Long-term outcomes of eccentric rotational acetabular osteotomy combined with femoral osteotomy for hip dysplasia

Running title: ERAO and ITVO for hip dysplasia

Abstract

Background: This study aimed to investigate the clinical outcomes of eccentric rotational acetabular osteotomy (ERAO) combined with intertrochanteric valgus osteotomy (ITVO) over a period of more than 10 years.

Methods

This is a case-control study of 39 patients (40 hips) who underwent ERAO combined with ITVO for hip dysplasia (ITVO group). Patients were matched for age, sex, follow-up period, and preoperative joint stage to 78 patients (80 hips) who underwent ERAO alone (ERAO group). We compared the clinical and radiographic outcomes and the survival rates between the groups.

Results

The HHS at the final follow-up was significantly lower in the ITVO group than in the ERAO group. The postoperative center edge angle, acetabular head index, and minimum joint space were significantly smaller in the ITVO group than in the ERAO group. The survival rates for the conversion to total hip arthroplasty (THA) endpoint were not significantly different between groups. However, survival rates for the HHS < 80 endpoint were significantly poorer in the ITVO group than in the ERAO group.

Conclusions

The long-term results of ERAO combined with ITVO were not satisfactory from a hip function perspective. ERAO combined with ITVO should be indicated in only young active patients with pre- and initial stages of osteoarthritis.

Keywords: eccentric rotational acetabular osteotomy, intertrochanteric valgus osteotomy, long-term outcomes, hip dysplasia

Introduction

Various types of periacetabular osteotomy (PAO) have been developed for hip dysplasia to prevent the progression of osteoarthritis (OA) [1-5]. We have previously developed a type of PAO, eccentric rotational acetabular osteotomy (ERAO) [6], which is an improved version of rotational acetabular osteotomy (RAO) [4]. Favorable long-term outcomes for RAO and ERAO have been reported [7-9]. However, there has been no unified consensus on the best treatment for dysplasia patients with a nonspherical femoral head and poor joint congruity. Several reports have recommended additional femoral osteotomy [10, 11] because the outcome of PAO alone for poor congruity has been considered to be unacceptable [11, 12].

We performed intertrochanteric valgus osteotomy (ITVO) combined with ERAO for cases with femoral head deformity where joint congruity did not improve in maximum hip abduction. Reports describing the clinical outcomes of PAO with femoral osteotomy for dysplasia with femoral head deformity are scarce. In our previous studies, the outcome of ERAO combined with ITVO was not necessarily good [7]. The long-term outcomes of PAO combined with femoral osteotomy are still unclear, although a small number of cases have been reported to be good [10, 13].

In the current study, we used a case-control design to compare ERAO combined with ITVO and ERAO alone. The groups were matched according to preoperative condition, and long-term clinical and radiographic outcomes over a period of more than 10 years were compared.

Patients and Methods

Our retrospective chart review was approved by our institutional ethics review board, and all patients provided written informed consent for their data to be used. The study included 43 consecutive patients (44 hips) who underwent ERAO combined with

ITVO for hip dysplasia between January 1989 and December 2008. From this initial group, one patient (1 hip), who could not be followed-up for at least ten years, was excluded from the study. The control group was also formed using the hospital records of 547 cases of ERAO without femoral osteotomy performed during the same period. The control group was then matched by age (± 5 years), sex, follow-up period (± 2 years), and preoperative joint stage to patients in the study group. We were unable to identify a matching patient who underwent ERAO only for 3 patients (3 hips) in the study group. The final study (ITVO) group included 39 patients (40 hips) who underwent ERAO combined with ITVO; the control (ERAO) group consisted of 78 patients (80 hips) who underwent ERAO alone.

The study included 39 females with a mean age of 41.6 years (range: 15–59 years) at the time of surgery for the ITVO group, and 78 females with a mean age of 42.3 years (range: 18–59 years) at the time of surgery for the ERAO group. The patients were followed for mean durations of 16.9 years (range: 10–27 years) for the ITVO group and 16.4 years (range: 10–27 years) for the ERAO group. When considering past medical history, 20 patients in the ITVO group had received previous treatments for dysplasia in childhood. Closed reduction was performed for six joints, open reduction for six joints, and femoral or pelvic osteotomy for six joints. Both open reduction and femoral osteotomy were performed for two patients. Preoperatively, two joints were in the pre-OA stage, five were in initial OA, 29 were in advanced OA, and four were in terminal OA according to the Japanese Orthopedic Association's system of stage classification for arthritis [14]. There were no significant differences between groups in terms of sex, age at surgery, height, weight, follow-up period, or the preoperative stage of arthritis (Table 1).

ERAO was indicated first in patients with hip pain who continued with conservative treatment but no improvement was observed; second, in patients who demonstrated improved joint congruity in maximum hip abduction; third, in patients aged 15 to 50 years; and fourth, in patients with pre- and initial OA (partially advanced; MJS > 2.0 mm) joint stages. ERAO combined with ITVO was indicated in patients with femoral head deformity where joint congruity was fair or poor in maximum hip abduction according to Yasunaga et al. [12]

The surgery was performed by a single senior surgeon. Following the protocol for Sugioka's valgus osteotomy [15], the osteotomy was performed with a 20–30° correction according to the degree of rotation of the acetabular fragment after resection of the greater trochanter. We planned an isosceles triangle with the lesser trochanter as the vertex and the osteotomy face of the greater trochanter as the base. The triangle of the bone was extracted and fixed with two screws or a compression hip screw after valgus displacement of the proximal bone fragment. After the femoral osteotomy was completed, the acetabular osteotomy was performed. During surgery, the osteotomy of the ilium was started from a position $\geq$ 1.5 cm away from the joint whilst checking the image. The osteotomy was extended using a circular shape from the ilium to the ischium. When osteotomy of the pubic bones was performed, the acetabular bone fragments became free to move. The acetabular bone fragment was rotated whilst using X-rays to confirm that the acetabular roof obliquity was horizontal. The acetabular bone fragment was then fixed using three or four absorption screws. The osteotomy was completed after the greater trochanter fragment had been fixed with a soft wire. The wire was passed through two holes of the greater trochanter and through the hole in the distal femoral fragment. Thereafter, both ends of the wire were passed twice through the distal femoral fragment side and then tightened over the greater trochanter. Regarding postoperative rehabilitation, range of motion (ROM) exercises were permitted immediately after surgery. Walking with partial and full weight bearing was permitted at one month and three months after surgery, respectively.

Clinical evaluations

The medical records of patients who underwent osteotomy were reviewed, and operative time, intraoperative blood loss, and postoperative complications such as infection, pseudarthrosis, nerve palsy, and ectopic ossification were investigated. In addition, we investigated hip function using the Harris Hip Score (HHS) and ROM before surgery and at the final follow-up. A single senior surgeon who performed the surgeries assessed the HHS and ROM annually. The cases that converted to total hip arthroplasty (THA) during the follow-up period were excluded from the final follow-up results.

Radiographic evaluations

A radiographic evaluation was performed using an anteroposterior (AP) hip joint image centered on the pubic symphysis in the supine position. The center-edge (CE) angle, acetabular head index (AHI), and minimum joint space (MJS) were measured using the AP image of the hip joint after the operation and at the final follow-up. Image measurements were performed three times by two physicians, and the median value was used. To assess the reliability of these measurements, 30 hips were randomly selected and assessed by the two surgeons. The inter-rater reliabilities of the CE angle, AHI, and MJS were 0.822, 0.804, and 0.784, respectively.

Statistical Analysis

Statistical analyses of the osteotomy and control groups were performed using SPSS, version 21 (IBM Corp., Armonk, NY, USA). Between-group differences were evaluated using the Student’s t-test and Fisher's exact test, as appropriate for the data distribution. Survival rates were examined using the Kaplan–Meier method, with THA conversion and an HHS < 80 as the endpoints. The groups were compared using a log-rank analysis. P-values less than 0.05 were considered statistically significant. In addition, for the subgroup analysis, the survival rate was evaluated for the cases in each group using an age at surgery of ≤ 40 years and a preoperative MJS < 2.0 mm as endpoints.

Results

Operative time was significantly longer in the ITVO group (163.8 ± 39.5 minutes) compared to the ERAO group (125.9 ± 27.7 minutes, p < 0.01). Intraoperative blood loss was significantly higher in the ITVO group (463 ± 192 g) compared to the ERAO group (353 ± 162 g, p < 0.01). The preoperative HHS was slightly lower in the ITVO group (65.2 ± 8.0) compared to the ERAO group (68.6 ± 6.3), but this was not significantly different. However, the HHS at the final follow-up was significantly different between the ITVO group (79.8 ± 13.3) and the ERAO group (85.5 ± 12.8, $p < 0.01$). Preoperative flexion, abduction, and internal rotation ROM were significantly poorer in the ITVO group compared to the ERAO group. Moreover, flexion, extension, and internal rotation ROM were significantly lower in the ITVO group compared to the ERAO group at the final follow-up (Table 2). Complications occurred in five cases in the ITVO group (greater trochanter pseudoarthrosis: n = 3; ectopic ossification: n = 2), and in three cases in the ERAO group (ectopic ossification: n = 2, nerve palsy: n = 1).

The preoperative CE angle and AHI were significantly smaller in the ITVO group (-5.7 ± 10.7º and 46.7 ± 6.2%, respectively) compared to the ERAO group (4.1 ± 8.6º and 52.7 ± 8.0%, respectively; $p < 0.01$ for both the CE angle and AHI). Moreover, the postoperative CE angle and AHI were significantly smaller in the ITVO group (30.6 ± 10.2º and 86.7 ± 12.1%, respectively) compared to the ERAO group (36.9 ± 8.1º and 95.4 ± 6.4%, respectively; $p < 0.01$ for the CE angle and AHI). The preoperative MJS was not significantly different between the groups. However, the postoperative MJS was significantly smaller in the ITVO group (1.7 ± 1.1 mm) compared to the ERAO group (2.2 ± 1.3 mm; $p < 0.01$; Table 3).

A conversion to THA was performed for 14 cases in the ITVO group and 20 cases in the ERAO group. The 10- and 20-year survival rates, using the conversion to

THA as the endpoint, were 90.0% and 80.1%, respectively, in the ITVO group and 91.0% and 70.3%, respectively, in the ERAO group ($p = 0.726$, Figure 1a). The 10- and 20-year survival rates, using an HHS < 80 as the endpoint, were 59.0% and 45.6%, respectively, in the ITVO group and 84.9% and 75.4%, respectively, in the ERAO group ($p < 0.01$, Figure 1b). For the sub-analysis of patients under 40 years of age at the time of surgery, the 10- and 20-year survival rates using an HHS < 80 as the endpoint, were lower in the ITVO group (n = 22; 61.9% and 51.6%, respectively) than in the ERAO group (n = 47; 82.8% and 77.6%, respectively; $p = 0.052$; Figure 1c). However, this difference was not significant. The 10- and 20-year survival rates for the HHS < 80 endpoint with a preoperative MJS wider than 2.0 mm were not significantly different between the ITVO group (n = 15; 85.6% and 76.0%, respectively) and the ERAO group (n = 32; 94.2 % and 89.2 %, respectively; $p = 0.225$; Figure 1d).

Discussion

Several reports have demonstrated favorable long-term outcomes of acetabular osteotomy for adult hip dysplasia [3,5,7-9, 13]. However, few reports have described the clinical outcomes of PAO combined with femoral osteotomy. Clohisy et al. reported that PAO combined with intertrochanteric osteotomy (ITO) was preferable for patients with femoral head deformity when examining short-term outcomes (mean follow-up: 4.5 years) in 13 cases [10]. Steppacher et al. reported that PAO combined with ITO did not increase the risk when long-term outcomes were evaluated in 16 cases [13]. In our previous report, the ERAO combined with ITVO 20-year survival rates, with conversion to THA as the endpoint (23 cases), were significantly poorer than those of ERAO alone (107 cases) [9]. However, in this study, it was not possible to directly compare the ERAO combined with ITVO and the ERAO alone groups, because the preoperative patient conditions were different. Furthermore, in the current study, the 20-year survival rate at the THA endpoint was 80.1% for ERAO combined with ITVO, demonstrating that this procedure may have had an effect on joint preservation. However, the survival rates for the HHS < 80 endpoint were poorer in the ERAO combined with ITVO group (45.6%) compared to the ERAO alone group (75.4%) at the 20-year follow-up.

Regarding hip joint function, several factors were considered to contribute to the poor outcomes in the ITVO group. The preoperative joint condition of many of the patients was classified as advanced OA. Several previous reports demonstrated that the clinical outcomes of PAO for advanced OA were poor [7, 9]. Conversely, our previous report demonstrated that the long-term outcomes of ERAO were preferable if the preoperative joint space was wider than 2.0 mm [16, 17]. The present study revealed that the survival rates for patients with preoperative MJS measurements of over 2.0 mm—using an HHS of < 80 as the endpoint—were similar following ERAO, regardless of whether the procedure was performed with or without ITVO. Therefore, surgical treatment should be considered before OA. Since the ITVO group exhibited femoral head deformities, the preoperative ROM was poor [10]. In addition, since the surgical invasion was greater when ERAO was combined with ITVO, compared to ERAO alone, soft tissue contracture may affect the postoperative ROM. As a result, poor ROM was thought to have influenced the final clinical outcomes.

The preoperative and final radiographic parameters demonstrated that the coverage of the femoral head with ERAO combined with ITVO was poor compared to ERAO alone. Regarding the postoperative CE angle, previous reports have demonstrated that the CE angle should be between 22º and 40º [18-20]. In the present study, the postoperative CE angle was significantly smaller when ERAO was combined with ITVO, compared to when ERAO was performed alone. The surgical technique of combining ERAO with ITVO makes it difficult to cover the femoral head sufficiently because the femoral head moves laterally as a result of the ITVO. It seems possible that insufficient acetabular coverage of the femoral head before and after surgery could affect the long-term results.

In the current study, 14 joints (32%) were converted to THA. There is no unified consensus on whether previous PAO affects the clinical outcomes of a subsequent THA [21-25]. When considering the surgical technique, previous reports have demonstrated that a THA after PAO is difficult to compare to a primary THA because of acetabular defects associated with rotating the acetabular bone fragment [26]. Our previous report demonstrated that the clinical outcomes of a THA after PAO combined with ITVO were extremely poor [27]. Therefore, it should also be noted that ERAO combined with ITVO may affect subsequent THA.

This study had several limitations. First, this was a retrospective study, and the number of cases (40 hips) was small. Second, many of the cases in the current study had advanced or terminal OA, and therefore the long-term results for pre- or initial OA were not investigated. In addition, there were few cases in patients $<$ 30 years of age; therefore, these findings cannot be applied to young people. Third, the preoperative ROM and radiographic parameters were poorer in the ITVO group than in the ERAO group. Therefore, the preoperative patient characteristics were different between the groups.

In the current study, the long-term results of ERAO combined with ITVO were not necessarily good. However, the survival rate, with a conversion to THA as the endpoint, was not significantly different between ERAO combined with ITVO and ERAO alone. Traditionally, the indication for osteotomy has been broad because of the large number of patients with hip dysplasia in Japan [28], and osteotomy was performed at advanced and terminal stages if the patients wanted to undergo joint preservation surgery because the long-term results of THA were not yet established at that time [29]; when THA is indicated for young people, multiple replacements may be required in the future [30]. Therefore, we considered that ERAO combined with ITVO was effective from the viewpoint of joint preservation. In principle, we consider osteotomy to be the first choice in patients under the age of 40 years with hip dysplasia. However, the long-term survival rate with the HHS < 80 endpoint was poor for ERAO combined with ITVO, even in cases ≤ 40 years of age. In addition, failed PAO combined with ITVO has been demonstrated to affect subsequent THA [27]. On the basis of the above results, we believe that ERAO combined with ITVO is indicated in only young active patients with pre- and initial OA (Figure 2a-d), and indications for advanced and terminal OA should be avoided (Figure 3a-d).

In conclusion, there was no significant difference in the long-term survival rate with the conversion to THA endpoint when ERAO in combination with ITVO was compared to ERAO alone after matching the groups for age, sex, follow-up period, and preoperative joint stage. However, the HHS at the final follow-up was significantly poorer in the ERAO with ITVO compared to the ERAO alone; and the survival rate with the HHS < 80 endpoint was significantly worse.

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