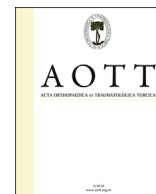




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Mid-term radiological and clinical results of incomplete triple pelvic osteotomy

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ABSTRACT

Objective: The aim of this study was to assess clinical and radiological results of incomplete triple pelvic osteotomy in acetabular dysplasia.**Patients and methods:** Twenty-six hips of 24 patients (5 males, 19 females) treated with incomplete triple pelvic osteotomy by a single surgeon from February 1995 to October 2001 were retrospectively reviewed at an average follow-up time of 12 years. The mean age at the time of surgery was 21.6 years (range: 14–41). Radiological evaluation was based on the central edge angle, acetabular angle, acetabular index, acetabular head index and lateralisation. Clinical and radiological scoring was performed using the Harris scoring system, Ömeroğlu scoring system and the Tönnis criteria for osteoarthritis.**Results:** There was significant improvements in all of the radiological parameters with 88.5% good radiological results, 96.2% excellent clinical results, no significant progression to osteoarthritis and no need for conversion to total hip arthroplasty. The rate of major complication was 11%. Retroversion was seen in 15.4% of the hips.**Conclusion:** Our results support the use of incomplete triple pelvic osteotomy as a safe choice in the treatment of acetabular dysplasia as it offers clinical and radiological benefits and contributes to the prevention of osteoarthritis.**Level of evidence:** Level IV, therapeutic study.© 2016 Turkish Association of Orthopaedics and Traumatology. Publishing services by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Introduction

Acetabular dysplasia, when untreated, results in pain, symptomatic disease and, in the long term, secondary osteoarthritis.^{1,2} Single, double and triple pelvic osteotomies and polygonal peri-acetabular and rotational acetabular osteotomies (RAO) are currently used in the treatment of acetabular dysplasia.^{3–6} The long-term results of these procedures with respect to the progression of osteoarthritis (OA) and patient satisfaction are of interest to

surgeons. Thus, the aim of this study was to assess the 12-year experience with incomplete triple osteotomy based on patients whose short-term results were published previously and to analyse those mid-term results with others reported in the literature.

Materials and methods

Twenty-six hips of 24 consecutive patients with hip dysplasia treated with incomplete triple pelvic osteotomy were evaluated for long-term results. The characteristics of these patients were published previously.¹ The mean follow-up was 12 years, the mean age at operation was 21.6 years (range: 14–41 years) and 19 (78%) of the patients were female. The right side was affected in 13 patients, the left side in 9 and both sides in 2. Patients with dysplasia due to

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neuromuscular and teratological conditions were excluded. Seven (26.9%) hip joints had undergone previous surgery because of developmental dysplasia of the hip (Table 1). The remaining 19 hips had not been treated previously. The major complaint of patients prior to the operation was pain of at least 6 months duration. The decision to perform a redirection osteotomy was made if the congruency and containment of the hip were considered to be acceptable as determined on an anteroposterior (AP) pelvic radiograph with the proximal femur abducted and internally rotated. Poor congruency, an open triradiate cartilage, complete dislocation of the hip and advanced OA were contraindications to the procedure.

Hip dysplasia was radiologically evaluated by one author (EE) from a standard (AP) pelvic radiograph using the lateral central edge angle (CEA) of Wiberg,⁷ the acetabular angle (AA) described by Sharp⁸ for the acetabular slope in the frontal plane, the acetabular index described by Tönnis⁹ for the obliquity of the acetabular roof and the acetabular head index¹⁰ for the percentage of femoral-head coverage. Lateralisation of the femoral head was evaluated by measuring the distance between its medial edge and the ilioischial line. Indication for the surgery by the means of radiological measurements were; CEA of Wiberg lesser than 20°, acetabular angle of Sharp greater than 40°, acetabular index greater than 15° and the acetabular head index smaller than 70%.

To assess the radiographic results in a standard manner, we used the Ömeroğlu scoring system,¹¹ which evaluates CEA, AA and the centrotrochanteric distance (CTD) according to a 6-point scale and rates radiographic improvement as poor, fair minus, fair plus, good or excellent.

The clinical evaluation included scoring of the overall result and the pain level, functionality (walking and daily activities), deformity and range of motion according to the Harris hip score.¹² FADIR (flexion, adduction, internal rotation) test was used to screen for Femoroacetabular impingement (FAI). The radiological grading of OA was done on standard AP radiographs of the pelvis according to the criteria of Tönnis.⁹

The surgery was performed by same surgeon (A.E.) in all patients using a technique described in a previous publication.¹ The mean operation time was 2 h (range: 1.5–2.5 h). On average, less than one unit of red blood cells was required to compensate for post-operative blood loss. The mean follow-up period for the 26 hips was 12 years (range: 9.1–15.9 years).

The NCSS 2007 package programme was used for statistical analyses. Student's *t*-test was used to evaluate the preoperative and postoperative radiological parameters and McNemar's test to evaluate the significance of the differences between the preoperative values and the clinical and radiological scores determined at the last follow-up. $p < 0.05$ was considered to indicate statistical significance.

Results

Radiographic results

The CEA, AA, acetabular index angle and acetabular head index differed significantly between the preoperative and last follow-up

(Figs. 1a, b and 2a). There was no significant change considering the lateralisation of the femoral head between preoperative and last follow-up evaluations (Table 2).

The Ömeroğlu scores changed significantly between the preoperative and last follow-up evaluations, from 2.32 (0–4) points to 5.62 (4–6) points ($p = 0.0001$). Good or excellent results were determined for 23 (88.46%) of the 26 hips at the time of the last follow-up (Table 3).

The hip joint was preserved in all of the hips that were followed for an average of 12 years. None of the hip joints were later revised to either total hip arthroplasty (THA) or hip fusion.

Clinical results

The Harris scores of the 26 hip joints changed significantly between the preoperative and last follow-up evaluations, from 74.9 points (range: 53–86) to 94.85 points (range: 77–100) ($p = 0.0001$). At the last follow-up, 25 (96.2%) hip joints were graded as excellent and one (3.8%) was graded as good (Table 4).

Osteoarthritis

There was no significant change in the Tönnis classification between the preoperative and last follow-up evaluations ($p = 0.368$) (Figs. 2 and 3). Preoperatively, 15 (57.7%) of the 26 hips had grade 0 or 1 (Table 5). At the last follow-up, 4 hip joints (15.4%) had no signs of osteoarthritis, 10 hip joints (38.5%) had grade 1 and 14 (53.8%) had grade 0 or 1. Degenerative signs had progressed in three hips (11.5%), including one with progression from grade 0 to grade 2, one with progression from grade 1 to grade 2 and one with progression from grade 2 to grade 3. One hip improved radiologically from grade 1 to grade 0.

Retroversion

Radiographic studies performed during the last follow-up showed the crossover sign in four hip joints (15.4%). These patients had no restriction in the range of motion. After a mean 12 years of follow-up, none of the hip joints showed signs of progression to OA (Fig. 3).

Femoroacetabular impingement

There were no sign of femoroacetabular impingement (FAI) in any patient including four hips that had crossover sign, as determined at the physical examination during the last follow-up.

Abductor mechanism

In an incomplete triple pelvic osteotomy, the tensor fascia lata and gluteus medius are sharply dissected from the lateral side of the ilium to the gluteal tubercle. After the osteotomy and correction, they are sutured back to the insertion site. Although the abductors had been dissected off the lateral side of the ilium, abductor weakness or Trendelenburg gait was not seen in any of the patients at the last follow-up.

Complications

There were three major complications in this group. A deep-wound infection developed in one patient 3 months post-operatively. It resolved after surgical drainage and appropriate antibiotics. An intra-operative intra-articular fracture and asymptomatic non-union of the ischial osteotomy occurred in one patient. Numbness in the distribution of the lateral femoral cutaneous

Table 1
Previous operations.

Previous operation	Number of hip joints
Closed reduction	6
Pelvic + femoral osteotomy	1
No intervention	19

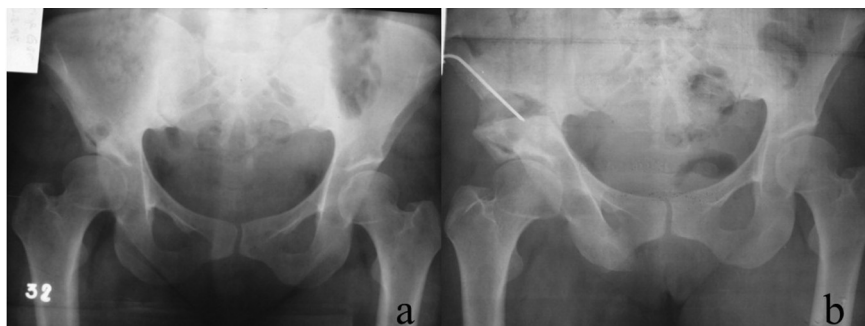


Fig. 1. Anteroposterior pelvic radiographs of a female with unilateral residual hip dysplasia. a) Preoperative and b) early postoperative radiographs. The patient was 47 years old at the time of the operation. After operation, both the lateral centre-edge (from 20° to 40°) and acetabular angles (from 38° to 22°) have improved significantly.

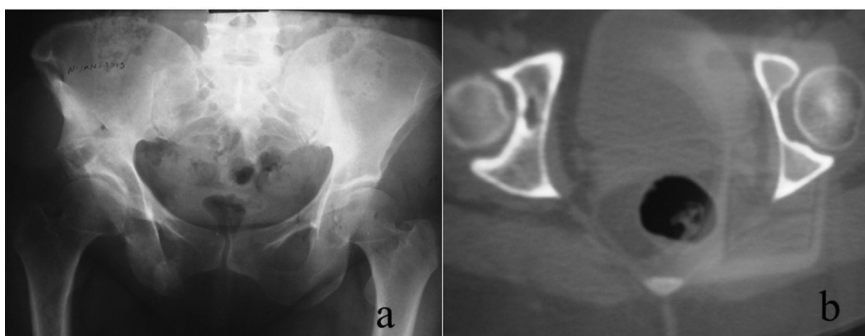


Fig. 2. Anteroposterior pelvic radiograph and axial computed tomography section of the same patient as in Fig. 1 after 11.2 years of follow-up. a) There is no osteoarthritic progression. b) Version of the acetabulum of the right hip is within the normal range.

Table 2

Radiographic parameters on preoperative and last follow-up radiographs in 26 hips.

Parameter	Preoperative	Last follow-up	Improvement	p value
Lateral centre-edge angle (mean)	7.35° (–8–18)	27.73° (21–37)	20.38°	p = 0.0001
Acetabular angle (mean)	48.19° (42–60)	37.35° (25–45)	10.84°	p = 0.0001
Acetabular index (mean)	25.27° (17–35)	8.69° (5–12)	16.58°	p = 0.0001
Acetabular head index (mean)	59.18% (28.2–68.1)	85.1% (63.88–100)	25.92%	p = 0.0001
Lateralisation (mean)	16.27 mm (10–29)	16.23 mm (8–25)	0.04 mm	p = 0.993

Table 3

Preoperative and last follow-up Ömeroglu scores.

Grade	Preoperative n (%)	Last follow-up n (%)
Poor (<3 points)	17 (65.4)	
Fair minus (3 points)	8 (30.8)	
Fair plus (4 points)	1 (9.8)	3 (11.5)
Good (5 points)		4 (15.4)
Excellent (6 points)		19 (73.1)

Table 4

Preoperative and last follow-up Harris scores.

Grade	Preoperative n (%)	Last follow-up n (%)
Fair (41–60 points)	2 (7.7)	
Good (61–70 points)	5 (19.2)	1 (3.8)
Very good (71–85 points)	18 (69.2)	
Excellent (86–100 points)	1 (3.8)	25 (96.2)

nerve was noted previously by 11 patients but they had no complaints at the last follow-up. There were no occurrences of FAI, posterior subluxation of the femoral head, major blood vessel damage, femoral palsy or heterotopic ossification.

Discussion

The literature contains several reports on the results of osteotomies frequently used in the treatment of acetabular dysplasia, including one report on the results of a Tönnis osteotomy, with a follow-up of 10 years,¹³ two reports on the results of Ganz osteotomy, with follow-ups of 20.4¹⁴ and 11.3 years¹⁵ and two reports on RAO, with follow-up periods of 10.5¹⁶ and 11.4 years.¹⁷ Following the introduction of incomplete triple pelvic osteotomy, the major concern was the long-term results. However, our study on the long-term results of incomplete triple pelvic osteotomy adds to those reporting on a follow-up period of more than 10 years. Together, they confirm the success of osteotomy procedures. In our patients good radiological results were achieved in 88.5%, with no significant progression to OA and no need for conversion to THA in any of the patients.

The Ömeroglu scoring system is used in the evaluation of radiological results.¹¹ In the classification of hip dysplasia, the Severin scoring system is the gold standard. However, the intra-observer reliability is poor for the Severin system because it makes use of subjective criteria which are prone to bias, such as mild deformity, mild dysplasia, subluxation and the continuity of the Shenton line. Furthermore, while the Severin system provides

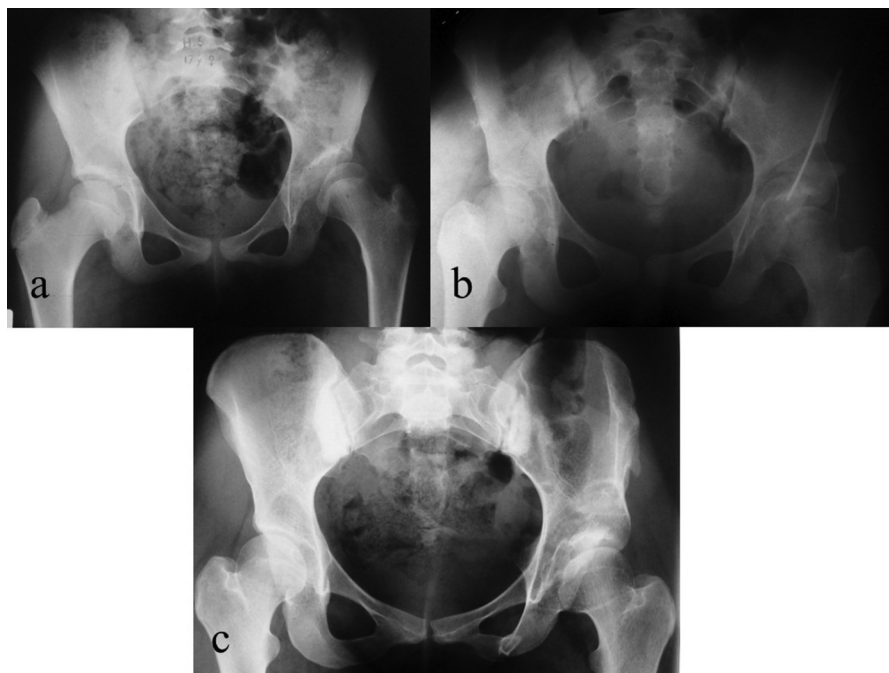


Fig. 3. Anteroposterior pelvic radiograph of a female with left acetabular dysplasia. a) Preoperative radiograph: the patient was 17 years old at the time of the operation. b) Early postoperative radiograph: the cranial acetabulum has retroverted (crossover at the cranial part of the acetabulum) postoperatively. c) Last follow-up radiographs: after 15.7 years of follow-up, there is no progression to osteoarthritis.

Table 5
Preoperative and last follow-up Tönnis scores.

Grade	Preoperative n (%)	Last follow-up n (%)
Grade 0	3 (11.5)	4 (15.4)
Grade 1	12 (46.2)	10 (38.5)
Grade 2	11 (42.3)	11 (42.3)
Grade 3		1 (3.8)

information about the final radiological status it does not evaluate treatment success. The Ömeroglu system employs objective criteria (CEA, AA and CTD), resulting in low intraobserver and interobserver variability.¹¹ In this study, we used the Ömeroglu system. The results showed that following incomplete triple osteotomy, good radiological results were obtained in 88.5% of the hips that were rated as poor preoperatively. The radiological results of hips treated by Ganz osteotomy,^{14,15} RAO^{16,17} and Tönnis osteotomy¹³ were expressed as angular improvements such that our radiological success rates cannot be compared with the rates obtained using those procedures. However, when the clinical results of patients who did not undergo revision THA were evaluated, 73% and 60.4% of the patients treated with Ganz (according to Merle d'Aubigné and Postel) and Tönnis (according to Merle d'Aubigné and Postel) osteotomies, respectively, had good results. To compare the long- and short-term clinical results,¹ we used the Harris hip score,¹² which showed a significant improvement between the preoperative and last follow-up scores (74.9 and 94.85 respectively). No clinical worsening was detected in any of the patients. There was no significant difference between the mean 3.3-year¹ and 12-year follow-up results (93.0 and 94.85 respectively). Since the aetiology of the acetabular dysplasia was developmental hip dysplasia, our results are based on a homogeneous group and are not influenced by factors independent of the osteotomy itself, since patients with confounding factors such as neuromuscular diseases were excluded from the study. However, in this retrospective analysis,

the different scoring systems used in the included studies and the variability of the preoperative clinical status of the patients rendered comparisons with other case series difficult.

According to Siebenrock et al,¹⁵ the rate of OA progression in hips that are not revised to THA is 25%, whereas Kleuver et al¹³ reported a 33.3% rate of OA progression after Tönnis osteotomy. By contrast, in our series the rate was 11.5%, demonstrating the better results obtained in our patients. Tsumura et al¹⁸ used computed-tomography-guided simulation software to evaluate the maximum pressure values at different rotation angles compared to the preoperative values. The largest decrease in maximum pressure occurred at a lateral rotation of 15–20° and an anterior rotation of 15–25°; the decrease in maximum pressure was as high as 40% at optimal rotation. The authors concluded that inadequate or over correction has a negative effect on the decrease in hip pressure. Based on the long-term follow-up in the studies included in our analysis, the improvement in the CEA was 28° in patients who underwent Ganz osteotomy,¹⁵ 34.3° in those treated with RAO¹⁶ and 19° following Tönnis osteotomy.¹³ An improvement of 20.38° in the CEA after incomplete osteotomy is defined as optimal and is thought to play a major role in avoiding OA progression or worsening.

The reason for treating acetabular dysplasia is to prevent OA. Indeed, according to the literature, after osteotomy few patients need THA. In our study, based on a follow-up of 12 years, none of the patients needed THA. Thus, the success rate of incomplete triple pelvic osteotomy was 100%. In the series of Siebenrock et al,¹⁵ 11 patients needed THA, corresponding to a success rate of 84.5%; Kleuver et al¹³ reported success rate of 94.1% (3 hips needed THA) while in the series of Nozowa et al¹⁷ the rate was 98% (1 patient needed THA).

Another controversial issue in the literature is the postoperative development of retroversion. In our series, this occurred in four (15.4%) of the hips; however, there were no poor radiological or clinical results. A decrease in the range of motion or FAI was not

observed in any of the hips. Rather, the detected crossovers were located proximally, indicative of cranial retroversion (Fig. 1). Siebenrock et al.¹⁹ reported FAI in 29% of the patients and Steppacher and Ziebarth et al.^{14,20} in 46% of the patients after Ganz osteotomy. FAI that develops after over coverage adversely affects outcome after acetabular osteotomy.²¹ In our opinion, retroversion that leads to symptomatic FAI is due to central or complete acetabular retroversion.²²

Labrum tears promoting hip pain in acetabular dysplasia is a well known issue and recent studies suggests that repair or debridement of these tears improves survival after periacetabular osteotomy.^{15,21} However, preoperative MRI images weren't obtained to screen for possible labrum tears and any concomitant surgery wasn't performed in our series. Thus it is impossible to make any certain comment about effects of labral tears after incomplete triple pelvic osteotomy. But we believe that proper acetabular reorientation alleviates symptoms caused by labrum tears by equalizing the load distribution on femoral head.

The rate of major complications in this series was 11%, compared to 23.9% in the series of Ganz osteotomy patients reported on by Siebenrock et al.¹⁵ 33.3% in the series of Tönnis osteotomy patients described by Kleuver et al.,¹³ 10% in the series of RAO patients of Hasegawa et al.¹⁶ and 10% in another series of RAO patients reported on by Nozawa et al.¹⁷ Our patient with deep infection required a secondary intervention; progression to OA corresponding to 2 grades was subsequently noted. Although the patient with an intra-articular fracture did not require a secondary intervention, the fracture prevented an improvement in the postoperative score. Based on our experience with this patient, in iliac osteotomies we now use a saw blade initially and then continue by using an osteotome. Since adopting this technique, there have been no further intra-articular fractures. Ischial non-union is a complication that does not necessitate intervention or aggravate the results. In a supra-retroacetabular osteotomy, we expose the outer aspect of the ilium. Elevation of the insertion of the abductor musculature can lead to a prolonged recovery period for these muscles. However, our data on the duration of post-operative abductor limping were insufficient to allow any conclusions to be drawn. However, at the previous 3.3 years of follow-up and at the last follow-up none of the patients had a Trendelenburg gait.

After the initial publication describing incomplete triple pelvic osteotomy, one comment regarding this technique was that it allows less than optimal correction and results in retroversion and lateralisation of the acetabulum. It was also noted that the follow-up period was probably too short to allow conclusions to be drawn regarding the success of the procedure.²³ We believe that incomplete triple pelvic osteotomy provides a controlled correction because it preserves the posterior column. The long-term results indicate that the rate of retroversion is lower than after Ganz osteotomy; it does not lead to FAI and the osteotomy has no effect on lateralisation.

There are few reports on the long-term results of osteotomies used in the treatment of acetabular dysplasia. Because of the high rate of complications that developed in the immediate post-operative period in patients treated with the most commonly used techniques, the difficulty of acetabular reorientation, and the difficulties in learning the technique the treatment of acetabular dysplasia fell out of favour. However, the long-term results of the

treatment of acetabular dysplasia show that, with an appropriately chosen osteotomy, many hips can be preserved and most patients can maintain their quality of life without aggravation for at least 10 years. After a mean follow-up of 12 years a decrease in the range of motion or FAI was not observed in any of the hips, none of the patients needed THA, there were no poor radiological or clinical results. Our results showed that incomplete osteotomy is a safe choice in the treatment of acetabular dysplasia as it offers both clinical and radiological success in these patients.

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