Transtrochanteric Rotational Osteotomy for a Subchondral Insufficiency Fracture of the Femoral Head in Young Adults

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Abstract

Background While subchondral insufficiency fracture of the femoral head is most frequently seen in elderly patients, this fracture has also been reported in some young individuals.

Questions/purposes We asked whether a transtrochanteric rotational osteotomy for a subchondral insufficiency fracture of the femoral head in young adults would (1) provide improvement in functional scores; and (2) lead to healing of the fractures.

Methods We retrospectively reviewed five young patients diagnosed with subchondral insufficiency fracture of the femoral head. Nonoperative treatment was administered initially. Four of these patients (average 22.3, years; range, 16–29 years) showed progressive collapse. An anterior rotational osteotomy was performed in these four patients since the fractured area was located in the anterosuperior portion of the femoral head. All patients were followed for a minimum of 2.0 years (average, 4.1 years; range, 2.0–9.1 years).

Results The average preoperative Harris hip score was 71.6 points, which improved to an average of 97.2 at the

latest followup. Radiographically, the fractured lesion healed and no progression of collapse was observed in any of the four patients.

Conclusions Anterior rotational osteotomy seems a useful surgical option for treating young patients with subchondral insufficiency fracture of the femoral head if symptoms persist.

Level of Evidence Level IV, therapeutic study. See Guidelines for Authors for a complete description of levels of evidence.

Introduction

A subchondral insufficiency fracture of the femoral head (SIF) is a recently proposed concept that has been observed in elderly women with osteoporosis and in patients who have undergone a renal transplantation [3, 6, 10, 12]. Patients usually complain of acute hip pain without any obvious antecedent trauma. Radiographically, a subchondral fracture is seen mainly in the superolateral portion of the femoral head. T1-weighted MR images show a very low-intensity band in the subchondral area of the femoral head, which tends to be irregular, disconnected, and convex to the articular surface [3, 6, 10, 12]. This low-intensity band in SIF was histologically proved to correspond to the fracture line with associated repair tissue [13, 15, 16]. In some patients, SIF is managed nonsurgically, while others with disease progression and collapse will undergo surgery [12].

SIF has also been observed in young military trainees, but such cases were considered due to a fatigue stress fracture [7, 11]. A study reported two young adults with SIF but without any evidence of overuse [14]. These patients were treated surgically.

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A SIF lesion is most often located in the anterosuperior aspect of the femoral head, in which the posterior aspect of the femoral head is normal and has smooth, healthy articular cartilage [13–16]. Therefore, a transtrochanteric anterior rotational osteotomy (ARO) [8], which was originally developed for patients with osteonecrosis and transposes the posterior intact area to a weightbearing portion of the joint, could be a useful procedure in young patients with SIF who have an intact area in the posterior portion of the femoral head. The survival rate for this procedure at 10 years is reported to be more than 80% in patients with osteonecrosis from several institutions [2, 9].

We therefore asked whether this procedure would (1) improve functional scores; and (2) lead to healing of the fractures.

Patients and Methods

We retrospectively reviewed five young patients (age range, 16–29 years) diagnosed with SIF between 2000 and 2008 (Table 1). We used an age cutoff in this study of younger than 30 years. Two patients played sports, including jogging as a hobby and badminton in high school. None of the patients had any history of glucocorticoid therapy, alcohol abuse, or smoking. The mean body mass index was 23.1 kg/m² (range, 20.2–26.6 kg/m²). Nonoperative treatment, including the use of antiinflammatory drugs and protected weightbearing for 6 to 8 weeks, was initiated in all five patients. The bone mineral density measured in the femoral neck using dual-energy xray absorptiometry showed osteopenia in three patients (T-score, –2.5 to –1.0). To obtain a histological diagnosis we performed a bone biopsy using a trephine needle in all four patients who underwent surgery; the biopsy was taken from the center of the collapsed lesion through the articular surface side. The diagnosis of SIF was based on published histologic criteria [12, 15]. Briefly, the subchondral area contained a prominent amount of fracture callus, reactive cartilage, and granulation tissue. Edematous changes were

seen in the marrow space and the bone trabeculae in the other zone were thin, disconnected, and sparsely arranged (osteopenic). No bone trabeculae showing total empty lacunae were observed in any of the biopsy specimens.

The hip pain resolved in one patient, while the other four patients showed progression of collapse. ARO was performed in these four patients based on the following criteria: (1) a fractured area in the anterior portion of the femoral head; (2) an intact healthy area in the posterior portion; and (3) a postoperative intact area ratio of more than 34% after the ARO [4, 8]. The average age of these patients (two males, two females) was 22 years (range, 16–29 years) at the time of surgery. All patients were followed for a minimum of 2 years (mean, 4.1 years; range, 2.0–9.1 years).

The basic surgical procedure has remained unchanged since it was originally described [8]. Briefly, this procedure incorporates three osteotomies; an osteotomy of the greater trochanter, an intertrochanteric osteotomy passing from the superolateral to the inferomedial position on the AP view, and an osteotomy passing from the proximal flare of the lesser trochanter inferolaterally toward the inferomedial extent of the primary osteotomy (Fig. 1). It is important to preserve the nutrient artery (medial circumflex femoral artery) located in the adipose tissue just beneath the quadratus femoris during these procedures. The degree of anterior rotation ranged from 75° to 90°, with an average of 85°.

Postoperatively, the patients were nonweightbearing for 5 weeks, after which gradual weightbearing was permitted. Full weightbearing was permitted after 6 months. Since this procedure needs to obtain bone remodeling at the weightbearing portion as well as bone union at the osteotomy site, we usually start full weightbearing around 6 months after the operation.

Followup examinations were performed radiographically and clinically at 3 months, 6 months, and yearly thereafter. The Harris hip score [1] was determined at each examination by two of us (TY, KI), including before ARO and at the most recent followup examination. Two of us (TY, KI) independently reviewed the preoperative and

Table 1. Clinical findings of the five patients

Patient number	Gender	Age (years)	Job	Sports activity	Body mass index (kg/m ²)	Bone mineral density (T-score)	Outcome	Harris hip score		Followup (years)
								At first visit	At latest followup	
1	Male	29	Seafood processor		26.6	Not performed	ARO	63	94	2.0
2	Female	23	Part-time worker		20.2	–0.64	ARO	51	100	9.1
3	Female	21	Beautician	Jogging	22.5	–2.0	ARO	78	96	2.8
4	Male	16	High school student	Badminton	20.3	–2.1	ARO	70	96	2.5
5	Male	28	Used-car salesman		26.0	–1.2	Nonoperative	96	100	3.1

ARO = anterior transtrochanteric rotational osteotomy.

Fig. 1 A diagram shows the orientation of the osteotomy line from the posterolateral view in the right femur after an osteotomy of the greater trochanter. Line a represents the longitudinal axis of the femoral neck and Line b the axis of the femoral shaft. An intertrochanteric osteotomy passing from the superolateral to the inferomedial position on the AP view (Line c) and an osteotomy passing from the proximal flare of the lesser trochanter inferolaterally toward the inferomedial extent of the primary osteotomy (Line d) are shown.

postoperative radiographs for any evidence of progression of collapse. The interobserver variability of the evaluation for the radiograph (whether progression of collapse existed or not) was assessed.

Results

The average preoperative Harris hip score of 71.6 points increased to an average of 97.2 points at the latest followup (Fig. 2). The average preoperative Harris hip score for ROM was 8.6 points, which was unchanged at the latest followup. However, the other two factors regarding pain and function improved after ARO: pain from 26.0 to 41.6 points and function from 37.0 to 47.0 points.

Radiographically, the fractured lesion healed, and no progression of collapse was observed in any of the four patients (Fig. 3). The two observers agreed no progression of collapse was observed in any of the four patients.

Discussion

A SIF is typically seen in elderly patients; however, this fracture has also been reported in some young individuals.

Fig. 2 A graph shows average preoperative and postoperative Harris hip scores. The preoperative Harris hip score of 71.6 points increased to an average of 97.2 points at the latest followup. The pain and function components improved after ARO whereas ROM was unchanged at the latest followup.

The indication for surgery and the results of surgery in SIF remain unclear. To our knowledge, this is the first report evaluating the results of ARO in young SIF patients. We examined whether an ARO would (1) provide improvement in functional scores; and (2) lead to healing of the fractures.

There are two major limitations to this study. First is the small number of patients. Since SIF in young patients is relatively uncommon, we only had five patients over an 8-year period. Second is the short followup, which ranged from 2-9 years. However, we believe that a minimum 2-year period is sufficient to assess at least the healing of a fracture after rotational osteotomy.

The average preoperative Harris hip score of 71.6 points increased to an average of 97.2 points at the latest followup. We consider this reasonable improvement. Since some cases of SIF resolved by nonoperative treatment [3, 6, 7, 10, 11], including nonweightbearing or partial weight bearing with use of crutches, nonoperative treatment would be the first choice in all patients. If progression of collapse is observed in spite of nonoperative treatment, surgical intervention may be necessary. A fractured lesion in SIF is most often located in the anterosuperior aspect of the femoral head in which the posterior aspect of the femoral head is normal and has smooth healthy articular cartilage [11–15]. Therefore, an ARO, which transposes the posterior intact area to a weightbearing portion of the joint, seems a useful procedure in young patients with SIF who need surgical treatment. In elderly patients or patients who do not have the posterior intact area, a THA may be necessary.

Radiographically, we observed no progression of collapse in any of the four patients on whom we operated. The most important factor affecting the results of a rotational

Fig. 3A–G Images illustrate the case of a 23-year-old female patient with SIF who underwent ARO. (A, B) AP radiographs show the left hip 2 months after the onset of pain. (A) A subchondral collapse is observed at the superolateral portion of the femoral head (arrow), but the joint space is preserved. (B) On a frog lateral view, a subchondral collapse and radiolucent area are observed at the anterior portion (arrow). (C, D) MR images obtained 2 months after the onset of hip pain show a bone marrow edema pattern. (C) On the T1-weighted image (TR/TE = 400/12 ms), a diffuse low signal intensity is seen associated with a somewhat serpiginous irregular low-intensity band (arrow). (D) On the gadolinium-enhanced image (TR/TE = 441/12 ms), the band and the proximal segment show a diffuse high signal intensity. Joint effusion is also seen. (E) A bone biopsy was performed from the center of the collapsed lesion through the articular surface side. An intraoperative photograph shows prominent bleeding in the collapsed lesion, indicating this area is not necrotic. (F) An 85° ARO was performed, and the postoperative radiograph shows the posterior intact area is transposed to the weightbearing portion. (G) A radiograph obtained 9 years after the ARO shows evidence of neither progression of collapse nor osteoarthritic changes. The preoperative Harris hip score of 51 improved to 100.

head is only involved in the majority of patients with SIF, an ARO seems a good indication for such patients.

Two studies have reported a total of 10 young patients with stress osteopathy of the femoral head and five patients with subchondral fatigue fracture [7, 11]. The ages ranged from 19 to 26 years, and all patients were male military recruits who were considered to have developed fractures as a result of a stress overload to the femoral head due to the military training (Table 2). None of our patients had any history of overexertion and it is unclear why SIF occurred in these young people. The bone mineral density (T-score, -2.5 to -1.0) in the femoral neck suggested osteopenia in three patients. In addition, the histology showed thin, disconnected bone trabeculae, thus indicating the presence of some degree of osteopenia [5]. Unrecognized trauma with associated bone contusion or preexisting processes such as transient osteoporosis of the hip or osteochondritis dissecans might be considered as one possible etiology. Further investigations based on the concept of localized osteopenia may be useful for elucidating its pathophysiology in young patients with SIF.

One of the important differential diagnoses in determining a SIF may include osteonecrosis. In SIF, the low-intensity band on T1-weighted MR images has been reported to correspond histologically to the fracture line and associated fracture repair tissue [16]. Therefore, the shape of the low-intensity band tends to be irregular, disconnected, and convex to the articular surface (Fig. 4). On the other hand, in osteonecrosis, since the low-intensity band represents repair tissue, it is generally smooth and circumscribes all of the necrotic segments [3, 6, 10, 12]. However, since a subchondral collapse is often associated with patients with osteonecrosis, imaging appearances have several overlaps between osteonecrosis and SIF. The final diagnosis of a SIF was confirmed in our four patients based on the findings of

osteotomy in osteonecrosis is the postoperative intact area ratio, which represents the ratio of the intact articular surface of the femoral head on postoperative AP radiographs. It is expressed as the intact area of the femoral head in the weightbearing portion divided by the acetabular weightbearing portion. The intact ratio should be more than 34% [4, 8]. Since the anterosuperior portion of the femoral

Table 2. Comparison of our data with those in the literature

Study	Patients/cases	Age (years)*	Treatment	Procedure
Song et al. [7]	5/7	21 (20–21)	4 nonoperative 3 surgery	THA, drilling, bone graft
Visuri [11]	10/10	20 (19–26)	All nonoperative	
Yamamoto et al. [current study]	5/5	23 (16–29)	1 nonoperative 4 surgery	ARO

* Values are expressed as means, with ranges in parentheses; ARO = anterior transtrochanteric rotational osteotomy.

Fig. 4 A T1-weighted MR image (TR/TE = 924/13 ms) obtained 5 months after the onset of left hip pain in a 16-year-old boy shows a serpiginous, irregular, very low-signal-intensity band (white arrows) surrounded by a low-intensity area (bone marrow edema).

the above-described histologic criteria. This short-term followup study suggests ARO might be a reasonable surgical option for treating young patients with SIF.

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