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ORIGINAL ARTICLE

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# Transtrochanteric rotational osteotomy for osteonecrosis of the femoral head

## 43 patients followed for at least 3 years

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**Abstract** We reviewed 48 hips in 43 patients 3–7.1 years (average 4.6 years) after Sugioka transtrochanteric rotational osteotomy for osteonecrosis of the femoral head. The average age at operation was 41 years. Thirty-four patients were men and 9 women. Overall results at the final follow-up were satisfactory in 30 hips (62%). Kaplan-Meier's survivorship was 62% at 3 years and 60% at 5 years postoperatively. Six hips for which the ratio of the intact area of the articular surface on the preoperative lateral radiograph was less than 30% showed further collapse. Five hips were converted to bipolar hemiarthroplasties or total hip arthroplasties. Complications, such as varus deformity, subtrochanteric fracture, and ectopic bone formation, occurred in eight hips. Five of them were operated on in the first 2 years of this series. Three of these five operations had unsatisfactory results. We conclude that satisfactory results can be achieved using this osteotomy by maintaining exact surgical technique and by limiting the surgical indications to hips with an intact area of more than one-third of the entire articular surface on the lateral radiograph of the femoral head.

## Introduction

Osteonecrosis of the femoral head (ONFH) occurs most commonly in middle-aged adults. It is mainly associated with steroid therapy, alcohol abuse, and hemostatic alterations. However, its exact etiology remains unknown. The natural history of ONFH in patients with extensive lesions involves progressive collapse leading to secondary osteoarthrosis. Total hip arthroplasty (THA) as treatment of ONFH has a high incidence of loosening because these patients are younger and more active [3, 6]. Results of THA in patients with ONFH are inferior to those in patients with osteoarthrosis [1, 4, 19]. For these reasons, a joint-preserving procedure should be considered, if possible. Core decompression [8, 10, 24], free or vascularized bone grafting [11, 14], and different types of intertrochanteric femoral osteotomies [8, 9, 16, 25] have been reported. However, these osteotomies have been successful mainly in cases involving small areas of necrosis.

Transtrochanteric rotational osteotomy (TRO), as described by Sugioka [21], involves the rotation of the affected femoral head anteriorly or posteriorly so that the weight-bearing force is transferred to the intact articular surface. It is a difficult but theoretically ideal joint-preserving operation.

We reviewed the clinical and radiological results in 48 hips, which were followed for more than 3 years after the procedure. We also considered the factors that influenced the results.

## Materials and methods

TRO for ONFH was performed on 48 hips in 43 patients from 1989 to 1993 at the Nagoya University Hospital (Table 1). We studied prospectively all 48 hips in 43 patients with at least 3 years' follow-up. The average follow-up was 4.6 years, with a range of 3–7.1 years. There were 34 men and 9 women. The average age at the time of operation was 41 years, with a range of 17–59 years. Five patients underwent procedures on both hip joints. As for the causes of ONFH, 29 were steroid-induced, 12 were alcohol-associated, 5 were idiopathic, 1 was posttraumatic, and 1 was associated with Gaucher's disease.

The progression of ONFH was classified into four stages as described by the Japanese Investigation Committee of Health and Welfare [18] (Table 2). The affected femoral heads were further classified into six types, according to the size and location of the necrotic area as related to the weight-bearing surface of the acetabulum [17] (Fig. 1). Twenty-six hips were considered to be stage 2; 22 hips were considered to be stage 3. Forty hips were classified as type I-C, 7 as type II, and 1 as type I-B. The indications for TRO were hips in stage 2 or 3 which were classified as type I-C or type II with an intact area exceeding one-third of the entire articular surface on the lateral hip radiograph. However, the procedure was performed on one hip in stage 2 classified as type I-B because of severe pain. Three hips, which had intact areas of less than one-third of the posterior articular surface, underwent transtrochanteric posterior rotational osteotomies (PROs) because they

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**Table 1** Clinical details of 48 hips which were treated by transtrochanteric rotational osteotomy (TRO) for osteonecrosis of the femoral head (ONFH) (*% Intact* the ratio of the intact area of the articular surface in frog leg position, *Pre-op* before operation, *3 years* = at 3 year follow-up, *Final* at final follow-up, *Varus* additional varus osteotomy, *PBG* pedicle bone graft, *BHP* bipolar hemiarthroplasty, *THA* total hip arthroplasty, *ARO* transtrochanteric anterior rotational osteotomy, *PRO* transtrochantric posterior rotational osteotomy, *OA* osteoarthrotic change)

| Case no. | Gender | Age (years) | Etiology | Type | Stage | Contralateral hip | % intact | Harris hip score | | | Radiological result | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Pre-op | 3 years | Final | | |
| 1 | M | 33 | Steroid | I-C | 2 | Case 48 | 40 | 66 | 79 | 70 | OA | Varus |
| 2 | M | 45 | Idiopathic | I-C | 2 | Type I-A | 41 | 72 | 94 | 71 | | |
| 3 | M | 29 | Steroid | II | 3 | | 50 | 75 | 100 | 100 | | |
| 4 | M | 49 | Steroid | I-C | 3 | Case 7 | 43 | 80 | 98 | 98 | | |
| 5 | M | 36 | Idiopathic | I-C | 3 | | 30 | 70 | – | – | | Fracture, ankylosis |
| 6 | M | 44 | Steroid | I-C | 3 | | 36 | 85 | 62 | 62 | Collapse | |
| 7 | M | 50 | Steroid | I-C | 3 | Case 4 | 43 | 76 | 98 | 98 | | |
| 8 | M | 21 | Steroid | I-C | 2 | | 30 | 66 | 44 | 44 | Collapse | |
| 9 | M | 35 | Steroid | I-C | 2 | | 50 | 100 | 93 | 80 | | |
| 10 | F | 40 | Alcohol | I-C | 3 | | 40 | 67 | 82 | 82 | | |
| 11 | M | 49 | Steroid | I-C | 3 | PBG | 43 | 91 | 93 | 94 | | |
| 12 | M | 52 | Idiopathic | I-C | 2 | | 41 | 82 | 100 | 100 | | Fracture |
| 13 | M | 47 | Steroid | I-C | 3 | BHP | 40 | 78 | 91 | 84 | | |
| 14 | M | 44 | Alcohol | I-C | 2 | | 36 | 86 | 100 | 100 | | |
| 15 | F | 40 | Steroid | I-C | 2 | | 45 | 66 | 100 | 100 | | |
| 16 | M | 31 | Alcohol | I-C | 2 | | 50 | 78 | 100 | 100 | | |
| 17 | F | 24 | Traumatic | I-C | 3 | | 27 | 54 | 64 | 64 | Collapse | |
| 18 | M | 46 | Steroid | I-C | 2 | Type I-A | 35 | 79 | 94 | 94 | | |
| 19 | M | 48 | Alcohol | I-C | 2 | | 50 | 88 | – | – | Collapse | BHP |
| 20 | F | 56 | Steroid | II | 2 | | 40 | 65 | 94 | 94 | | |
| 21 | M | 32 | Steroid | I-B | 2 | PBG | 52 | 90 | 78 | 78 | | |
| 22 | M | 47 | Steroid | I-C | 3 | Type II | 50 | 76 | 93 | 52 | Collapse | |
| 23 | M | 24 | Steroid | II | 3 | | 40 | 53 | 99 | 99 | | |
| 24 | M | 52 | Alcohol | I-C | 3 | BPH | 50 | 91 | 93 | 93 | | |
| 25 | M | 30 | Steroid | I-C | 3 | | 50 | 81 | 97 | 97 | | |
| 26 | M | 46 | Steroid | I-C | 3 | Case 38 | 17 | 51 | 53 | 53 | | PRO |
| 27 | M | 44 | Alcohol | I-C | 3 | | 30 | 88 | 67 | 57 | OA | |
| 28 | F | 27 | Steroid | I-C | 3 | | 30 | 81 | 97 | 97 | | PRO |
| 29 | M | 50 | Idiopathic | I-C | 2 | PBG | 43 | 74 | 87 | 87 | | |
| 30 | M | 45 | Alcohol | II | 2 | BHP | 30 | 46 | – | – | Collapse | THA |
| 31 | M | 50 | Steroid | I-C | 2 | PBG | 57 | 57 | 86 | 88 | | |
| 32 | M | 47 | Alcohol | I-C | 2 | Case 42 | 45 | 82 | 86 | 86 | Collapse | |
| 33 | F | 59 | Steroid | I-C | 3 | | 40 | 68 | 97 | 97 | | |
| 34 | M | 56 | Steroid | I-C | 2 | | 43 | 60 | 93 | 93 | | |
| 35 | M | 30 | Steroid | I-C | 3 | | 45 | 90 | 85 | 85 | | |
| 36 | M | 43 | Idiopathic | I-C | 3 | ARO | 50 | 95 | 95 | 95 | | |
| 37 | F | 37 | Steroid | I-C | 3 | | 40 | 71 | 94 | 94 | | |
| 38 | M | 47 | Steroid | II | 2 | Case 26 | 40 | 52 | 88 | 88 | | |
| 39 | M | 21 | Alcohol | I-C | 2 | | 46 | 82 | – | – | Collapse | BHP |
| 40 | M | 29 | Alcohol | I-C | 2 | Case 46 | 50 | 85 | 97 | 97 | | |
| 41 | M | 55 | Steroid | I-C | 2 | BHP | 10 | 80 | – | – | Collapse | PRO, THA |
| 42 | M | 47 | Alcohol | I-C | 2 | Case 32 | 43 | 78 | 58 | 58 | Collapse | |
| 43 | F | 43 | Steroid | II | 2 | ARO | 50 | 54 | 83 | 67 | OA | |
| 44 | M | 17 | Gaucher | I-C | 3 | | 40 | 56 | 90 | 90 | OA | |
| 45 | M | 56 | Steroid | I-C | 3 | | 40 | 75 | 87 | 87 | | |
| 46 | M | 31 | Alcohol | I-C | 2 | Case 40 | 50 | 84 | 94 | 94 | | |
| 47 | F | 51 | Steroid | II | 2 | | 30 | 46 | – | – | Collapse | BHP |
| 48 | M | 37 | Steroid | I-C | 2 | Case 1 | 50 | 58 | 92 | 96 | | |

**Table 2** Staging of ONFH

| | |
|---|---|
| Stage 1: | Pre-radiological stage. There are neither symptoms nor radiographic changes in the femoral head. However, a definite abnormality, diagnosable by magnetic resonance imaging or bone scintigraphy, is present. |
| Stage 2: | Early stage. Radiographs show abnormality in the femoral head with no collapse or collapse of less than 2 mm. |
| Stage 3: | Advanced stage. Radiographs show irregular density with obvious collapse of the femoral head. |
| Stage 4: | Late stage. Severe deformity of the femoral head and secondary osteoarthrosis are evident. |

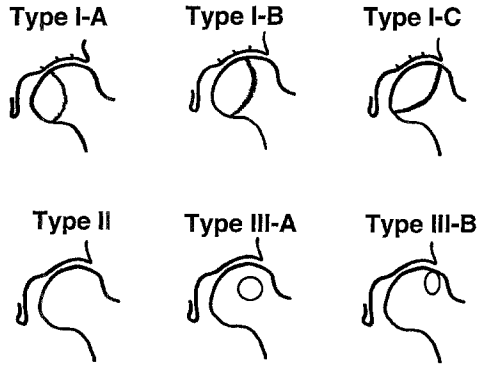
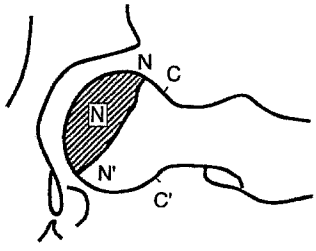



**Fig. 1** Radiographic classification of osteonecrosis of the femoral head (ONFH). *Type I* is characterized by the presence of a demarcation line in the femoral head and is divided into three subtypes according to its relationship to the weight-bearing surface: *I-A*, necrotic area less than 1/3 of weight-bearing surface; *I-B*, necrotic area more than 1/3 but less than 2/3 of weight-bearing surface, *I-C*, necrotic area more than 2/3 of weight-bearing surface. *Type II* shows early flattening of the weight-bearing surface but has no demarcation line around the necrotic area. *Type III* has cystic lesions and is divided into two subtypes according to their site in the femoral head: *III-A*, cystic lesions in the nonweight-bearing surface; *III-B*, cystic lesions in the weight-bearing surface




$$\text{Ratio} = \frac{N'\text{-}C'}{C\text{-}C'} \times 100\ (\%)$$

**Fig. 2** Method of measuring the ratio of the intact area of the posterior surface of the femoral head to the total articular surface on the lateral view of hip radiograph (*N-N'* necrotic focus, *C-C'* total articular surface)

had an intact anterior articular surface greater than one-third of the entire articular surface.

### Operative procedures

Under general anesthesia and in a lateral decubitus position, a modified Ollier's skin incision was made. In all patients, we used Sugioka's original procedure [21], fixing the transtrochanteric osteotomy with two or three large titanium (Ti-6Al-4V) alloy screws (Mizuho Ikakogyo, Tokyo, Japan). The reflected greater trochanter was reduced and fixed to the original cut surface of the shaft of the femur by a titanium wire. We took care to avoid injury to the posterior column vessels that lie in the adipose tissue just beneath the quadratus femoris muscle.

Postoperatively, skin traction of 2 kg was applied continuously for the first week and for an additional 2 weeks at night only. Partial weight-bearing with crutches was permitted at 10 weeks postoperatively, and full weight-bearing was started at about 4 months postoperatively. The use of a crutch gait was recommended for 6 months postoperatively. For an extensive lesion, a crutch should be used up to a year following the operation.

### Assessment

The Harris hip score was used for the assessment of clinical symptoms preoperatively and at every year postoperatively. We considered an excellent result to be scores of 90 points or more, a good result to be 80 points or more, a fair result to be 70 points or more, and a poor result to be less than 70 points.

The ratio of the intact area of the posterior part of the femoral head to the total articular surface on the preoperative lateral radiograph (frog leg position) was measured (Fig. 2). The incidence of collapse and osteoarthrotic change of the new weight-bearing surface of the femoral head on the postoperative anteroposterior (AP) view was calculated.

A result was considered satisfactory if there was an excellent or good Harris hip score and no progressive collapse or osteoarthrotic changes.

### Statistical analysis

Statistical analysis of the data was performed using the chi-square test. The Wilcoxon signed-rank test was used to evaluate the Harris hip scores. The probability of clinical failure was expressed as survivorship with the use of the Kaplan-Meier's method [12]. Probability values of less than 0.05 were considered to be significant.

## Results

### Clinical results

The average preoperative Harris hip score was 74 ± 14 points (average ± SD). At 3 years after surgery and final follow-up (average 4.6 years), this score was 87 ± 14 points and 85 ± 17 points, respectively. These differences were statistically significant ($P < 0.001$). After 3 years and at final follow-up, 34 hips (71%) and 31 hips (65%), respectively, were rated as excellent or good. In 31 hips at 3 years postoperatively and final follow-up, the pain score was 40 points and 44 points, respectively. There was no significant difference in the Harris hip score between stage 2 and stage 3 hips.

The postoperative range of motion at the final follow-up had decreased significantly in flexion and internal rotation from 101 ± 21 deg to 90 ± 23 deg and from 24 ± 13 deg to 13 ± 17 deg, respectively ($P < 0.001$). In 5 hips, an external rotation contracture (5–15 deg, average 9 deg) was found.

### Radiographic results

At final follow-up, progressive collapse was noted in 11 hips, and osteoarthrotic changes were seen in 4 hips. In 14

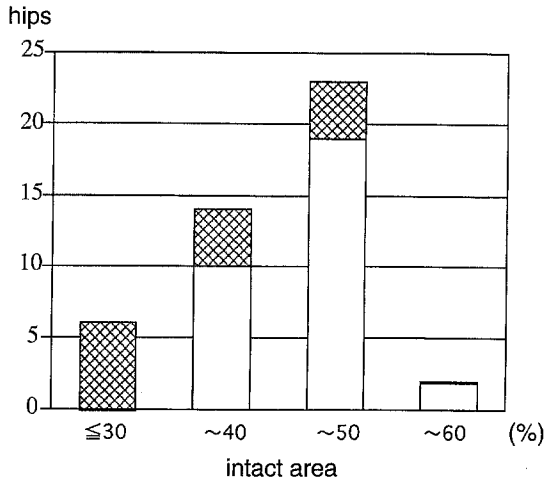



**Fig. 3** Relationship between the intact area of the posterior femoral articular surface on the lateral radiograph and results in cases where anterior transtrochanteric rotational osteotomy was performed (mean follow-up 4.5 years), □, successful; ▨, unsuccessful

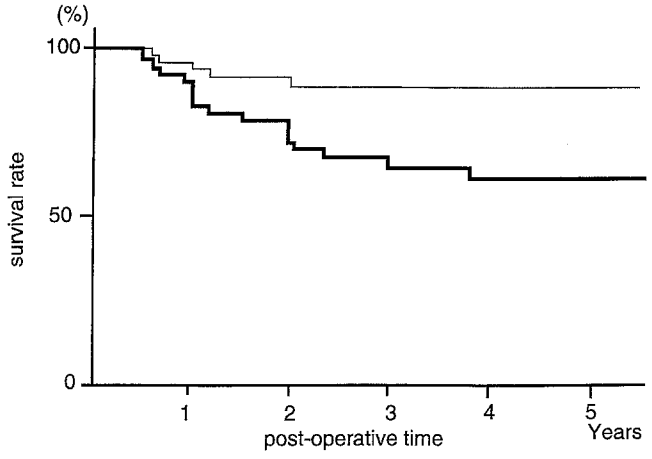



**Fig. 4** Kaplan-Meier survivorship curve whose endpoint was defined as the time when total hip arthroplasty or hemiarthroplasty was performed *(thin line)* or when the Harris hip score fell below 70 points or the progressive collapse was more than 5 mm or osteoarthrotic changes were seen in the new weight-bearing surface *(thick line)*

of these 15 hips, these changes were seen within 3 years after the operation.

In 6 hips treated by a transtrochanteric anterior rotational osteotomy (ARO), the ratio of the intact area of the posterior part of the femoral head to the total articular surface on the lateral radiograph was less than 30%. All of these hips showed progressive collapse exceeding 5 mm (Fig. 3).

Nine hips with an intact area of more than 30% showed progressive collapse or osteoarthrotic changes. Of these 9 hips, 5 were steroid-induced, 3 were alcohol-associated, and 1 accompanied Gaucher's disease. For 2 of the steroid-induced 5 hips, the osteotomy was performed in 1989 and 1990. For all 3 alcohol-associated hips, the osteotomy was performed after 1991. The ratio of the intact area in all 3 hips treated by PRO was less than 20%. Two of them showed progressive collapse and were converted to THA.

The overall results at 3 years postoperatively and at final follow-up (average 4.6 years) were satisfactory in 32 hips (67%) and 30 hips (62%), respectively. The Kaplan-Meier's survivorship with the endpoint defined as the time when the hip was converted to an arthroplasty was 88%, both at 3 years and 5 years postoperatively. The Kaplan-Meier's survivorship with the endpoint defined as the time when the Harris hip score fell below 70 points or when the progressive collapse was more than 5 mm or osteoarthrotic changes could be seen on the new weight-bearing surface was 62% and 60% at 3 years and 5 years postoperatively, respectively (Fig. 4).

## Complications

There were postoperative complications in eight hips (17%). There were four varus deformities, two postoperative subtrochanteric fractures, one case of ectopic bone formation, and one pseudoarthrosis of the greater trochanter. Five of these eight operations were performed in 1989 or 1990 (Table 3). The complication rate of cases performed in 1989 or 1990 was higher than for those performed after 1991.

In all four hips with a postoperative varus deformity, no additional operation was necessary, but progressive collapse occurred in two. Two of these patients had started weight-bearing 8 weeks postoperatively. In one of the two hips with fractures, a subtrochanteric fracture was the result of a traffic accident. After an additional operation using an AO angle plate (Mathys, Bettlach, Switzerland), an infection appeared, resulting in ankylosis. In the other case, a subtrochanteric fracture through the screw hole occurred. Therefore, osteosynthesis with an AO angle plate was performed. The overall result at final follow-up in this hip was satisfactory.

The case of ectopic ossification was classified as class 1 in Brooker's classification [2], and no treatment was necessary.

In six of 48 hips, reoperation or additional surgery was necessary. Because of progressive collapse with severe pain, 5 hips were converted to bipolar hemiarthroplasties (BHPs) or THAs at an average of 1.1 years (range 8 months to 2 years) following the osteotomy.

**Table 3** Surgical cases and complications as related to year of operation

| | Number of complications | Number of operations (hips) |
|---|---|---|
| 1989 | 2 | 6 |
| 1990 | 3 | 6 |
| 1991 | 1 | 15 |
| 1992 | 2 | 16 |
| 1993 | 0 | 5 |
| Total | 8 | 48 |

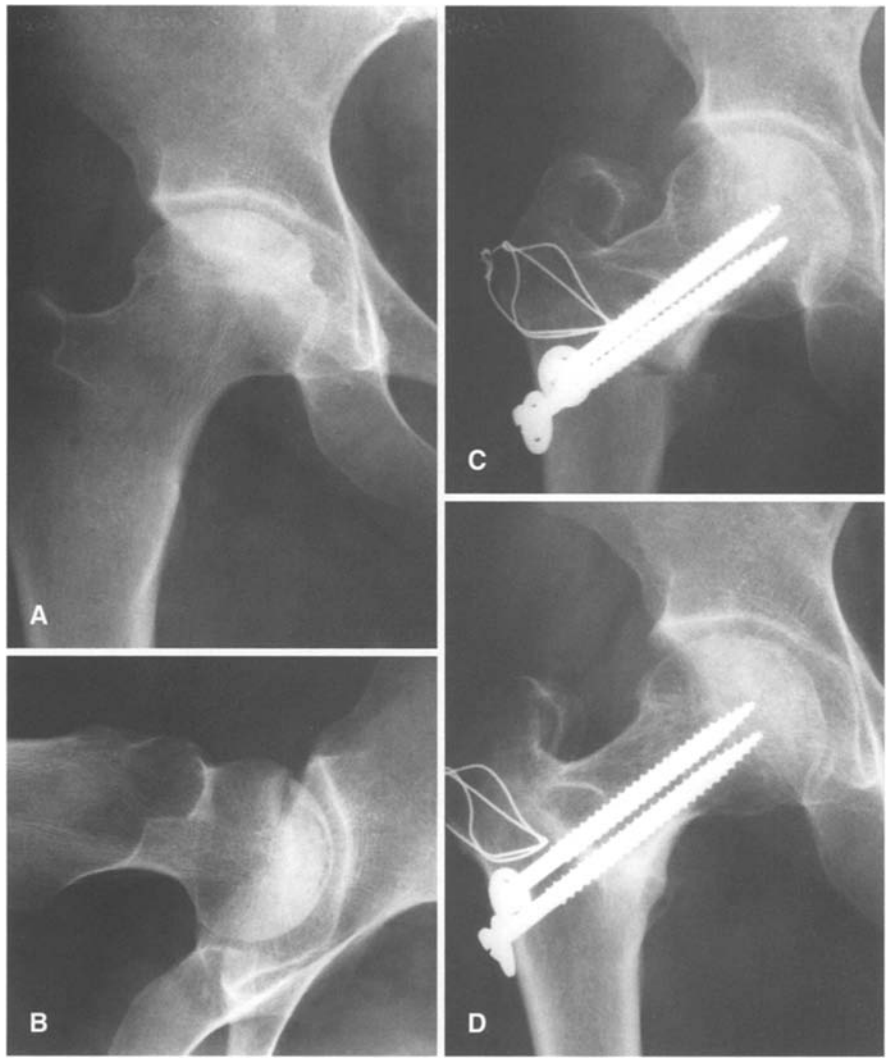



**Fig. 5 A, D** A 37-year-old woman with a type I-C and stage 3 steroid-induced osteonecrosis of the right hip who underwent a transtrochanteric rotational osteotomy with 85° anterior rotation and 5° intentional varus position. Three years following osteotomy, excellent clinical and radiographic results have been obtained. **A** Preoperative AP radiograph. **B** Preoperative lateral radiograph in the frog leg position. Ratio of the intact area of the posterior articular surface was 40%. **C** AP radiograph immediately after operation. **D** AP radiograph at the final follow-up

A varus osteotomy was performed in one hip because of a valgus position following TRO. In this patient, osteoarthrotic changes were seen at final follow-up.

## Case report

Case 37

A 37-year-old woman with steroid-induced right ONFH (Fig. 5). Preoperatively, the AP radiograph showed type I-C, stage 3 ONFH. The Harris hip score was 71 points, and the ratio of the intact area of the posterior surface of the femoral head on the lateral radiograph was 40%. We performed ARO with 85 deg of anterior rotation and 5 deg of intentional varus position. The Harris hip score at 3 years and at final follow-up was 93 points. At final follow-up, radiographs showed no evidence of collapse.

Case 28

A 27-year-old woman with steroid-induced left ONFH (Fig. 6). Preoperatively, the AP radiograph showed type I-C, stage 3 ONFH. The Harris hip score was 81 points. The ratio of the posterior intact area on the lateral view was only 10%. Because there was an intact area of more than one-third of the anterior articular surface on the lateral radiograph, we performed PRO with 115 deg of posterior rotation and 20 deg of intentional varus position. At final follow-up, the Harris hip score was 98 points, and the radiographs showed no evidence of collapse or osteoarthrotic change.

## Discussion

Several authors have described the results of series of TRO [5, 7, 15, 20, 23]. Sugioka et al. have reported 78% success rate in 295 cases at a follow-up of 2–16 years [22]. However, other authors have found less satisfactory results. Masuda et al. noted 69% satisfactory results in 52 cases at 5.1 years [15]. Dean and Cabanela reported only 17% satisfactory results in 18 cases at 5 years [5]. They identified the operative indications, the difficulty of the operative technique, the stabilization of the osteosynthesis, differences in the schedule of postoperative rehabilitation, and race-dependent variations as the reasons for the variation between Sugioka et al.'s results and those of others. In our report, all 6 patients in whom there was less than 30% intact articular surface seen on the lateral radiograph had a poor result following Sugioka's osteotomy.

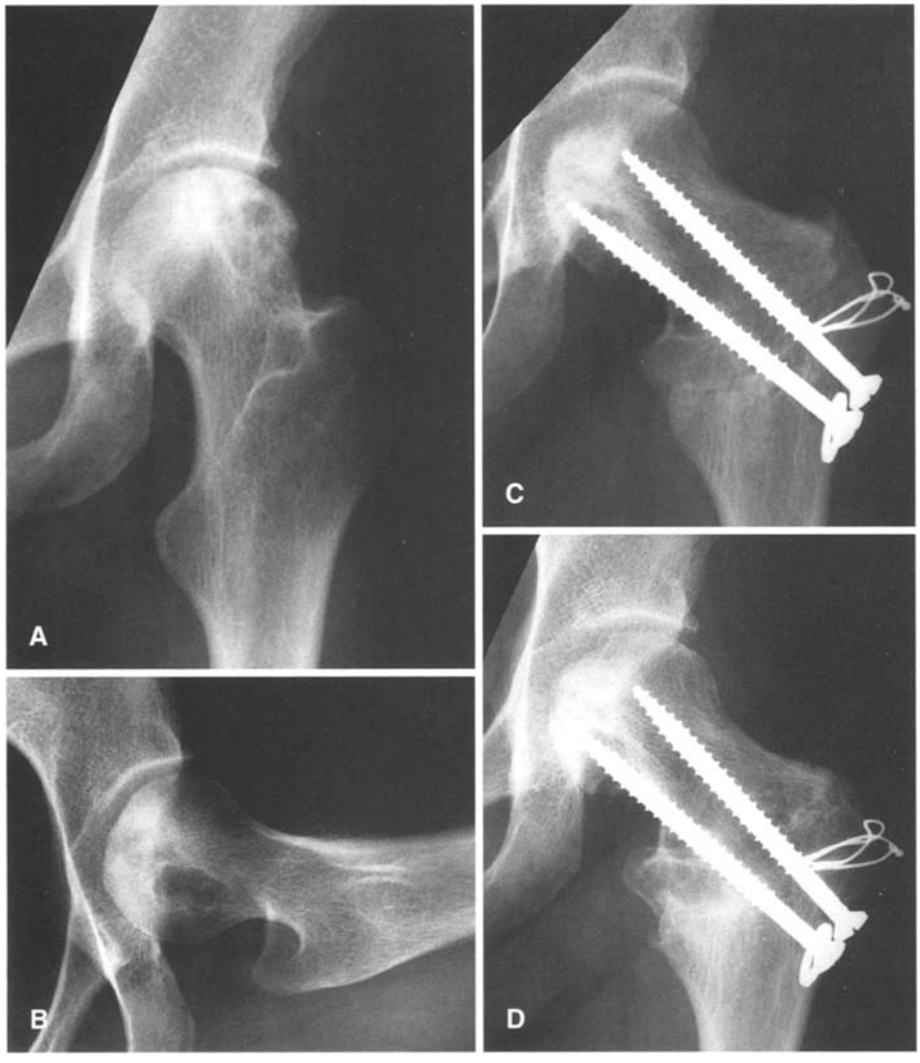



**Fig. 6 A, D** A 27-year-old woman with multiple sclerosis and type I-C, stage 3 steroid-induced osteonecrosis who underwent a transtrochanteric osteotomy with 115° posterior rotation and 20° intentional varus position. **A** Preoperative AP radiograph. **B** Preoperative lateral radiograph in the frog leg position. Ratio of the intact area of the posterior articular surface was 10%. **C** AP radiograph immediately after operation. **D** AP radiograph shows no evidence of collapse and osteoarthrotic change at final follow-up

We consider that the articular surface, which needs to match anteriorly or posteriorly more than one-third of the femoral head on the preoperative lateral radiograph, must be maintained.

For operations performed in 1989 or 1990, the rate of complications was higher than in those done after 1991. The occurrence of a complication tended to lead to unsatisfactory results. We consider that a learning curve was necessary in order to obtain optimal results.

One possible reason for the varus deformity postoperatively is insufficient fixation. We hypothesize that the fixation might not be sufficiently solid in patients with an intentional varus angle of more than 20 deg as described by Sugano et al. [20]. We are currently developing a more rigid device like the compression hip screw.

We encountered two cases of alcohol-associated ONFH with unsatisfactory results despite the procedure being technically flawless. These patients ambulated without crutches against medical advice. Patients being considered for this procedure should be clearly informed that TRO requires a longer period of rehabilitation than arthroplasty does.

To achieve a successful osteotomy, we conclude that it is necessary to: (1) understand the basic theory of this operation to acquire the proficiency to carry out the operative procedure, (2) select patients who understand the necessity for long-term postoperative rehabilitation, and (3) ensure that more than one-third of the entire articular surface on the lateral radiograph of the hip remains intact.

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