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The Treatment Strategies for Failed Fixation of Intertrochanteric Fractures

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ABSTRACT

Introduction: Despite the generally successful outcome of intertrochanteric fracture fixation, the treatment is challenging when fixation failure occurs. Some studies have reported a systemic treatment strategy for salvaging failed intertrochanteric fracture fixation. This prospective study with a retrospective review of data aimed to evaluate and validate the efficacy of an evidence-based protocol developed for the treatment of failed intertrochanteric fractures.
Patients and methods: : Between 1997 and 2016, 83 patients who could be followed up for more than 1 year after treatment were enrolled at an academic medical centre. An evidence-based protocol was established in July 2008 and was implemented prospectively. The treatment protocol was determined keeping in mind the condition of the femoral head, the deformation of the fracture site and the bone defect. Clinical results were evaluated, and fracture union and femoral neck-shaft angle were evaluated radiographically for patients in valgus osteotomy and re-fixation subgroups.
Results: The Pain score, leg length discrepancy, Koval score for ambulatory levels and modified Harris Hip Score showed statistically significant improvement after the implementation of the new protocol. The radiographic success rate was 73% (27 of 37 patients) in the pre-protocol group and 91% (42 of 46 patients) in the post-protocol group, which shows statistically significantly improvement.
Conclusion: The new treatment strategy for failed intertrochanteric fracture fixation based on the condition of the femoral head, deformation of the fracture site and bone defect is successful based on clinical and radiographic results. Restoration of NSA of failed intertrochanteric fractures is a key factor for obtaining successful results.

INTRODUCTION

With contemporary surgical technique and fixation devices, most intertrochanteric fractures can be treated successfully.[1,2] However, fixation failure or non-union occurs occasionally, commonly in patients with unfavourable fracture patterns, unsatisfactory reduction quality, poor bone quality, inappropriate choice of internal fixation devices, or improper implant position.[2–6] Despite generally successful outcomes of intertrochanteric fracture fixation, the treatment is challenging when failure occurs. Most surgeons prefer salvage with internal fixation for physiologically younger patients with a long-life expectancy. In elderly patients, hip arthroplasty is usually performed owing to the complexity of the surgery for preserving the joint. However, information on success rates with these salvage procedures has been limited to reports of small case series.[3,4] Few studies have reported a systemic treatment strategy for salvage of failed intertrochanteric fractures.[4,7,8] Based on a literature review concerning treatment strategies in cases of failed intertrochanteric fracture fixation, an evidence-based protocol for the surgical treatment of failed intertrochanteric fracture fixation was developed. This study aimed to evaluate and validate the efficacy of the treatment protocol and to evaluate the functional and radiographic results of revision surgery for failed intertrochanteric fracture fixation.

PATIENTS AND METHODS

The Study Group

In this study, 101 consecutive patients with failed intertrochanteric fracture fixation were treated between July 1997 and June

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2016. The patients were followed up at the time of scheduled patient visits to evaluate the clinical and radiographic outcomes. An evidence-based protocol was established based on the results of previous surgical treatments for failed intertrochanteric fracture fixations by a senior author (BWM) in July 2008. Following this, the protocol was implemented prospectively. All patients provided written informed consent for participation in the study. Approval was obtained from the Institutional Review Board to identify cases for this cohort study. A minimum of 1-year follow-up period was required for patient inclusion. Six patients were lost to follow-up before the end of the minimum 1-year follow-up period. Further, eight patients who had active infections and four patients with pathologic fractures were excluded. Thus, the remaining 83 patients (83 hips) were included in this retrospective study. The mean patient age at the time of accident was 62.1 years (range: 18–85 years); the mean patient age at the time of revision surgery was 64.6 years (range: 19–87 years). The patients were divided into pre-protocol group and post-protocol group to compare the clinical and radiographic outcomes before and after the implementation of the new protocol. The mean follow-up period was 3.5 years (range: 1.3–9.0 years). The pre-protocol group comprised 37 patients who were managed prior to protocol implementation (1997-2007). The post-protocol group comprised 46 patients who were managed according to the new protocol (2008-2016) (Fig. 1).

Evidence-Based Protocol

Prior to protocol implementation, the treatment method was independently chosen based on patient age. Hip arthroplasty was considered for older patients and salvage re-fixation was preferable in younger patients. After implementation, the treatment choice was made following the protocol, solely based on the femoral head condition. If femoral head destruction had already occurred, the patient was treated by hip arthroplasty (arthroplasty subgroup). Total hip arthroplasty or hemiarthroplasty was determined according to the patient's demand of physiological activity. [9] Further, for patients with a preserved femoral head with a varus deformity, valgus osteotomy and internal fixation (valgus osteotomy subgroup) were performed for correction. If the femoral head was not damaged and had an appropriate neck-shaft angle (NSA), re-fixation of the failed intertrochanteric fracture (re-fixation subgroup) was performed. Different fixation devices were used depending on the position of intact portion of the femoral head. A 95° angled blade plate was used when the inferior portion of the femoral head was intact. If the superior portion of the femoral head was intact, a 130° angled blade plate, dynamic hip screw (DHS), or intramedullary nail was used. A bone graft was added if necessary (Fig. 2). Thus, there were two main groups (pre-protocol and post-protocol) and three subgroups (arthroplasty, valgus osteotomy and re-fixation) for analysis.

Surgical Procedure

The presence of infection was excluded in all patients by an intraoperative frozen biopsy of the joint capsule and Gram staining of the joint fluid.

1) For patients undergoing re-fixation or valgus osteotomy:

The choice of implant and the type of bone graft used was at the discretion of the treating surgeon (BWM). Implants used for revision internal fixation were as follows: 22 hips were revised using an angled blade plate (8 hips, 95° angled blade plate; 14 hips, 130° angled blade plate) (Synthes, Chur, Switzerland), 14 hips were revised using DHS (Synthes, Oberdorf, Switzerland) and 3 hips were revised using an intramedullary nail (PFNA, Proximal Femoral Nail Antirotation, Synthes, Paoli, Switzerland) (Table 1). Autogenous cancellous bone grafting was performed in two patients where the graft was taken from the ipsilateral iliac bone when the removed wedge was insufficient. The mean operative time was 130.5 min (range: 105–170 min). Valgus osteotomy as described by Pauwels[10] and modified by Mueller[11] was performed in the intertrochanteric region to allow valgus positioning of the proximal fragment and good bony apposition with lateral displacement of the femoral shaft to avoid stress concentration into the medial side of the knee joint (Figs. 3 and 4). The removed wedge was morsellized and used as a bone graft at the osteotomy site.

2) For the patients undergoing arthroplasty:

Arthroplasty was performed with an anterolateral approach in the lateral position. The procedures were performed at a single institution by the same surgeon (BWM). The replacement type was selected as hemiarthroplasty in 25 patients or total hip arthroplasty in 19 patients depending on the patient's demand of physiological activity. Two different cementless hip systems were used because of the evolving inventory at our hospital. Ten patients received a highly cross-linked polyethylene (HXLPE) liner (Durasul®, Zimmer, Warsaw, IN), a cementless acetabular cup (Converge®, Zimmer, Warsaw, IN), a cementless femoral component (CLS®, Zimmer, Warsaw, IN) and a 28-mm cobalt-chromium

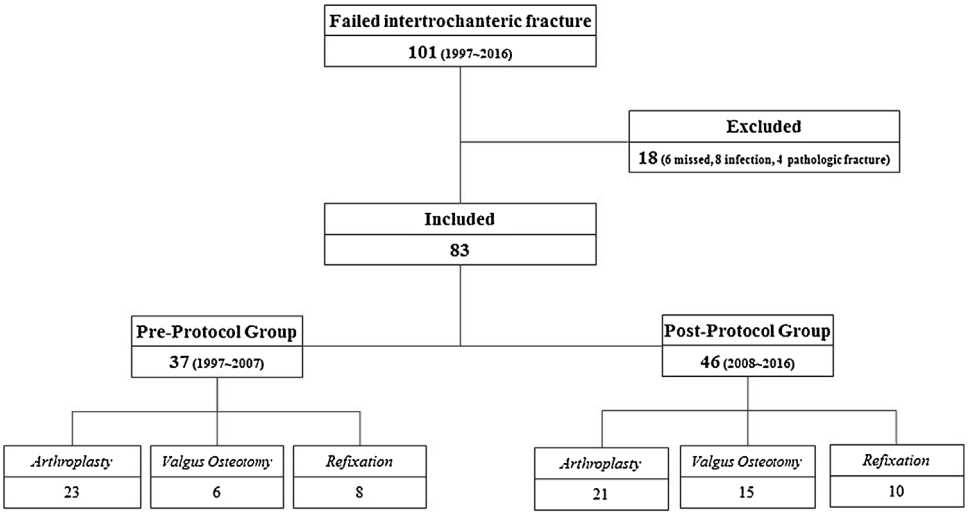

Fig. 1. The profile of patients included in the study.

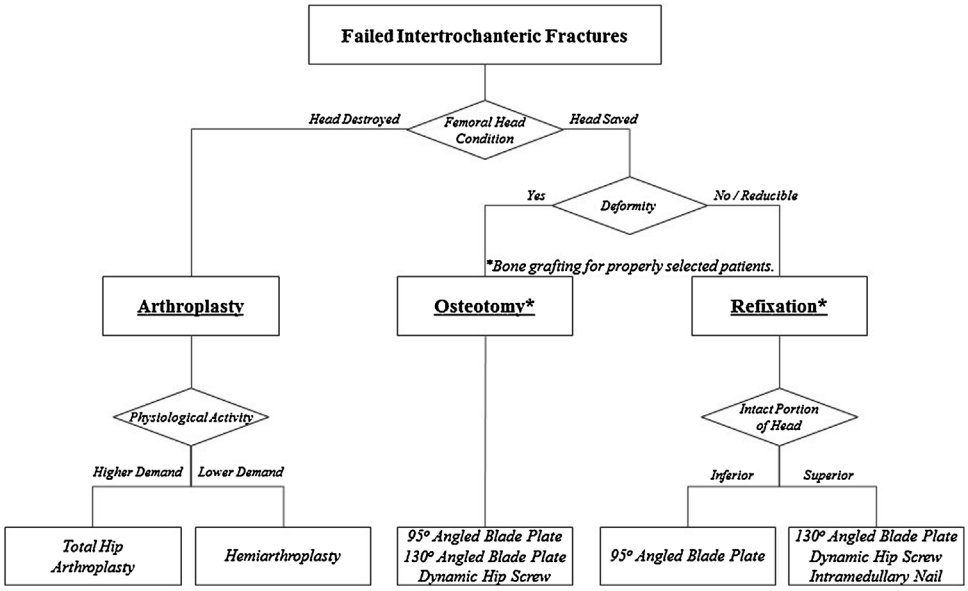

Fig. 2. Treatment protocol for failed fixation of intertrochanteric fractures.

Table 1
Patients Profiles of Groups and Surgical Instruments.

	Pre-protocol	Post-protocol	Total
Arthroplasty subgroup	23 (52%)	21 (48%)	44
Total hip arthroplasty	11	8	19
Hemiarthroplasty	12	13	25
Valgus osteotomy subgroup (%)	6 (29%)	15 (71%)	21
95° angled blade plate	1	2	3
130° angled blade plate	3	8	11
Dynamic hip Screw	2	5	7
Re-fixation subgroup (%)	8 (44%)	10 (56%)	18
95° angled blade plate	3	2	5
130° angled blade plate	1	2	3
Dynamic hip screw	3	4	7
Intramedullary nail	1	2	3

femoral head between 1997 and 2005. The other nine patients received a different HXLPE liner (Longevity®, Zimmer, Warsaw, IN), a cementless acetabular cup (Trilogy®, Zimmer, Warsaw, IN), a cementless femoral component (CLS®, Zimmer, Warsaw, IN) and either a 28-mm (3 patients) or a 36-mm (6 patients) cobalt-chromium femoral head between 2006 and 2016. A 36-mm head was implanted except in cases where a shell smaller than 56 mm was required (Table 1).

All patients received antibiotic prophylaxis for 24 h and thromboembolic prophylaxis with low-molecular-weight heparin for 30 days. No patient received prophylaxis against heterotopic ossification. The postoperative rehabilitation protocol was the same for all patients, who were allowed progressive weight bearing as tolerated on the third day after surgery.

Clinical Evaluation

Each patient was assessed clinically and radiographically before and after surgery at 4 weeks, 3 months, 6 months, 12 months and annually thereafter. Clinical and radiographic outcomes were reviewed retrospectively and evaluated by comparing the two groups (pre-protocol group vs post-protocol group).

The pain score was measured preoperatively and at the final follow-up, with 1 point for no pain at all, 2 points for mild pain, 3 points for moderate pain and 4 points for severe pain. The leg length discrepancy (LLD) was calculated by measuring the distance between the anterior superior iliac spine and the medial malleolus; the LLD difference between the shortened ipsilateral limb and healthy contralateral limb was compared.[12] Preoperative and final follow-up ambulatory levels were evaluated according to the Koval score as a clinical parameter.[13] A modified Harris hip score (HHS) was also evaluated before surgery and at final follow-up. An HHS is one of the most commonly used systems.[14,15]

Radiographic Evaluation

Different radiographic assessments were performed for determining radiographic outcomes in each group as different treatment methods were followed in each group, and the results with different assessments were then compared. For patients in valgus osteotomy and re-fixation subgroups, fracture union was considered radiographically if callus formation was seen in three of the four cortices on anteroposterior and lateral radiographs. NSA was measured with a goniometer. Under-correction of varus deformity was defined as more than 5 degrees of varus measurement on comparison with contralateral NSA and over-correction was defined as more than 5 degrees of valgus measurement.[16] The radiographic evaluation was conducted by two independent observers (KJL, BSK) who did not participate in internal fixation or hip arthroplasty.

For patients treated with arthroplasty, the primary outcomes were revision and incidence of complications. Secondary outcomes were radiographic signs of heterotopic ossification or implant loosening. Standard radiographs included an anteroposterior view of the pelvis and anteroposterior and lateral views of the proximal part of the femur. Radiographs taken 4 weeks after the index operation served as the baseline for all subsequent comparisons. The acetabular component was considered radiographically loose when migration had occurred or when a circumferential radiolucency of 2 mm was noted. Evidence of cup migration was measured on serial radiographs, and a linear change of greater than 3 mm or a rotational change of 8° or greater was considered migration.[15] Femoral component stability and osseointegration were assessed according to the method described by Zicat et al.[17] Radiographic evaluations of the socket were described using DeLee and Charnley

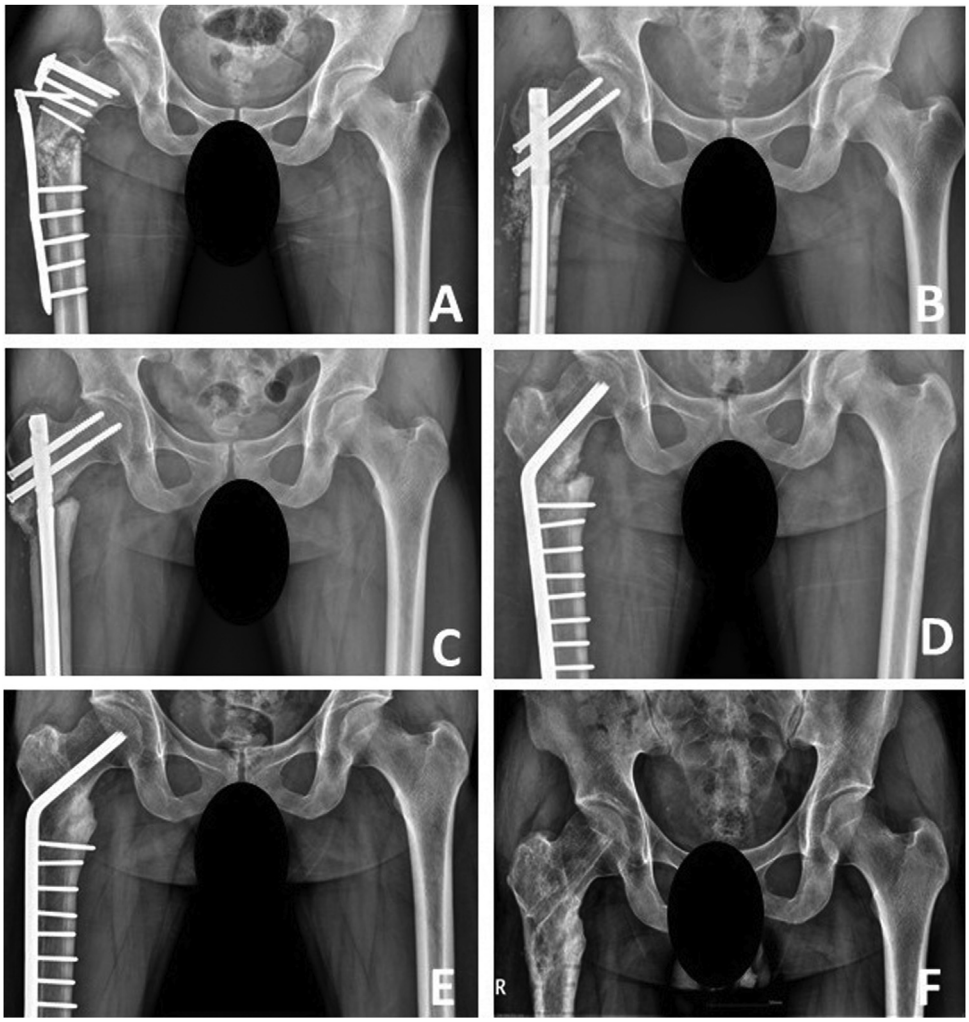

Fig. 3. A 27-year-old man underwent valgus intertrochanteric osteotomy because of fixation failure of intertrochanteric fracture. (A) Radiograph obtained 6 months after fixation shows non-union of intertrochanteric fracture and fixation failure of the locking compression plate. (B) Radiograph obtained 2 weeks after re-fixation with intermedullary nail. (C) Radiograph obtained 11 months after re-fixation shows non-union of the intertrochanteric fracture. (D) Radiograph obtained 4 weeks after valgus intertrochanteric osteotomy shows restoration of the neck-shaft angle. (E) Radiograph obtained 2 years after osteotomy shows union at the osteotomy site. (F) Radiographs obtained 2 weeks after removal of implant shows complete bony union at the osteotomy site.

system[18] and those of the femur using the system reported by Gruen et al.[19] Polyethylene wear was determined based on annual radiographs using a computer-assisted method with PolyWare software (Draftware Developers, Vevay, IN, USA). Osteolysis was defined as the radiographic appearance of any focal area of bone resorption that was 2 mm wide or greater and was not evident on the radiograph obtained immediately after surgery.[17] Heterotopic ossification was classified according to the system developed by Brooker et al.[20] Acetabular erosion was evaluated based on its radiographic appearance, which showed development of signs of narrowing of the articular cartilage, acetabular bone erosion, or protrusio acetabuli.[21] Displacement into the acetabular bone determined by the distance of proximal, horizontal and vertical movements between the centre line of femoral head and the lowest line of the ipsilateral tear-drop was compared.[22,23]

The criteria for successful treatment were determined as the presence of bone ingrown stability of acetabular cup and femoral stem, no detectable wear, no periprosthetic osteolysis and no other complication such as joint dislocation and periprosthetic fracture in the arthroplasty subgroup. In the valgus osteotomy and re-fixation subgroups, bony union was determined as the criterion for the success of treatment.

Statistical Analysis

To confirm whether two samples are significantly different from each other, t-test was used as the statistical hypothesis test. Mean comparison was used to verify the validity of a certain sample. In this study, for ensuring that the two groups being compared are not overlapped, the independent sample t-test was used. To analyse the differences in demographic parameters, chi-square tests and Mann–Whitney tests were used. To test the assumption of normal distribution and homogeneity of variance, independent sample t-test, Kolmogorov–Smirnov test and Levene's test were performed. The level of significance was set at $P < 0.05$. The SPSS statistical package (version 22.0; IBM, Armonk, NY, USA) was used for analysis and modelling of the data.

RESULTS

There were no statistically significant differences between pre-protocol group and post-protocol groups in terms of age, sex, height, weight and BMI (Table 2). The prevalence of osteoporosis was higher in the post-protocol group, although not statistically significant ($p = 0.352$).

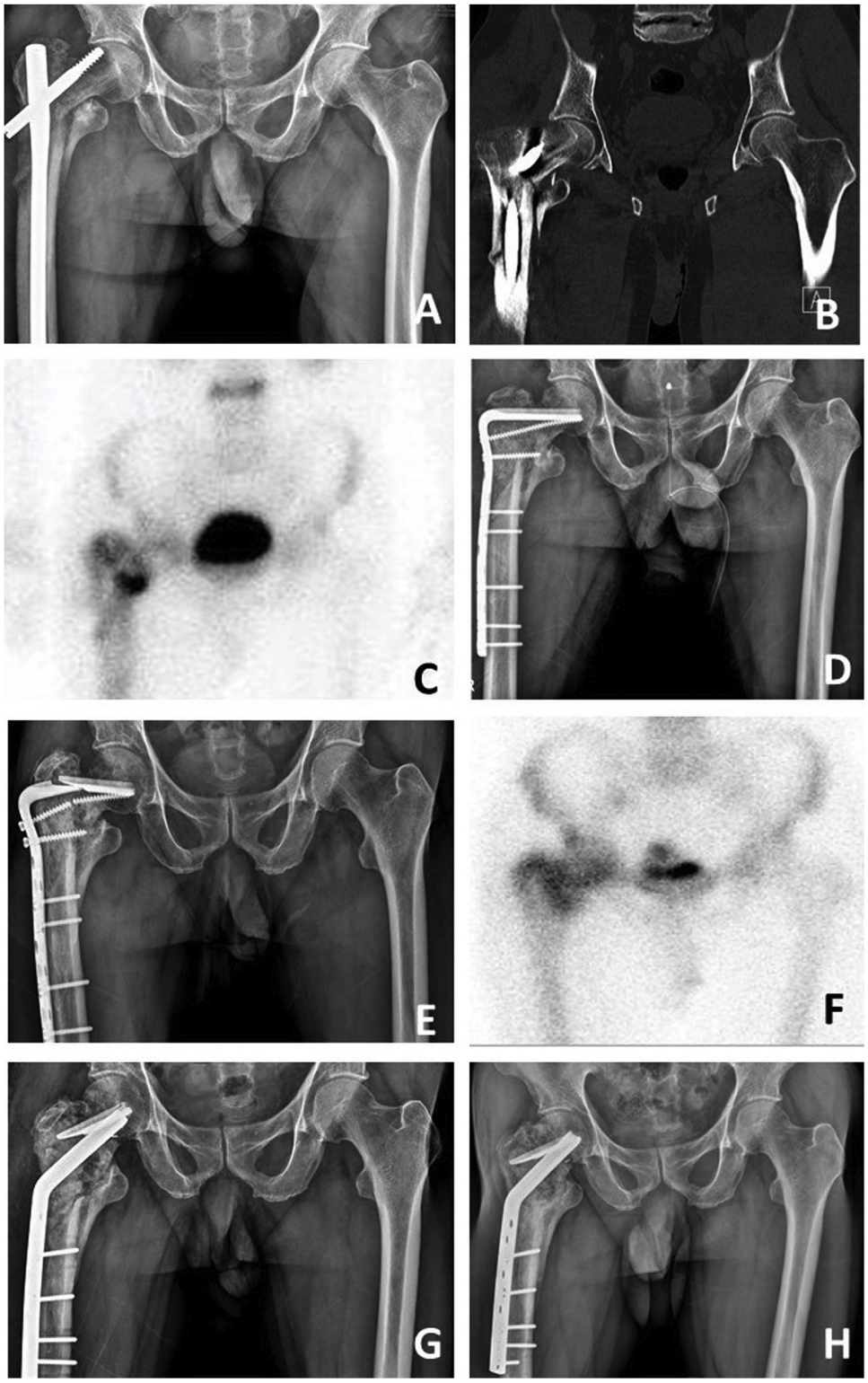

Fig. 4. A 67-year-old man underwent valgus intertrochanteric osteotomy because of fixation failure of intertrochanteric fracture. (A) Radiograph obtained 3 months after fixation shows fixation failure with a cut-off of the cephalomedullary screw. (B) Computed tomography image shows destruction of the superior portion of the femoral head with non-union of intertrochanteric fracture. (C) Bone scintigraphy image shows viability of femoral head. (D) Radiograph obtained 2 weeks after re-fixation with 95° angled blade plate shows under-correction of the neck-shaft angle. (E) Radiograph obtained 10 months after re-fixation shows fixation failure with non-union. (F) Bone scintigraphy image shows viability of the femoral head. (G) Radiograph obtained 4 weeks after valgus intertrochanteric osteotomy shows restoration of the neck-shaft angle. (H) Radiograph obtained 15 months after osteotomy shows union at the osteotomy site.

Table 2
Patient Demographics.

	Pre-protocol	Post-protocol	Total	*P* value
Number of patients	37	46	83	
Gender (male:female)	20:17	30:16	50:33	0.152
Body mass index	23.0 (17.325.7)	23.1 (17.024.9)	23.0 (17.325.7)	0.264
Age at salvage surgery (years)	63.5 (1983)	65.6 (2787)	64.6 (1987)	0.193
Side (right:left)	16:21	25:21	41:42	0.175
Length of follow-up (years)	3.2 (1.38.0)	3.6 (1.59.0)	3.5 (1.49.0)	0.188

In the pre-protocol group, 20 of 37 patients (54.1%) were treated with the same algorithm as that used in the new protocol. In the post-protocol group, 42 patients of 46 patients (91.3%) were clearly treated according to the new protocol. Four patients did not follow the new protocol; these patients needed to undergo valgus osteotomy and internal fixation as per the new protocol, but they strongly wanted undergo arthroplasty.

Results of Clinical Outcomes

The preoperative the pain score, LLD, walking ability by Koval classification and modified HHS were similar between groups, with no statistically significant difference (Table 3). However, clinical results at the time of final follow-up were different. The post-protocol group showed significantly better results in the walking ability by Koval classification, pain score and modified HHS at final follow-up (Table 3). LLD in the post-protocol group was better, but not statistically significant ($p = 0.087$). In comparison between subgroups, the post-protocol group showed better clinical results (Table 4).

Results of Radiographic Outcomes

In the pre-protocol group, 27 of 37 patients (73%) achieved successful treatment. On the other hand, in the post-protocol group, 42 of 46 (91%) patients achieved successful treatment. This difference was statistically significant (Table 5).

In the patients with arthroplasty, neither femoral nor acetabular components displayed radiographic evidence of mechanical loosening or periprosthetic osteolysis of the pelvis or femur, and no components had been revised in 19 of 23 patients (82.5%) in pre-protocol group and 19 of 21 patients (90.5%) in post-protocol group. Of the patients in the pre-protocol group, two patients underwent acetabular cup revision owing to polyethylene wear, and one patient had recurrent hip dislocation. Of the patients in the post-protocol group, one patient underwent acetabular cup revision owing to polyethylene wear and one patient with periprosthetic fracture was treated with open reduction and internal fixation.

Table 3
Clinical Outcomes by Main Treatment Group.

Clinical outcomes		Main group	Measurements	*P* value
Koval score	Preoperative	Pre	3.0	0.794
		Post	3.1	
	Last follow-up	Pre	1.9	< 0.001*
		Post	1.5	
Pain score	Preoperative	Pre	4.0	0.864
		Post	3.9	
	Last follow-up	Pre	2.3	0.018*
		Post	1.6	
mHHS	Preoperative	Pre	56.6	0.987
		Post	57.6	
	Last follow-up	Pre	75.2	0.023*
		Post	82.0	
LLD	Preoperative	Pre	2.3	0.836
		Post	2.3	
	Last follow-up	Pre	0.7	0.087
		Post	0.4	

LLD: leg length discrepancy; mHHS: modified Harris hip score; Post: post-protocol group; Pre: pre-protocol group.
* Significant.

Table 4
Clinical Outcomes by Treatment Subgroups at Final Follow-up.

Subgroup	Outcomes	Pre-protocol	Post-protocol	*P* value
Arthroplasty	Koval score	2.4	1.5	0.052
	Pain score	1.8	1.3	0.087
	mHHS	68.0	79.8	0.014*
	LLD	1.0	0.5	0.052
Valgus Osteotomy	Koval score	1.8	1.4	< 0.001*
	Pain score	2.0	1.6	0.257
	mHHS	69.2	82.8	< 0.001*
	LLD	0.9	0.5	0.046*
Re-fixation	Koval score	2.8	1.9	< 0.001*
	Pain score	2.4	1.2	0.021*
	mHHS	63.8	81.6	< 0.001*
	LLD	0.8	0.4	< 0.001*

LLD: leg length discrepancy; mHHS: modified Harris hip score.
* Significant.

In patients in the valgus osteotomy and re-fixation subgroups, union after revision of failed intertrochanteric fracture was achieved in 8 of 14 patients (57.1%) in the pre-protocol group and 23 of 25 patients (92.0%) in the post-protocol group. The union rate was significantly higher in the post-protocol group than in the pre-protocol group. NSA was preoperatively measured as 118.5° in the pre-protocol group and 118.0° in the post-protocol group, and it was not different preoperatively between two groups ($p = 0.385$). In measurements at final follow-up, it the angle was 130.4° in the pre-protocol group and 134.2° in the post-protocol group. These measurements also showed significantly positive results in the post-protocol group ($p = 0.023$).

In the patients with re-fixation, 5 of 8 patients (62.5%) had radiographic failure in the pre-protocol group: three patients with non-union and two with malunion. In the three non-union patients, re-valgus osteotomy and internal fixation were performed after an average of 9 months and bony union was observed in all patients; the two patients with malunion were treated with conservative management. In the post-protocol group, 2 of 25 patients (8%) developed complications in valgus osteotomy and re-fixation subgroups. One patient who developed avascular necrosis of the femoral head was treated using conversion total hip arthroplasty in the osteotomy subgroup and one patient in the re-fixation subgroup was treated with conservative treatment because of rejection of revision surgery.

DISCUSSION

This study aimed to evaluate and validate the efficacy of our treatment protocol for patients with failure of intertrochanteric fracture fixation. Our new protocol is based on the bone condition

Table 5
Radiographic Outcomes in Main Groups and Subgroups.

	Pre-protocol		Post-protocol		Total		*P* value
	Success	Failure	Success	Failure	Success	Failure	
Total	27	10	42	4	69	14	< 0.001*
Arthroplasty	19	4	19	2	38	6	0.102
Valgus Osteotomy	5	1	14	1	19	2	0.094
Re-fixation	3	5	9	1	12	6	< 0.001a*

* Significant.

of the femoral head rather than patient age. Clinical and radiographic outcomes according to our newly established protocol were satisfactory.

The limitations of this study include the retrospective design, relatively small number of patients in subgroups, and relatively short-term follow-up period (average, 3.4 years) in the arthroplasty subgroup. The patient cohort at the most recent follow-up comprised fewer living patients and an increased number of patients lost to follow-up. Six hips (6%) from the original cohort were lost to follow-up because of patients' reluctance to return as they had relocated or as they were doing well clinically. Further, 54% of the patients in the pre-protocol group were undergoing management according to the same algorithm as that used in the new protocol, which is a relatively large percentage for comparison with the post-protocol group. However, this problem was inevitable for maintaining the ethical standards. Despite these limitations, the findings are of value because this study included consecutive patients treated by a single surgeon at a single institution. Moreover, it is advantageous that we studied the results of multiform treatment methods according to various fracture failure types.

Recently, with contemporary surgical technique and fixation devices, most intertrochanteric fractures can be treated successfully.[1,2]. However, various types of fixation failures have also been reported with a high frequency.[24,25] Treatment of failed intertrochanteric fractures is often difficult because of deformation of the fracture site, bone defect and consequent concentration of varus stress.[4,6,26,27]

Some studies have reported a systemic treatment strategy for salvage treatment of failed intertrochanteric hip fractures.[4,28] However, information about success rates with these salvage procedures has been limited to reports of small case series.[3,7,8] In these studies, age was the first criterion for defining treatment. Petrie et al.[28] reported that the patient's age and remaining bone stock affected the rate of treatment failure for femoral intertrochanteric fractures. They reported that older patients should be treated with hip arthroplasty. In the study by Haidukewych and Berry[4], treatment involving revision internal fixation with or without osteotomy or bone graft had better clinical and radiologic outcomes in younger patient. Hip arthroplasty is the treatment of choice in the case of severely damaged femoral head, but technical challenges include broken hardware, deformity and femoral bone defects and attention to technical details can minimize potential complications.[29,30]

It is necessary to determine the treatment protocol according to various patient conditions because of the difficulties in various treatments. Therefore, a new protocol considering previous surgical outcomes was established. On initial implementation of the new protocol, patients with good bone quality and salvage treatment options for failed intertrochanteric fracture fixations had satisfactory results without hip arthroplasty. Therefore, the treatment strategy was based on the condition of the femoral head. When the femoral head was already destroyed, hip arthroplasty was performed. In the remaining patients, the treatment option was decided according to the presence or absence of varus deformity.

The results were analysed between the pre-protocol and post-protocol group to validate the protocol and were verified by classifying the patients who followed the protocol and those who did not. The success rate in the post-protocol and the followed protocol group was significantly higher than that in the pre-protocol and the not followed protocol group (Table 6).

In the clinical outcomes, four categories of outcomes were compared between the pre-protocol and post-protocol groups and significant improvements were observed after protocol application, particularly in the Koval classification and the modified HHS corresponding to the functional score. Significant improvements of clinical outcomes were specially observed in the re-fixation and osteotomy subgroups. The modified HHS was 75.5 in the patients treated with hip arthroplasty in the two subgroups, similar to previous studies, but the Koval score was 1.9, which was slightly better than that reported in previous studies.[4,30–33] In contrast, in he re-fixation subgroup, the functional score was significantly lower than that in other groups. This was because of the persistent pain and decreased ability to walk resulting from the complications occurring when NSA was not actively restored in the pre-protocol group.

In the arthroplasty subgroup, the complication rate as determined by radiography was relatively low, which is believed to be because of the improvement in the proficiency of the surgery. In this study, 5 of 44 patients (11.4%) underwent revision surgery for any reason, and 1 patient (2.3%) had a dislocated hip joint. In a rather recent study, in comparison with the results of conversion total hip arthroplasty using cementless stems in patients with fixation failure for intertrochanteric fractures, the results of our study were not different.[29,31,34,35] Thus, in patients with proper indications, hip arthroplasty is an important surgical option for the treatment of failed intertrochanteric fracture fixations, as suggested by other previous studies.

In the osteotomy subgroup, a union rate of 90.5% was obtained (19 out of 21 patients). The mean preoperative NSA was 118.3° and postoperative NSA was 135°. Previously, there was a paucity of studies published regarding salvage treatment options for failed intertrochanteric fracture fixations. Wu et al.[27] reported 14 patients treated with reinsertion of a lag screw more inferiorly in the femoral head, cement augmentation and valgus-producing subtrochanteric osteotomy, and bony union was achieved in all patients. Sarathy et al.[26] achieved bony union in 6 of 7 patients using a combination of valgus osteotomy, medial displacement and 130-degree blade plate fixation. Haidukewych and Berry[4]

Table 6
Cross Validation Based on Main Groups and in Accordance with the New Protocol.

	Radiologic outcome			*P* value
	Total	Success	Failure	
Pre-protocol group	37	27	10	< 0.001*
Post-protocol group	46	42	4	
Protocol followed	65	58	7	< 0.001*
Protocol not followed	18	11	7	

* Significant.

reported a series of 20 patients revised with open reduction and internal fixation and selected bone grafting. Fixed-angle devices were used in 15 patients. Overall, 95% of all patients showed healing of their non-unions. Said et al.[8] used salvage technique in 18 of 26 patients and performed DHS fixation with valgus osteotomy in 10 patients and all of them reported bony union. Our study included a greater number of patients and relatively diverse surgical techniques compared with previous studies.

In this study, bone grafting was performed in only two patients with significant bone defects. Haidukewych and Berry[4] reported that of 20 non-union patients, autogenous bone grafting was performed in 19 patients and union was observed in all cases. However, in a study by Said et al.[8], they reported that bony union was achieved without bone grafting in all 18 cases. In this study, successful results were obtained without bone grafting because the cause of non-union was mechanical rather than biological.

Varus deformation is the most frequent biomechanical complication following treatment of unstable trochanteric fractures.[36,37] Displacement to varus alignment results in limb shortening, imbalance of gluteal muscles and limping, and overloading of the knee joint and lumbar spine. Restoration of NSA is important in the treatment of failed intertrochanteric fracture fixations. In this study, six patients had failed restoration of varus deformity in the valgus osteotomy and re-fixation subgroup. Of those patients, non-union occurred in three patients, malunion occurred in two and blade penetration occurred in one. This was statistically significant, indicating a positive effect on restoration of NSA ($p < 0.001$).

CONCLUSIONS

The new treatment strategy for failed internal fixation of intertrochanteric fractures based on the condition of the femoral head, the deformation of the fracture site and the bone defect is successful based on clinical and radiographic results. Restoration of NSA of failed intertrochanteric fractures is a key factor for obtaining successful results.

The Conflict of Interest statement

This study was not funded. The authors report that they have no conflicts of interest in the authorship and publication of this article. All work, including writing, was done by the authors.

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