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Comparison of surgical dislocation and impacting bone graft and surgical dislocation and rotational osteotomy for the treatment of ARCO III femoral head necrosis

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Abstract

Hip preserving procedures are still a challenge in late-stage osteonecrosis of femoral head (ONFH) patients. We aimed to compare the clinical outcomes of surgical dislocation and impaction bone graft and surgical dislocation and rotational osteotomy for treatment of ONFH in Association Research Circulation Osseous (ARCO) stage III patients.

We retrospectively reviewed 30 ARCO stage III patients (33 hips) who had surgical dislocation and impaction bone graft or surgical dislocation and rotational osteotomy in our center from June 2012 to December 2017. Baseline characteristics, clinical evaluation using Harris score and radiologic evaluation up to 12 months after surgery were recorded and compared.

Fifteen patients (17 hips) were in the surgical dislocation and impaction bone graft group and 15 patients (16 hips) were in the surgical dislocation and rotational osteotomy group. No significant differences in age, gender, etiology, ARCO stage, duration of illness, operation time, and length of hospitalization were observed between the 2 groups. Compared to preoperation Harris score, the Harris score of 6 months postoperation and 12 months postoperation significantly improved. At 12 months postoperation, the excellent and good rate was 76.5% in the impaction bone graft group and 87.5% in the rotational osteotomy group. No significant difference in Harris scores was detected in the 2 groups.

Surgical dislocation and impaction bone graft and surgical dislocation and rotational osteotomy had satisfactory 1-year efficacy for ARCO III ONFH patients. Surgical dislocation and rotational osteotomy had better short-term efficacy than surgical dislocation and impaction bone graft.

Abbreviations: AP = anteroposterior, DSA = digital substraction angiography, NVBG = nonvascularized bone grafting, ONFH = osteonecrosis of femoral head.

Keywords: impaction bone graft, osteonecrosis of femoral head, rotational osteotomy, surgical dislocation

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1. Introduction

Osteonecrosis of the femoral head (ONFH) is a devastating disease that often leads to destruction of the hip and needs total-hip arthroplasty.[1] ONFH is an increasing worldwide health problem.[2,3] The etiology of ONFH remains unclear. Femoral neck fracture, hip dislocation, long-term high-dose use of glucocorticoids, alcohol, organ transplantation, and decompression sickness are among the identified risk factors.[4] ONFH commonly affects patients between 30 and 50 years of age and progresses to complete collapse in 80% of untreated patients.[5]

In early stages of the ONFH, joint preserving treatments such as core decompression, osteotomy, and vascularized or nonvascularized bone grafting (NVBG) are often utilized to defer head-replacing options such as total-hip arthroplasty.[6–9] Though hip arthroplasty is generally associated with good long-term outcome, in young patients, the young age and high demands placed on the hips might result in poor long-term outcomes.[10,11] Unfortunately, hip preserving therapies for ONFH above Association Research Circulation Osseous (ARCO) stage III are challenging in orthopedics, and the success rate was not satisfactory according to a previous study.[12]

Bone graft and rotation osteotomy were commonly used in early stage ONFH, but the usage and efficacy in late stage ONFH was not explored and compared before. In our study, we retrospective reviewed these 2 hip preserving options, surgical dislocation and impaction bone graft, and surgical dislocation and rotational osteotomy in 30 ARCO stage III ONFH patients (33 hips) in our center. We compared the clinical and radiologic results of these 2 therapies to evaluate their efficacies.

2. Patients and methods

This study was approved by the Ethics Review Board Committee of the Affiliated Hospital of Nanjing University of TCM (Nanjing, China). Written consents were obtained from each patient. All investigations were conducted according to the Declaration of Helsinki as well as national/ international regulations.

2.1. Patients

A total of 30 patients with ONFH (33 hips) who underwent surgical dislocation and impaction bone graft or surgical dislocation and rotational osteotomy from June 1, 2012 to December 31, 2017 were included in the study. Key procedures in all surgeries were performed by the corresponding author.

Inclusion criteria were: aged 18 to 50 years old; classified as stage III (IIIA, IIIB, and IIIC) according to the system of the ARCO[13]; strong desire for hip-preserving surgery; signed informed consent; and were followed for at least 12 months. Exclusion criteria were: preoperative ARCO stage IV or hip osteoarthritis; diagnosis of acute myocardial infarction, cerebrovascular accident, severe trauma, or other major surgery within 1 year before operation; diagnosis of hypertension, coronary heart disease, or diabetes; mental illness; and with severe liver, kidney, or hematopoietic illness.

2.2. Operation
2.2.1. Anesthesia and surgical dislocation. The procedure was performed with the patient lying in the lateral decubitus position. An incision of approximately 10 cm was made to the hip over the greater trochanter for an anterolateral approach (Watson–Jones approach), which was used to preserve the blood supply to the femoral head. The fascia lata was split in the direction of the skin incision, and the anterior gluteus medius was detached. The anterior joint capsule was longitudinally spilt along the femoral head between the gluteus medius muscle and tensor muscle of fascia lata to expose the head–neck junction. A greater trochanter osteotomy (with a thickness of 1.0–1.5 cm) was performed. The osteotomy block and the lateral femoral muscle attached were pulled forward to protect the external rotator muscle group (Fig. 1A). A Hohmann hook was used to extend into the osteotomy space, and under the flexion, abduction and external rotation of the hip joint, the apex of the greater trochanter was bluntly separated. The switch capsule was exposed and incised. The round ligament was cut to dislocate the femoral head outward (Fig. 1B).

2.2.2. Necrotic bone cleaning and impaction bone graft. An approximate 1.0 cm × 1.5 cm bone window was made at the femoral head–neck junction using osteotomes. A mushroom-tipped burr was used to curette a cavity to the subcartilage bone lamella in the femoral head using the window as an entrance, and

all of the necrotic bone was removed. The volume of cavity was measured by saline and the sclerotic bone was perforated using an electric drill until bleeding bone was encountered. The cavity was then filled with an auto-iliac cancellous bone (Fig. 1C). The dead bones were cleared (Fig. 1D). After that, the cartilage morphology of the collapsed part returned to normal. The cortical bone at the fenestration was covered in situ and fixed with a 4.0-mm cannulated screw. After the hip joint was restored, the greater trochanter osteotomy block was repositioned, and two 4.0 mm cannulated screws were used.

2.2.3. Rotational osteotomy. A 1.5-mm diameter Kirschner wire was placed as a rotating shaft from the outer lower part of the greater trochanter along the axis of the femoral neck (as close as possible to the axis). Two 1.5 mm diameter Kirschner wires were placed at the proximal and the distal end of the expected osteotomy line (the base of the femoral neck) to assist the rotational positioning (Fig. 1E). Femoral neck was truncated (Fig. 1F). The femoral head was rotated to displace the necrotic segment anteriorly (Fig. 1G) and to bring the intact portion of the head to the weight-bearing region. Cannulated screws or dynamic hip screws were used for final fixation (Fig. 1H). The hip joint was reset, and the greater trochanter osteotomy block was reset and fixed.

2.2.4. Postoperative care. After the surgery, all patients followed a strict rehabilitation and training program. Patients were maintained at toe-touch weight bearing with 2 crutches for 12 weeks and then advanced to approximately 50% weight bearing for the second 12 weeks using a cane or crutch in the opposite hand. They began full weight bearing as tolerated 6 months after operation.

2.2.5. Clinical and radiologic follow-up. All patients were clinically and radiographically followed-up at 1 week, 3 months, 6 months, and 12 months after operation. Pre- and postoperative serial Harris hip scores were measured, respectively. The scores were categorized into excellent ($\geq$90 points), good (70–89), and poor (<70). Digital substraction angiography (DSA), serial anteroposterior (AP), frog lateral radiographs, computed tomography scan and magnetic resonance imaging scan if necessary were used for the radiographic follow-up.

2.3. Statistic analysis

The data were analyzed using SPSS version 17.0 statistical software (SPSS Inc, Chicago, IL). Assessment of normality was performed using the Shapiro–Wilk test. Continuous variables were expressed as mean $\pm$ standard deviation if following normal distribution and median (interquartile range) if not. Categorical variables were expressed as number (percentage). T test and paired t test were used for continuous variables, and Chi-squared and Fisher exact tests were used for categorical variables. Two-sided P values of <.05 were considered statistically significant.

3. Results

3.1. Patient characteristics

We retrospectively reviewed a total of 30 patients (33 hips) in this study. Fifteen cases (17 hips) underwent the surgical dislocation and impaction bone graft surgery and 15 cases (16 hips) underwent surgical dislocation and rotational osteotomy. The
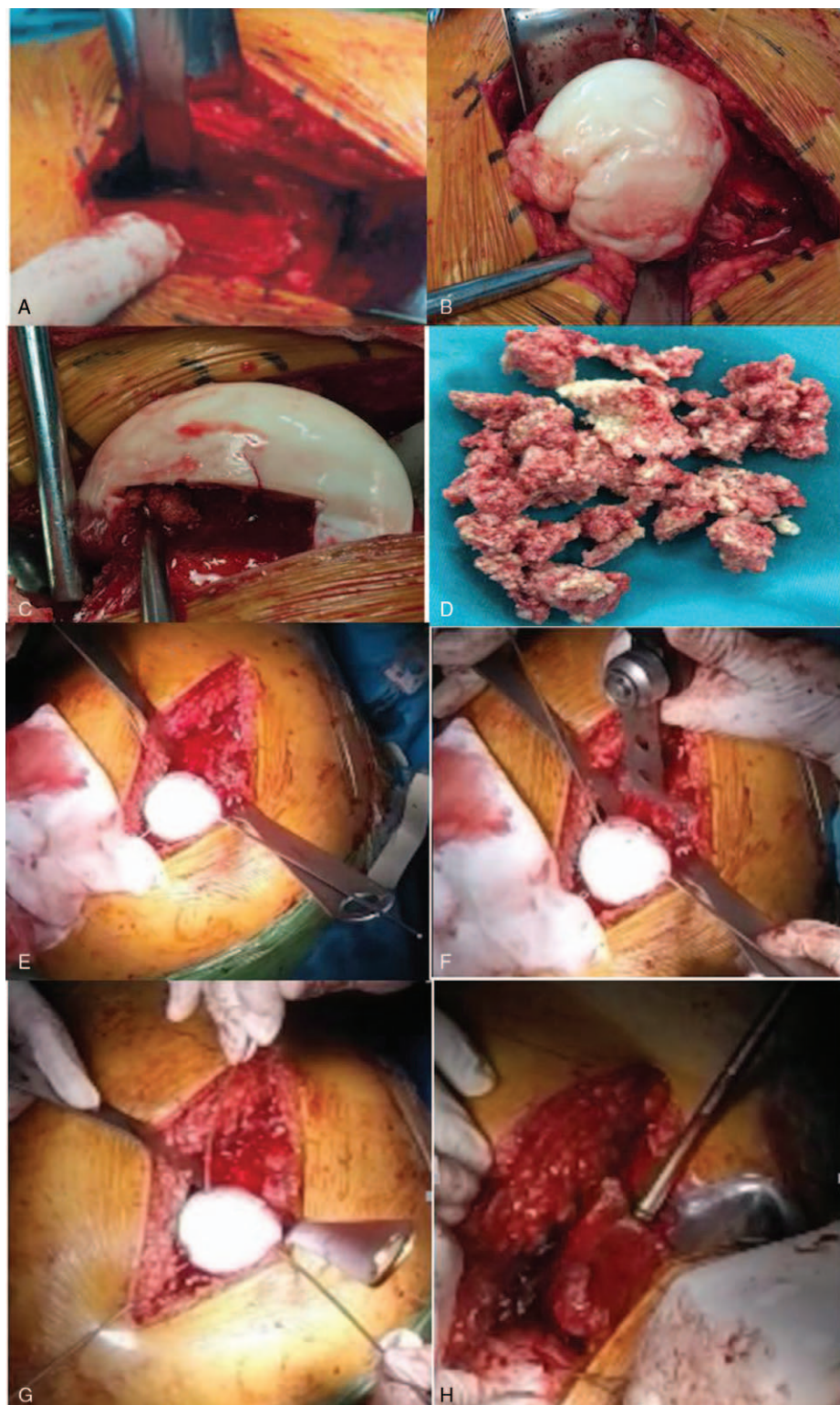
Figure 1. Operations. (A) Surgical dislocation. The intraoperative osteotomy block was pulled forward together with the lateral femoral muscle and the gluteus medius attached thereto to protect the external rotation muscles. (B) Surgically dislocated the hip joint. (C and D) A 32-year-old male ARCO IIIB patient had the compression and bone graft. (C) Completely exposed the femoral head and open a window on the femoral head to clean the debris. (D) The dead bones cleared during the operation. (E–H) A 27-year-old male ARCO IIIC patient had the rorational osteotomy. (E) Positioned and fixed with 3 Kirschener wire. (F) Used the oscillating saw to cut the base of the femoral neck. (G) Rotated the femoral head and neck. (H) Final fixation of the osteotomy block with lag screws.

Table 1

Baseline characteristics of participants.

	Impaction bone graft group (n = 15 patients, 15 hips)	Rotation osteotomy group (n = 15 patients, 16 hips)
Age, yrs	31.9 ± 8.0	31.5 ± 5.4
Male	10 (12 hips)	10 (11 hips)
[0,1-3]Etiology		
Steroids	6 (6 hips)	5 (6 hips)
Alcohol	5 (7 hips)	5 (5 hips)
Traumatic	3 (3 hips)	4 (4 hips)
Unknown	1 (1 hip)	1 (1 hip)
Length of diagnosis, yrs	6.8 ± 3.0	7.7 ± 2.9
[0,1-3]ARCO stage		
IIIA	7 (8 hips)	7 (8 hips)
IIIB	6 (7 hips)	7 (7 hips)
IIIC	2 (2 hips)	1 (1 hip)

Table 2

Operation and follow-up of the patients.

	Impaction bone graft group (n = 17 hips)	Rotational osteotomy group (n = 16 hips)
Operation time per hip, min	138.7 ± 21.9	144.3 ± 20.4
Days of hospitalization	14.6 ± 5.0	14.3 ± 4.4
Harris score		
Preoperation	55.7 ± 5.6	56.9 ± 5.4
6 months postoperation	62.2 ± 7.4[*]	65.9 ± 5.5[*]
12 months postoperation	78.4 ± 8.5[†,‡]	84.8 ± 7.9[†,‡]

[*] $P < .01$ for comparisons between preoperation Harris score and 6 months postoperation Harris scores.

[†] $P < .01$ for comparisons between preoperation and 12 months postoperation Harris scores.

[‡] $P < .01$ for comparisons between 6 months postoperation and 12 months postoperation Harris scores.

mean age (range) was 31.9 (20–43) years in the bone graft group and 31.5 (19–46) years in the rotational osteotomy group (Table 1). No significant differences were observed in age, sex, etiology, ARCO stage, and duration of illness.

3.2. Clinical follow-up

Surgery was successfully performed in all 30 patients. The mean operation time per hip was 138.7 ± 21.9 minutes in the impaction bone graft group, and 144.3 ± 20.4 minutes in the rotational osteotomy group (Table 2). No significant differences in operation time per hip, days of hospitalization were observed.

The mean preoperation Harris score was 55.7 ± 5.6 in the impaction bone graft group, and 56.9 ± 5.4 in the rotational osteotomy group (Fig. 2). Six months after operation, the Harris scores improved significantly in both groups ($P < .01$ for both). Moreover, the Harris score in 12 months after operation were significantly higher than those in preoperation and in 6 months postoperation ($P < .01$ for all). No significant difference in Harris scores were observed between the impaction bone graft group and the rotational osteotomy group. Twelve months after surgery, in the impaction bone grating group, the Harris scores of 3 hips were excellent, 10 hips were good, and 4 hips were poor, with 76.5%

excellent and good rate. While in the rotational osteotomy group, the Harris scores of 5 hips were excellent, 9 hips were good, and 2 hips were poor, with 87.5% excellent and good rate.

3.3. Radiologic evaluation in patients before and after surgery

The DSA was performed before and after operation in every patient, and the blood supply around the femoral head was preserved in each case (Fig. 3).

In both groups, the greater trochanter osteotomy healed well. In the impaction bone graft group, the greater trochanter of 5 hips healed within 3 months after operation, 8 hips healed within 6 months after operation, and 1 hip healed within 12 months after operation. In the rotational osteotomy group, the greater trochanter of 5 hips healed within 3 months after operation, and 6 hips healed within 6 months after operation.

In the rotating osteotomy group, the femoral neck osteotomy was fixed with cannulated screws, and the healing was good within 12 months after operation. No complications such as femoral neck fracture or hip varus occurred during follow-up.

Up to 12 months after operation, 10 patients (12 hips) in the impaction bone graft group had no further collapse of the femoral head based on AP and frog lateral radiographs (Fig. 4). New
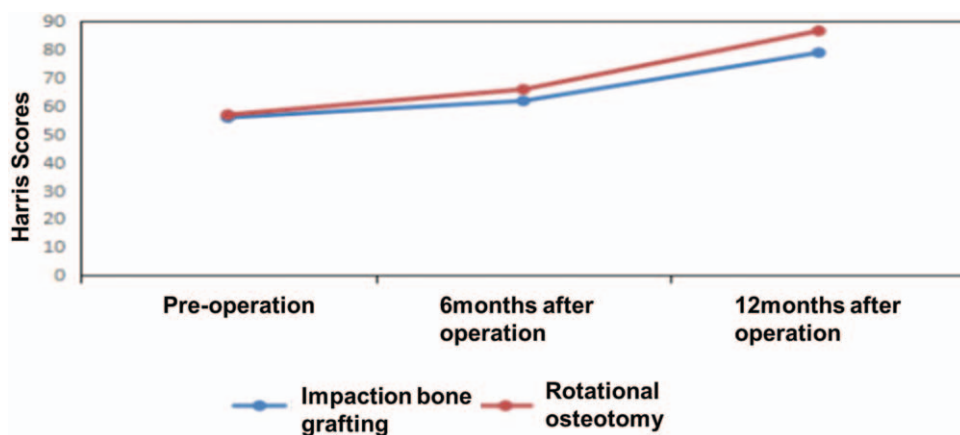
Figure 2. Harris scores before and after operation. Significant improvement in Harris scores were observed in both the impaction bone graft group and the rotational osteotomy group.
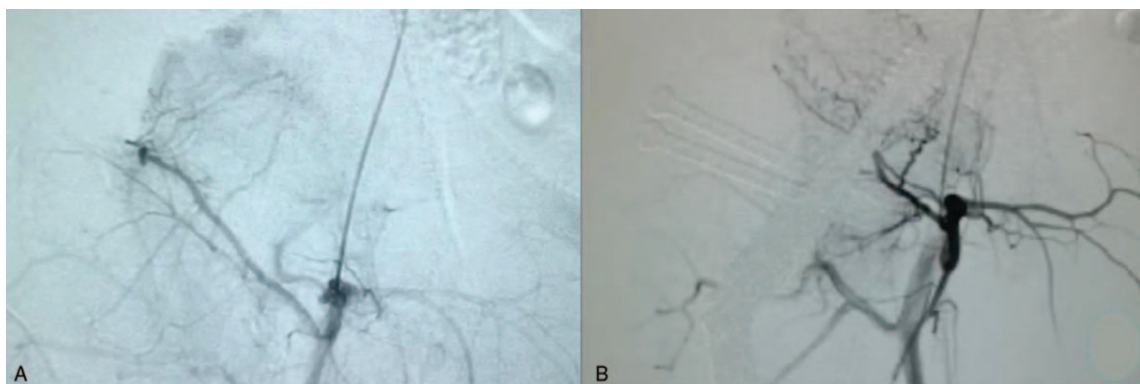
Figure 3. Digital substraction angiography of the femoral head before operation (A) and after operation (B). The blood supply to the femoral head was well preserved.
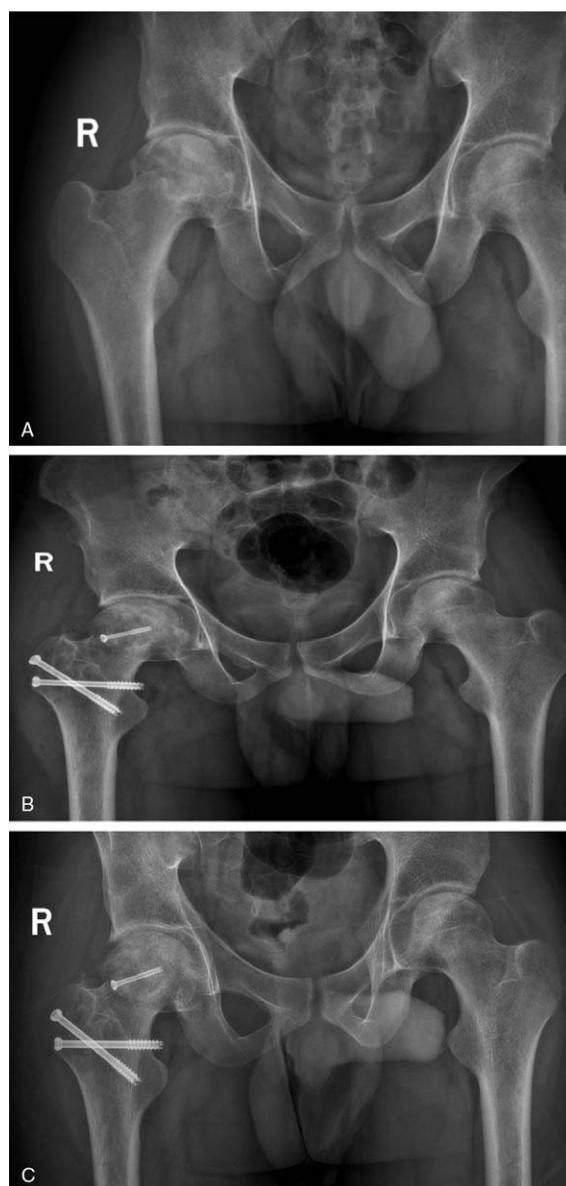
Figure 4. A 30-year-old female, ARCO IIIC stage patient (left osteonecrosis of femoral head) had impaction bone graft surgery. (A) Preoperative, (B) 3 months postoperative, and (C) 12 months postoperative hip anteroposterior radiography showed no further collapse of the femoral head.

collapse was observed in 2 patients (1 in ARCO IIIC stage and another one in ARCO stage IIIB). The ARCO IIIC patient had osteophyte hyperplasia in the collapse area and had joint arthroplasty 12 months after the operation. No stenosis in the joint space, subchondral bone sclerosis, or bone cyst formation were observed in any patients.

In the rotational osteotomy group, no further collapse of the femoral head was observed in any patient (Fig. 5). No stenosis in the joint space, no subchondral bone sclerosis, or bone cyst formation were observed in any case.

4. Discussion

In this study, we observed that for ARCO stage III ONFH patients, both surgical dislocation and impaction bone graft and surgical dislocation and rotational osteotomy performed well within 12 months follow-up, and rotational osteotomy may be slightly better than impaction bone graft surgery.

Currently, core decompression, core decompression with bone graft, core decompression with vascularized bone graft are widely used hip preserving procedures.[6] Hip preserving procedures are often used in precollapse or early postcollapse disease,[14] where the articular surface is intact or has <2 mm of depression of the femoral head.[5] In more advanced stage cases, joint preserving options are less effective than joint arthroplasty. However, there is concern about joint arthroplasty in young ONFH patients whose functional demands are high and there is a high possibility of the need of revision arthroplasty.[15] Hip preserving procedures in young ONFH patients are still a challenge and need further studies.

The technique of safe surgical dislocation was developed by Ganz et al, which is able to preserve the femoral head blood supply and allow direct visualization of the intra-articular lesion.[16] Traditionally, minimally invasive techniques are used in joint-preserving procedures. Concerns of these techniques in treating ONFH are that the surgical field is small, and the necrotic bones may not be cleaned thoroughly, which may limit the use of joint preserving procedures in late-stage ONFH. Surgical dislocation is commonly used in the treatment of femoral acetabular impingement fracture of acetabulm and ONFH.[17] Previously, we showed for grade IIIA-IIIB aseptic necrosis of femoral head patients, surgical dislocation with sequestrum clearance and impacting bone graft could possibly achieve satisfactory clinical benefit, particularly for the young patients.[18] Therefore, in this study, we combined the surgical dislocation with bone graft and rotational osteotomy.
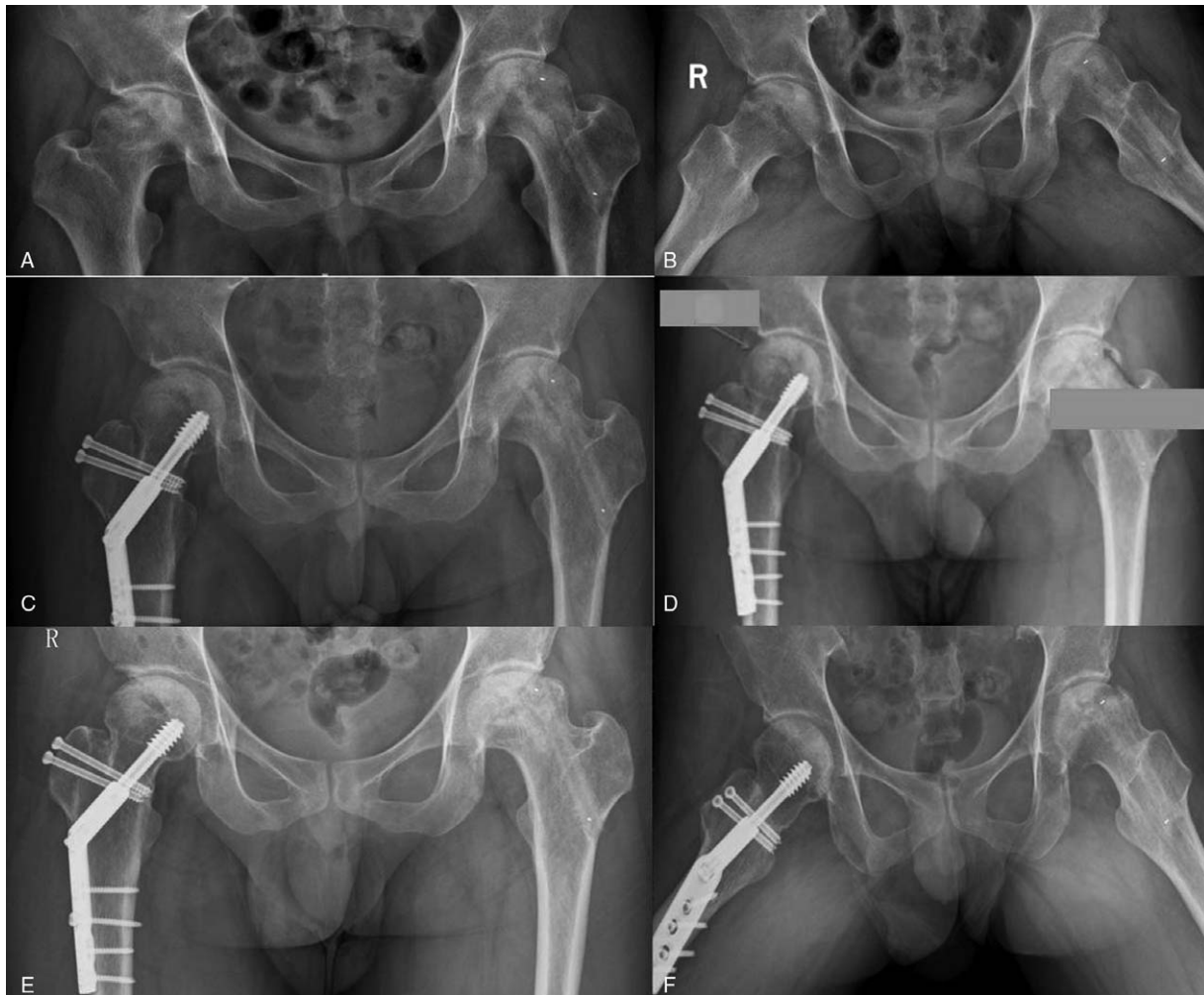
Figure 5. A 27-year-old, male, ARCO IIIC stage patient (right osteonecrosis of femoral head) had rotational osteotomy. The preoperative anteroposterior (AP) (A), frog lateral radiography (B), 3 months postoperation AP (C), 6 months postoperation AP (D), 12 months postoperation AP (E), and frog-lateral (F) radiography showed no further collapse of the femoral head after surgery.

The NVBG has been used for precollapse and early postcollapse lesions.[15] The rational is to achieve necrotic segment decompression and provide structural support to allow healing and subchondral bone remodeling. After treatment with autogenous cancellous grafting through a core track, 44 (56%) of 78 patients had not required total-hip arthroplasty at a mean follow-up of 7 years.[19] Another study using light-bulk technique and allograft with bone morphogenetic protein showed success in 26 (67%) of 39 hips, and with better success in early stage lesions.[15] In our study, in the relatively late-stage patients, 1 hip (8.3%) required hip arthroplasty in 1 year. Though long-term follow-up is still in need, our short-term results supported NVBG is promising in ARCO stage III patients.

Transtrochanteric anterior rotational osteotomy was introduced in 1978.[20] The rational of rotational osteotomy is to rotate the necrotic area of the femoral head to the nonweight-bearing area, thereby avoiding further collapse of the femoral head. The clinical efficacy ranges from 17% to 100%.[21–24] It is generally believed that for patients with a large range of necrosis and obvious collapse, the effect of anterior rotational osteotomy is limited. Atsumi et al proposed posterior rotational osteotomy for the treatment of advanced ONFH with large necrotic area and collapse.[25] Considering that the patients in our study are in the ARCO stage III, intertrochanteric posterior rotational osteotomy was used. Generally, intertrochanteric rotational osteotomy had success rates of 82% to 98% at 6 to 18 years after surgery.[21,26–28] However, rotational osteotomy is associated with a higher rate of complications such as nonunion or delayed union and loss of fixation and/or position.[29] In our study in relatively late-stage ONFH, the 12-month success rate was 100% and no such complications were observed, but longer follow-up is in need.

Several limitations in our study are worth mentioning. First, out study was based on experience from a single center. The generalizability of our results should be tested in other hospitals with different patient population. Second, our study is limited by the small sample size and short follow-up. Though both procedures in our study achieved relatively satisfactory efficacy in short-term, long-term follow-up is needed to determine the usage of these procedures in relatively late-stage ONFH patients.

5. Conclusion

To our knowledge, no direct comparison between surgical dislocation and impaction bone graft and surgical dislocation and rotational osteotomy in relatively late-stage ONFH has been made. In our work, both procedures had promising short-term efficacy, and rotational osteotomy was relatively better than impaction bone graft with a higher success rate. More research involving long-term follow-up and different patient population are needed.

Author contributions

Conceptualization: Tianwei Xia, Jirong Shen.
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Investigation: Tianwei Xia, Le Shi, Chen Yao.
Methodology: Le Shi, Chen Yao.
Writing – original draft: Tianwei Xia, Jirong Shen.
Writing – review & editing: Tianwei Xia, Jirong Shen.

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