Transtrochanteric Posterior Rotational Osteotomy for Osteonecrosis

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Abstract When osteonecrosis is located in the mid- to posterior region, we generally perform a transtrochanteric posterior rotational osteotomy. We retrospectively reviewed the clinical and radiographic results in 47 consecutive patients (51 hips) in whom we performed posterior rotational osteotomies. The average age was 37 years at the time of surgery. There were 30 male and 17 female patients. Thirty-six hips were ARCO Stage III, and 15 were Stage IV. Conversion to THA was defined as the failure end point. Three patients died and one was lost to followup. We were therefore able to follow 43 patients (46 of the 51 hips, or 90%) a minimum of 1.2 years (average, 12 years; range, 1.2–21 years). We used the Harris hip score for preoperative and most recent followup. The average preoperative Harris hip score of 52 points improved to an average of 84 at the latest followup. Radiographically, the osteonecrosis in 30 hips (65%) had no progressive collapse, and 13 (28%) showed osteoarthritic changes, but no patients underwent THA. A posterior rotational osteotomy appears useful for patients with extensive necrosis and advanced collapse.

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

Introduction

Once subchondral collapse occurs in osteonecrosis (ON) of the femoral head, osteoarthritis subsequently develops [8, 14, 15]. ON occurs predominantly in the middle-aged population. A higher risk of mechanical failure is reported following THA in patients with osteonecrosis who are younger than 50 years old than in age-matched osteoarthritis patients [11]. The best surgical treatment for osteonecrosis thus remains to be determined in these patients with collapse.

The natural history of ON depends on the location and extent of the necrotic region [6, 10]. If the necrotic region is located in the nonweightbearing middle part of the femoral head, it will not collapse [6, 10]. Therefore, we believe the principles of the treatment of ON are (1) to eliminate the shear stress from the necrotic region and to prevent a progression of collapse, and (2) to obtain joint realignment of the femoral head subluxated due to collapse. To satisfy these principles, transtrochanteric rotational osteotomy was developed to transpose the necrotic area to the nonweightbearing portion [15].

ON of the femoral head is generally 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. In these patients, several authors recommend an anterior rotational osteotomy. Clinical followup studies from several institutions suggest this procedure has merit to preserve the joint [2, 3, 13, 15]. On the other hand, when ON is located in the mid- to

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posterior portion, in which the intact area is located in the anterior portion of the femoral head, a transtrochanteric posterior rotational osteotomy is logical because this procedure transposes the necrotic area to the posterior nonweightbearing portion [1, 13, 14].

We therefore asked whether posterior rotational osteotomy would preserve the joint as reflected in survival (with conversion to THA as an endpoint), Harris hip scores, and radiographic collapse or osteoarthritis. We further asked whether the ARCO staging system would predict progressive osteoarthritis.

Materials and Methods

We retrospectively reviewed 47 consecutive patients (51 hips) with clinical and radiographic evidence of ON of the femoral head treated by a posterior rotational osteotomy from 1981 to 1996. We used a posterior rotational osteotomy in patients with: (1) the necrotic area in the posterior portion of the femoral head; (2) an intact healthy area in the anterior portion; and (3) a postoperative intact area ratio over 34% after the posterior rotational osteotomy (Fig. 1) [1, 8, 13]. During this same period we treated a total of 581

patients with ON with either other osteotomies (412) or THA/hemiarthroplasty (169). Thirty patients were male and 17 were female. Nine hips were ARCO Stage III-A, 13 Stage III-B, 14 Stage III-C, and 15 Stage IV [9]. One hip was categorized as Type B, 15 Type C1 and 35 Type C2 [12]. The average age was 37 years at the time of surgery (range, 9 to 58 years). The etiology of ON was idiopathic in four hips, alcohol abuse in 12, trauma in 14, and corticosteroids in 21. Four patients (four hips) had bilateral disease and underwent bilateral posterior rotational osteotomy. Three patients died and one was lost to followup. This left 43 patients (46 hips) in the study. The minimum followup was 1.2 years (mean, 12 years; range, 1.2 to 21 years).

The basic surgical procedure has remained unchanged since it was described by one of the authors (YS) [13–15] and all operations were performed by that surgeon. Briefly, this procedure contains three osteotomies: (1) an osteotomy of the greater trochanter; (2) an intertrochanteric osteotomy which passes from superolateral to inferomedial on the AP view; and (3) an osteotomy which passes from the proximal flare of the lesser trochanter inferolaterally towards the inferomedial extent of the primary osteotomy. During these osteotomies, preservation of the nutrient artery located in the adipose tissue just beneath the quadratus femoris is important. The degree of posterior rotation ranged from 90° to 180°, with an average of 105°, which was determined to obtain a sufficient postoperative intact area (more than 34%). In three cases, 180° of posterior rotation was performed because the intact area was very small and 180° of posterior rotation was necessary to obtain a sufficient intact area. In these three cases the postoperative scintigram showed no uptake indicating insufficiency of blood supply of the femoral head and these three were converted to THA secondary to subcapital fracture (not osteoarthritic changes) within 1.6 years of posterior rotational osteotomy. We therefore excluded these three cases from further analysis.

Postoperatively, the patients were nonweightbearing for 5 weeks, after which gradual weightbearing was permitted. Full weightbearing was permitted after 6 months.

Followup radiographic and clinical examinations are performed at 3 months, 6 months, and yearly thereafter. A bone scintigram was routinely performed 5 weeks postoperatively to confirm the blood supply to the rotated femoral head. At each exam we (YS, TY) determined the Harris hip score [4] including prior to the posterior rotational osteotomy, before conversion to THA, and at the most recent followup examination.

We (YS, TY) reviewed the preoperative and postoperative radiographs to establish the size and location of the necrotic lesion [12] and evidence of the progression of collapse and/or development of osteoarthritis. Osteoarthritic changes were diagnosed based on the presence of

Fig. 1 Postoperative intact area ratio is the most important factor influencing the results of a rotational osteotomy. This ratio is expressed as C-D/A-B and should be over 34% after the rotational osteotomy. Point A is an edge of the acetabulum and Point E is the lowest point of the teardrop. Point B is determined by drawing a perpendicular line from the midpoint of line of AE. Point C is the lateral edge of the loaded portion and point D represents the medial edge of the intact articular surface of the femoral head.

joint space narrowing, osteophyte formation, and/or sclerotic changes in both the femoral head and acetabulum.

We defined conversion to THA as the end point of failure of the posterior rotational osteotomy in the survival analysis including the patients who died or were lost to followup. We compared the preoperative Harris hip scores with the last postoperative scores using a paired t-test. The correlation between the preoperative ARCO stage and a progression of osteoarthritis was assessed using the Mann-Whitney U test. Among the etiologies of ON (steroids, alcohol, trauma and idiopathic), both the postoperative Harris hip score and a progression of osteoarthritis were compared using one-way ANOVA and Fisher's exact probability test, respectively. Statistical analyses were performed using the Stat View J-5.0 software package (SAS Institute Inc, Cary, NC, USA).

Results

The overall rate of survival was 93%. Three patients underwent THA, all for subcapital fracture in patients having an osteotomy with 180 degrees rotation.

The average preoperative Harris hip score of 52.4 points increased ($p < 0.0001$) to an average of 83.7 points at the latest followup. The average preoperative Harris hip score for range of motion was 4.5 points, which was unchanged at the latest followup. However, the other two factors of pain and function improved after posterior rotational osteotomy: pain from 15 to 36 points ($p < 0.0001$) and function from 29 to 39 points ($p < 0.0001$).

We observed no progressive radiographic collapse in 30 hips (69.8%) (Fig. 2A–D). Thirteen hips (30.2%) developed osteoarthritic changes. However, no patient underwent THA due to progressive osteoarthritic changes.

The progression of osteoarthritis correlated ($p = 0.0004$) with the preoperative ARCO stage. In the six early ARCO Stage III-A cases there was no progression of osteoarthritis, while in the advanced ARCO Stage IV cases, eight of the 12 cases progressed to osteoarthritis (Table 1). We observed progression of osteoarthritis in three of 16 cases with steroid-induced ON, three of 10 cases with alcohol-related disease, six of 13 with traumatic ON, and one of four with idiopathic ON. There was no difference in the rate among etiologies (Table 2). We observed no differences in postoperative Harris hip scores based on etiology or location of ON (Type of ON).

Discussion

ON of the femoral head is generally located in the anterosuperior aspect of the femoral head, in which the posterior

Fig. 2A–D Posterior rotational osteotomy. (A) The preoperative anteroposterior radiograph of a thirty-six-year-old man with preoperative ARCO Stage III-A is shown. The osteosclerotic line is seen in the femoral head. (B) The preoperative lateral view indicates the intact area in the anterior portion is wider than that in the posterior portion. The arrows indicate the margin of the necrotic area. (C) A radiograph obtained 1 year after the 90° posterior rotational osteotomy is shown. The postoperative intact area ratio is about 70%. (D) A radiograph obtained 13 years after the operation shows no evidence of a progression of collapse or the development of osteoarthritis. The size of the necrotic area, which is surrounded by a sclerotic line, has decreased (arrows), thus indicating a sufficient repair was obtained by the rotational osteotomy.

Table 1. Summary of data according to the ARCO stage

ARCO stage(pre-operation)	No. of hips	Progression of osteoarthritis**	
		—	+
III-A	6	6	0 (0%)
III-B	13	12	1 (8%)
III-C	12	8	4 (33%)
IV	12	4	8 (67%)
Total	43*	30 (70%)	13 (30%)

* Three cases in which 180° posterior rotation was performed are not included, because all of them underwent a subcapital fracture within 1.6 years.

** Based on the Mann-Whitney U test, a significant correlation was seen between the preoperative ARCO stage and the progression of osteoarthritis.

Table 2. Summary of data according to the etiology of osteonecrosis

Etiology	No. of hips	Progression of osteoarthritis**	Harris hip score (points)		ARCO stage			
			Preop.	Postop.***	III-A	III-B	III-C	IV
Steroids	16	3 (19%)	50.8	80.8	3	6	3	4
Alcohol	10	3 (30%)	55.6	84.5	3	3	1	3
Trauma	13	6 (46%)	49.5	85.1	0	2	7	4
Idiopathic	4	1 (25%)	60.9	88.8	0	2	1	1
Total	43*	13 (30%)	52.4	83.7	6	13	12	12

* Three cases in which 180° posterior rotation was performed are not included, because all of them underwent a subcapital fracture within 1.6 years.

** Based on the Fisher's exact probability test, no significant difference was seen in the progression of osteoarthritis among the etiologies of osteonecrosis.

*** Based on the one-way analysis of variance, no significant difference was seen in the postoperative Harris hip score among the etiologies of osteonecrosis.

aspect of the femoral head is relatively normal. In these patients, some authors recommend an anterior rotational osteotomy. On the other hand when ON is located in the mid- to posterior portion, in which the intact area is located in the anterior portion of the femoral head, a transtrochanteric posterior rotational osteotomy is logical. We therefore asked whether posterior rotational osteotomy would preserve the joint as reflected in survival (with conversion to THA as an endpoint), Harris hip scores, and radiographic collapse or osteoarthritis. We further asked whether the ARCO staging system would predict progressive osteoarthritis.

The major limitation of this study is the small number of patients, since most ON lesions are located in the anterior portion of the femoral head, in which anterior rotational osteotomy is considered. The large number of confounding variables (e.g., stages, etiologies) and relatively small numbers of patients preclude more complete analysis of predictive variables and thus more clear indications. The followup was limited to a minimum of 1.2 years but the mean was 12 years with a range of 1.2–21 years. Many patients who collapse and develop progressive osteoarthritis will not do so for a number of years and not by 1.2 years. However, the mean followup was 12 years, at which time most patients with collapse would have been detected.

Serial studies of patients administered corticosteroids suggest ON can be asymptomatic (silent hip) and can heal spontaneously if the lesion is located in the nonweightbearing area and if the articular surface is prevented from collapsing [6, 7]. In addition, healing of ON has been demonstrated in histopathologic investigations of femoral heads removed from patients who have undergone rotational osteotomy which transposed the necrotic area into the nonweightbearing portion [13]. On the other hand, if the osteonecrotic lesion is located in the major

weightbearing area, it will eventually undergo collapse, and a collapsed femoral head tends to be subluxated anterolaterally, thus resulting in a further collapse. Once collapse progresses, the reparative tissue is exposed to greater mechanical stress which we suspect impairs the reparative process [6, 10, 13].

Based on our experience we derive two important principles in the treatment of ON of the femoral head. First is to eliminate the shear forces from the necrotic focus, which leads reduces the risk of progressive collapse and enhances the repair process. The second is to realign the femoral head subluxation that occurs due to the collapse of the articular surface. A transtrochanteric rotational osteotomy, which transposes the necrotic area into a nonweightbearing area, appears an effective method for preventing collapse by diverting mechanical stress from the lesion [8, 13, 14].

We have previously reported the outcomes of anterior rotational osteotomy in 136 hips [5]. In that study, patients in the early stages such as ARCO Stage II or III-A had a low rate of conversion to THA (6.8%) over the long-term. On the other hand, patients with ARCO Stage III-C and IV had conversion rates of 21% and 24%, respectively. Thus, to prevent long-term osteoarthritis, we believe an anterior rotational osteotomy should be performed in the early stages with minimum collapse such as ARCO Stage II or III-A.

In our current study, 30 hips (70%) had no progressive collapse after posterior rotational osteotomy. Thirteen (30%) had osteoarthritic changes but the preoperative stages were advanced ARCO Stage III-C and IV in 12 of these 13 hips. Nevertheless, no patient had conversion to THA due to the progression of osteoarthritic changes even in such advanced preoperative stages. These results seem better than those after an anterior rotational osteotomy. An anterior rotational osteotomy transposes the necrotic area to the anterior portion. After the anterior rotation, the

Fig. 3 Posterior rotational osteotomy for the treatment of ON of the femoral head. When ON is located mainly in the mid- to posterior portion, a transtrochanteric posterior rotational osteotomy, which transposes the necrotic area to the posterior nonweightbearing portion, is considered. In this procedure, the collapsed joint surface of the femoral head was transposed to the acetabulum, and thus joint stability was obtained. In addition, because the tension to the nutrient vessels decreases after the posterior rotation, the femoral head can be rotated by more than 100° . The upper limit is around 140° to 150° .

collapsed lesion still exists in the anterior portion of the joint. Therefore, hip instability, especially anterior to posterior direction, cannot be solved, especially in patients with advanced collapse. In addition, this collapsed lesion may cause crepitus to the anterior edge of the acetabulum when taking a flexion position. However, with a posterior rotational osteotomy the collapsed joint surface is transposed into the acetabulum, joint stability can be restored (Fig. 3). The original anterior acetabular coverage, which is generally difficult to ascertain on the AP view, can enhance the weightbearing area, especially in patients with posterior rotation (Fig. 4).

The most important factor affecting the results of a rotational osteotomy is the postoperative intact area ratio, which should be over 34% [8]. In order to evaluate the exact intact area preoperatively, it is important to take a precise lateral view of the femoral head with 90° of flexion and 45° of abduction. The more flexion of the hip, the more the inferior part of the femoral head can be seen on this lateral view. By taking a lateral view over 90° of flexion, one can identify the intact area located in the anteroinferior part of the femoral head which will be transposed to the weightbearing portion after a posterior rotational osteotomy over 90° .

We believe the indications for posterior rotational osteotomy can be derived from our data. In every ARCO stage, if the intact area is located in either the anterior portion or located equally in the anterior or posterior portion (Fig. 2B), then we consider a posterior rotational

Fig. 4 The sagittal CT image shows original anterior acetabular coverage (arrow line), which is not generally visible on the AP radiograph. This original anterior acetabular coverage can enhance the intact weightbearing area, especially in patients with posterior rotation.

osteotomy. In advanced ARCO stages, the indications for posterior rotational osteotomy can be expanded. If the intact area is located primarily in the posterior portion at 90° of hip flexion, then an anterior rotational osteotomy may be considered. However, if the anterior intact area is much wider with 120° of flexion, then we recommend a 120° posterior rotational osteotomy rather than a 90° anterior rotational osteotomy, in order to prevent osteoarthritic changes after the osteotomy.

Because the tension to the nutrient vessels decreases after posterior rotation, the femoral head can be rotated more than 100° (Fig. 3). However, the upper limit is around 140° to 150° , because patients with 180° of posterior rotation had cold lesions on postoperative scintigram indicating insufficient blood supply to the femoral head, and all later had a subcapital fracture necessitating THA. In the posterior rotational osteotomy an anteversion angle yields a valgus position after the osteotomy if the osteotomy line was determined without reducing the anteversion angle. In addition, postoperative treatment should be approached carefully because the posterior part of the bone, not originally strong, is transposed to the calcar. Since this procedure needs to obtain such bone remodeling at the weight bearing portion as well as bone union at the osteotomy site, full weightbearing should not be started until at least 6 months after the operation. This may cause an extension of the hospitalization period. Atsumi et al. [1] reported similarly encouraging results for posterior rotational osteotomy in ON patients, in which the survival rate was 78% at an average of 5 years.

In summary, when ON is located in the mid- to posterior portion and the intact area is located in the anterior portion of the femoral head a transtrochanteric rotational osteotomy appears to delay the need for THA in the majority of patients.

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