a complete transverse greater trochanter fracture involving both insertion footprints of the gluteus medius muscle and gluteus minimus muscle. Type B was defined as a partial oblique greater trochanter fracture involving the insertional footprint of the gluteus medius muscle but with the insertional footprint of the gluteus minimus muscle partially or completely intact (Fig. 2). Based on our classification, there were 12 Type A fractures, 35 type B fractures.

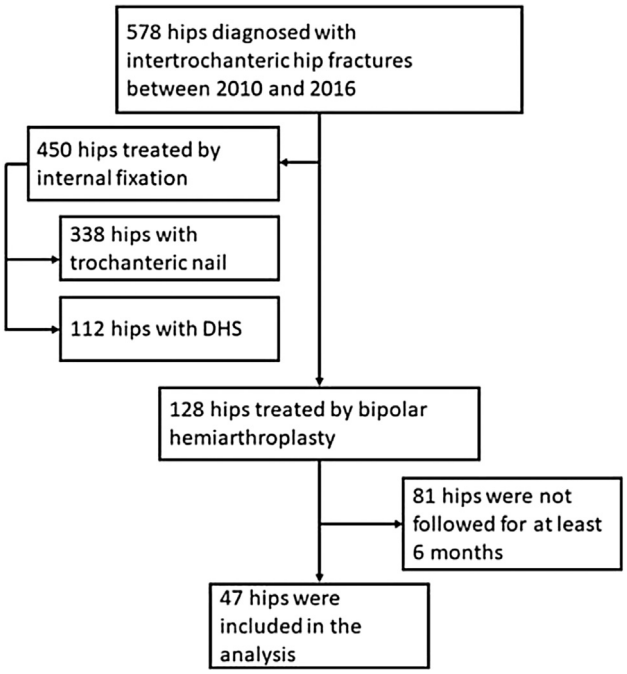

Fig. 1. Flowchart of enrolled intertrochanteric hip fracture patients.

Table 1
Functional status of patients before injury by Koval score.

Koval score	Number of patients
7 (Independent community ambulatory)	17
6 (Community ambulatory with cane)	7
5 (Community ambulatory with walker)	4
4 (Independent household ambulatory)	1
3 (Household ambulatory with cane)	4
2 (Household ambulatory with walker)	7
1 (Nonfunctional ambulator)	5

There were 46 cases of non-cemented bipolar hemiarthroplasty, and 1 case of cemented bipolar hemiarthroplasty. Four different types of implants were used. 17 cases were performed with the non-cemented Summit® Tapered Hip System (Depuy Synthes, Warsaw, IN, USA), 5 cases were performed with the noncemented AML® Hip System (Depuy Synthes, Warsaw, IN, USA), 1 case was performed with the cemented CSTEM® AMT Hip System (Depuy Synthes, Warsaw, IN, USA), 24 cases were performed with the non-cemented Bencox® Hip System (Corentec, Seoul, Korea).

The greater trochanter suture technique was used for fixation of the greater trochanter fragments in 43 cases. There were 4 cases in which the greater trochanter fracture fragments were stable due to soft tissue attachments and no fixation was needed.

2.2. Surgical techniques

All surgical procedures were performed by the same surgeon. The operation was performed by using a modified posterolateral approach of the hip. The soft tissue was meticulously dissected, preserving the bursa as much as possible. The piriformis tendon was preserved and only the superior gemellus, obturator internus, inferior gemellus tendons were detached from the greater trochanter insertion. After a longitudinal incision of the capsule, the femoral head was cut off and manually dislocated. Most of the fractured fragments were preserved as long as the soft tissue attachments were intact. The femoral canal was prepared by progressive rasps to the appropriate stem size and diameter. After implantation of the femoral stem and head prosthesis, leg length, range of motion, and hip stability were checked. The fractured fragments were left undetached as much as possible during this procedure.

After the hip capsule was repaired, the greater trochanter fragments were reduced and fixed by Ethibond No. 2 sutures. K-wires were used for drilling holes on the greater trochanter fragment and the intact femur. Ethibond sutures were passed through the holes and tied tightly by simple sutures. The number of sutures varied from one to three based on the size and instability of the fracture fragments. (Fig. 3) After fixation of the greater trochanter, the external rotators were sutured to their insertion sites in a likely manner by additional bone drilling on the greater trochanter with Ethibond No. 2 and Vicryl 2-0 sutures passed through the drilled holes.

The incision was closed layer by layer after insertion of a negative suction drain.

2.3. Postoperative management

Patients were encouraged to receive physical training from the first postoperative day. Continuous passive motion, quadratus strengthening exercise, and use of tilting tables were started. Patients that are able were ambulated by full weight bearing as soon as possible with the aid of walkers or crutches. Independent ambulation was started 6 weeks after the operation.

2.4. Analysis of outcome

Patients were followed up at 6 weeks, 3 months, 6 months and 1 year after the operation. The minimal follow up of patients was 6 months. Clinical outcomes were analyzed by reviewing the inpatient and outpatient records. Radiologic evaluation was done by examination of greater trochanter union and measurement of

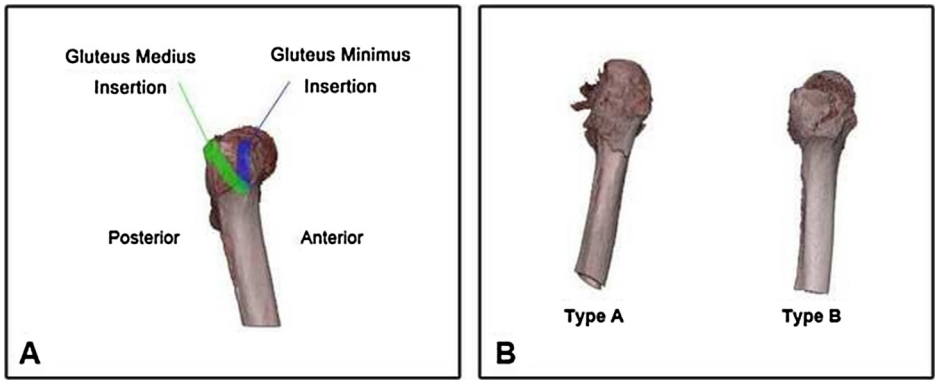

Fig. 2. Abductor muscle insertions and classification of intertrochanteric fractures. A. Gluteus medius & gluteus minimus insertions at the greater trochanter. B. Type A and B of intertrochanteric fractures according to the fracture shape at the greater trochanter.

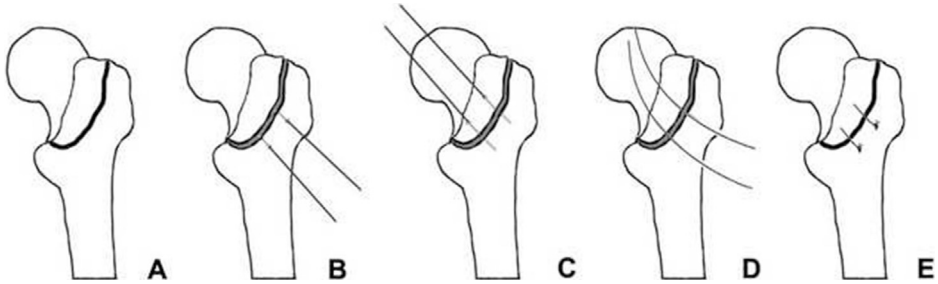

Fig. 3. Greater trochanter suture technique on posterolateral view of the proximal femur. A. Greater trochanter fracture fragment. B. Drilling holes with K-wires on the intact femur. C. Drilling holes with K-wires on the fracture fragment. D. Ethibond sutures passed through drilled bone tunnels. E. Ethibond sutures tied by simple suture.

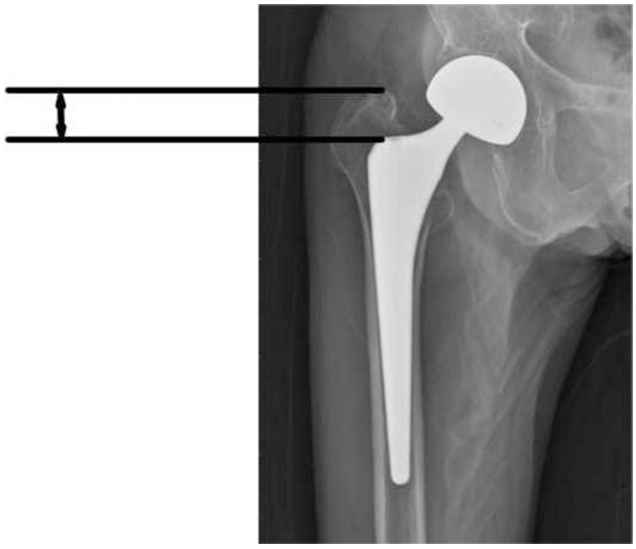

Fig. 4. Stem to tip distance.

migration of the greater trochanter. The measurement of migration of greater trochanter was done by comparing the stem-to-tip distance (Fig. 4) of the postoperative x-ray to that of the latest follow-up x-ray. Functional evaluation was analyzed by assessing change of mobility according to the Koval score.

3. Results

3.1. Radiologic evaluation

The mean migration of the greater trochanter of all cases was 5.98 mm The mean migration was larger in complete greater trochanteric fractures compared to partial greater trochanteric fractures; 7.5 mm in type A, 5.46 mm in type B. The mean migration of patients without fixation of the greater trochanter fragment was 8.75 mm, and that of patients with Ethibond suture fixation was 5.72 mm (Fig. 5).

The mean union rate and nonunion rate of all cases was 76.6% (36 out of 47) and 23.4% (11 out of 47) respectively. The mean union rate was 82.9% in type B fractures compared to 58.3% in type A fractures. The mean union rate of the patients without greater trochanter fragment fixation was 100% (4 out of 4) and that of patients with Ethibond suture fixation was 74.4% (32 out of 43) (Table 2).

3.2. Functional evaluation

There was no difference in the ambulation status in 65.2% of patients in all cases, in 69.4% (25 out of 36) of patients with complete union, and in 54.5% (6 out of 11) of patients with nonunion.

There was no difference in the ambulation status in all cases (4 out of 4) of patients without greater trochanter fragment fixation. 65.1% (28 out of 43) of patients with Ethibond suture fixation had no difference in ambulation status. 25.6% (11 out of 43) had a lower Koval stage by 1 level compared to the pre-injury ambulation status; 9.3% (4 out of 43) by 2 levels, and 2.3% (1 out of 43) by 5 levels.

3.3. Complications

There were 11 cases of nonunion. One patient suffered a cerebrovascular attack postoperatively, whose ambulation status declined by 5 levels (from community ambulatory with cane to nonfunctional ambulatory) compared to the pre-injury ambulation status. Two patients had periprosthetic joint infection. Both patients had revision total hip replacement arthroplasty

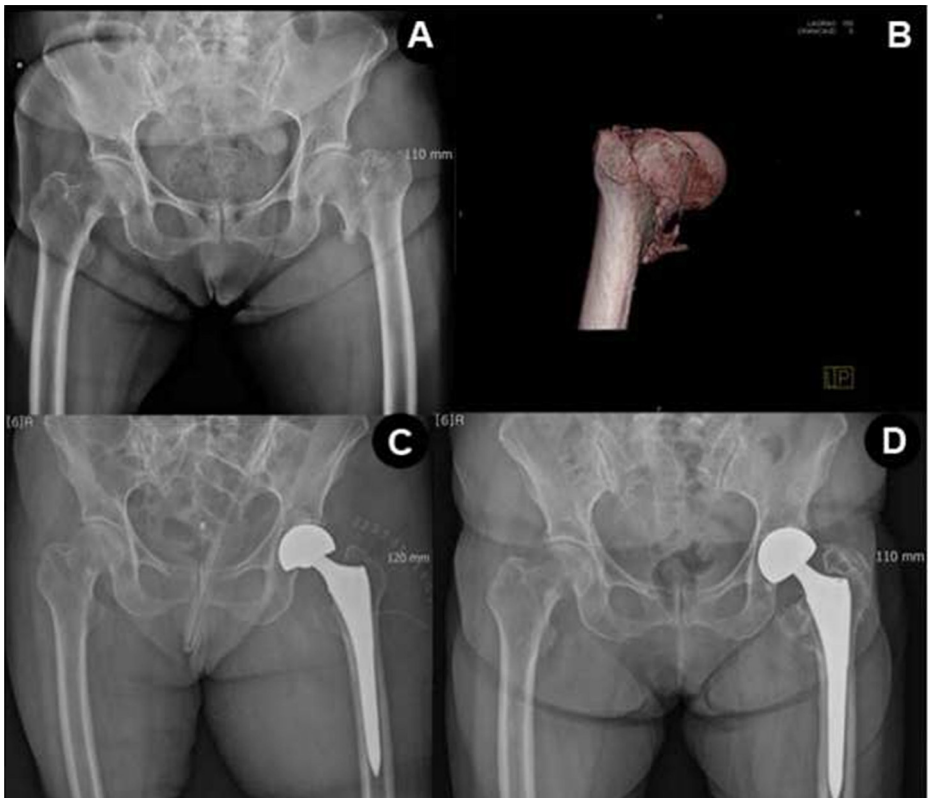

Fig. 5. 82 year-old patient with AO classification type A2.2 intertrochanteric hip fracture had bipolar hemiarthroplasty with ethibond suture of the greater trochanter fragments. A. Preoperative x-ray. B. Preoperative CT scan. C. Postoperative X-ray. D. Follow-up X-ray 2 years and 1 month after the operation. Union was achieved and the patient had no change in ambulation status. (Independent community ambulatory to Independent community ambulatory).

Table 2
Functional outcomes by comparison of pre-injury and postoperative ambulation status.

	No difference (%)	Decreased by 1 level (%)	Decreased by 2 levels (%)	Decreased by 5 levels (%)
All cases	65.2	21.7	8.7	2.2
By union status				
Union	69.4	13.9	13.9	2.8
Nonunion	54.5	45.5		
By mode offixation				
No fixation	100			
Ethibondsuture	65.1	25.6	9.3	2.3

after removal of the primary prosthesis. Their ambulatory status decreased by 1 and 2 levels respectively.

4. Discussion

The importance of fixation of the greater trochanter after arthroplasty was originally introduced due to nonunion after trochanteric osteotomy, which was used for better exposure of the acetabulum and the proximal femur in total hip replacement. Nutton and Checketts [6] proposed that migration and nonunion of the greater trochanteric fragment compromises abductor muscle power resulting in positive Trendelenburg's sign. The current literature on bipolar hemiarthroplasty for intertrochanteric hip fractures also has emphasis on preservation of the abductor lever arm and the need for fixation of the greater trochanter fragments [7–17].

Suh [8] et al. compared the results of figure of 8 wiring, cerclage wiring, and tension band wiring for fixation of the greater trochanter fragment. The rate of fragment migration was 22.2%, 52.2%, 9.1% respectively.

The functional result evaluation according to the Merle d'Aubigne scale was 78.6%, 82.4%, 88.9% respectively. They proposed that the tension band wiring method was a useful method for fixation of the greater trochanter fragments.

Kim [9] et al. reported good outcomes with greater trochanter fixation by AO TRD, (Trochanteric reattachment device, Synthes, Swiss) after bipolar hemiarthroplasty on patients with intertrochanteric hip fractures. A total of 19 patients with unstable intertrochanteric hip fractures by the Evans classification were studied. Functional evaluation was done according to visual analog scores and ambulation abilities. After minimum follow up of 12 months the mean VAS score was 4.37. Successful greater trochanter union was observed in all 19 patients. There was 1 case of TRD loosening and 2 cases of irritation.

Zhang [8–11] et al. evaluated the efficacy of supplementary fixation in hip arthroplasty with the use of Kirschner-wires and tension band wiring for geriatric unstable intertrochanteric fractures. A total of 103 patients with type A2.2 or A2.3 intertrochanteric fractures by the AO classification were studied. Physical component summary (PCS), mental component summary (MCS), visual analog scale (VAS), and Harris hip score were utilized to evaluate the patients' hip pain and function. The patients showed improvement in all scores with no cases of dislocation or nonunion of the fracture.

Grimsrud [11] et al. proposed a cerclage cable technique with cemented hip arthroplasty for unstable intertrochanteric hip fractures. A total of 39 patients with unstable three or four part intertrochanteric hip fractures were studied. At minimum 1 year follow up, all trochanters healed. There were 5 cases of cable breakage but no more than 5 mm of greater trochanter proximal migration was observed.

Ozan [12] et al. analyzed clinical and radiologic results of greater trochanteric fixation using a cable system after partial hip arthroplasty. A total of 32 patients with type III and IV trochanteric

fractures by the Evans classification were studied. They immobilized the lesser trochanter and greater trochanter by using cables (Zimmer, Warsaw, IN, USA) and tensioners. The mean follow up was 13 months. Presence of continuity observed on the X-ray was defined as healed fractures. Fibrous union was defined as a distance of ≤ 1.5 cm and nonunion as > 1.5 cm between the adhesion site and the trochanteric fragment after its proximal migration. Union was observed in 43.7% of cases, fibrous union in 37.5% of cases, and nonunion in 18.7% of cases. 8 patients showed Trendelenburg's sign.

This is the first study to report good fixation by using only non-absorbable Ethibond sutures after hemiarthroplasty of unstable intertrochanteric fractures. A union rate of 74.4% was observed in all cases. The mean migration of greater trochanter fixation after Ethibond sutures was 5.72 mm Functional outcomes were excellent as 86.9% of patients had no difference in ambulation or had a difference of only 1 level by the Koval score.

There were 11 cases of nonunion, but the ambulatory status of these patients were preserved as only 5 patients had a change in mobility of 1 level by the Koval score. The reason why there were so few complications is probably due to careful soft tissue handling during the operation. The piriformis tendon was left intact, most of the soft tissue adjacent to the fracture site were preserved, and the fracture fragments were not detached as much as possible during the operation.

The degree of abductor muscle insertion footprint involvement was related to migration of the greater trochanter fracture fragment and the union rate. Type A fractures involving both insertional footprints of the gluteus medius muscle and gluteus minimus muscle had more migration than type B fractures. Higher union rate was observed in type B fractures compared to type A fractures.

This study has several limitations. First, the size of the study is small, which may compromise the accuracy of the results. Second, this study has no control group. There were four patients without fixation of the greater trochanter but the size too small to make a proper comparison. Third, there was a lack of information for proper functional evaluation. There was limited information about the patients' pre-injury ambulation. The patients were examined after immobilization due to injury. Whether the patient had Trendelenburg' sign prior to injury is unknown, therefore was incomparable postoperatively. Also, visual analog scale (VAS) and Harris hip scores would have provided better information of the patients' postoperative functional status. Fourth, different bipolar hemiarthroplasty implants were used, which may influence the outcomes.

5. Conclusions

Fixation of the greater trochanter is important to maintain abductor lever arm. Greater trochanter fixation in arthroplasty of unstable intertrochanteric hip fractures by non-absorbable Ethibond sutures is a time saving, cost-effective, sufficient method with no irritation caused by implants.

Disclosure of interest

The authors declare that they have no competing interest.

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Authors' contribution

All authors have participated in the research.

Kee Haeng Lee M.D., Ph.D & Yoon Vin Kim M.D. participated in the surgical technique, and data analysis.

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