Joint congruency in abduction before surgery as an indication for rotational acetabular osteotomy in early hip osteoarthritis

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Abstract We conducted a retrospective review of the results of rotational acetabular osteotomy (RAO) procedures in 92 hips of 89 patients (81 females and eight males) with early-stage osteoarthritis. In this study, we discuss the indications for this surgery based on the preoperative congruency in abduction. The mean postoperative follow-up was 12.2 (7–19) years. The mean age at operation was 32.5 (13–54) years. Two hips with apparent technical failure were excluded. During follow-up, the osteoarthritic stage remained unchanged in 76 hips (good group) and progressed in 14 hips (poor group). Preoperative joint congruency in abduction was excellent in 20 hips, good in 62, and fair in eight. All eight hips with fair joint congruency showed progression to osteoarthritis at follow-up. Patients without good congruency in abduction may experience progression of osteoarthritis after RAO procedures even in early-stage osteoarthritis.

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Resumé Nous avons réalisé une étude rétrospective des résultats de l'ostéotomie acétabulaire (RAO) sur 92 hanches chez 89 patients (81 femmes et 8 hommes). Ces patients présentaient une arthrose précoce de hanche. Nous avons discuté dans cette étude les indications de la chirurgie basée notamment sur la congruence préopératoire en abduction de l'articulation. Le suivi moyen postopératoire a été de 12,2 ans (de 7 à 19 ans). L'âge moyen d'intervention de 32,5 ans (de 13 à 54 ans). 2 hanches présentaient un défaut technique et ont été exclues de l'étude. Durant le suivi, l'arthrose n'a pas évolué sur 76 hanches (groupe bon) et a progressé dans 14 hanches (groupe mauvais). La congruence préopératoire de l'articulation de la hanche en abduction était excellente dans 20 hanches, bonne dans 62 et médiocre dans 8 hanches. Les 8 hanches présentant une congruence médiocre ont montré en préopératoire une progression de l'arthrose tout au long du suivi. En conclusion, les patients avec une bonne congruence en abduction ont profité de l'ostéotomie de rotation acétabulaire y compris quand il existe une arthrose précoce.

Introduction

Developmental dysplasia of the hip (DDH) is one of the most common causes of secondary osteoarthritis in young adults [6]. Steel's triple osteotomy [25], Eppright's dial osteotomy [3], the rotational acetabular osteotomy (RAO) developed by Ninomiya and Tagawa [17], and Ganz periacetabular osteotomy [5] allow the femoral head to be covered with articular cartilage and have been used successfully in patients with DDH, with or without early osteoarthritic involvement [16, 18, 22, 24, 26].

Many factors influence the long-term results of periacetabular osteotomy, including age at operation [33], operative

technique [12], and osteoarthritis stage [16]. Postoperative joint congruency was reported to be an important factor influencing the postoperative results [33]; however, the information was obtained just after the operation. Preoperative information that can be used in determining indications for periacetabular osteotomy is important to avoid performing osteotomy in young patients who would be unlikely to achieve substantial benefit. Preoperative functional radiographs have been used in preoperative assessment for candidates of periacetabular osteotomy [2, 13, 27, 33]; however, to our knowledge, no studies have analysed the relationship between results of periacetabular osteotomy for early stage osteoarthritis and preoperative congruency in abduction.

We therefore asked whether preoperative joint congruency is directly correlated with clinical success of RAO for early-stage osteoarthritis.

Patients and methods

Between 1985 and 2007, we performed the RAO procedure developed by Ninomiya and Tagawa [17] on 263 hips in 242 patients with DDH. Between 1985 and 2000, we performed the RAO without concomitant femoral osteotomies for early-stage osteoarthritis with DDH on 102 hips of 99 patients. The indications for RAO were acetabular dysplasia that was characterised by a centre-edge angle (CE angle) [29] of less than 20° on radiographs, progressive pain that interfered with daily activities, and age of less than 60 years.

Acetabular osteotomy was performed according to the technique of Ninomiya and Tagawa [17]. The patient was placed in the lateral decubitus position. We used a combination of anterior iliofemoral and posterior approaches through a single, anteriorly convex skin incision. After circumferential exposure, an osteotomy was performed using a special curved osteotome, starting just outside the capsule. The acetabular fragment was rotated anterolaterally and transfixed to the pelvis with two Kirschner wires. Non-weightbearing mobilisation was allowed after operation. One-third partial weightbearing with crutches was allowed in the sixth postoperative week, two-thirds partial weightbearing at three months, and full weightbearing at four months.

One patient was excluded from the study group because she developed a systemic disease that affected her ambu-

lation significantly after the operation. Nine patients were lost to follow-up after more than seven years. We were able to contact two of these patients by telephone; however, they did not visit our hospital. We could not contact the other seven patients, because they had moved elsewhere. Their mean age at the time of surgery was 34.1 (range 21–45) years, and the mean duration of follow-up was 4.2 (1–6) years. Radiographically, none of these patients showed signs of progression of arthritis. The remaining 89 patients (81 females and eight males) with 92 hips attended the follow-up for clinical and radiographic assessment for more than seven years (recall rate of 90%). The mean postoperative follow-up was 12.2 (7–19) years, and the mean age at operation was 32.5 (13–54) years.

The severity of osteoarthritis was radiographically staged into four groups based on the joint space using a modified version of the classification system advocated by the Japanese Orthopaedic Association [16]. *Early stage* is defined as more than 2 mm of joint space remaining, *early-advanced stage* as less than 2 mm of joint space but with no contact between the subchondral bone of the acetabulum and the femoral head, *late advanced stage* as the subchondral bone of the acetabulum and the femoral head in contact within a localised area (less than 15 mm width) or less than 2 mm of joint space (more than 15 mm width), and *end stage* as extensive loss of joint space (more than 15 mm width). In patients with a normal contralateral hip, half of the contralateral hip joint space was measured in the classification system instead of 2 mm. The inclusion criteria for this study was early stage.

The functional results were evaluated by Merle d'Aubigne and Postel's [14] hip joint scoring system, which assigns a maximum of six points for each of the three categories of pain, mobility, and gait function.

To aid the evaluation, the preoperative joint congruency in abduction and postoperative joint congruency in the neutral position were classified into four grades according to Yasunaga et al. [32]. The preoperative joint congruency was graded as *excellent* if the curvature of the acetabulum and that of the femoral head were almost identical and the joint space was adequately maintained, *good* if the curvature of the acetabulum and the femoral head were not identical but the joint space was adequately maintained, *fair* if partial

Fig. 1 Classification of joint congruency

Fig. 2 Radiographic parameters in abduction. Angle *A* is the center-edge (CE) angle. Acetabular head index (AHI) = $a/b \times 100$. Dotted and base lines of the CE angle lie parallel to the longitudinal axis of the femur

narrowing of the joint space occurred, and *poor* if partial disappearance of joint space occurred (Fig. 1).

Anteroposterior radiographs were taken preoperatively, three months postoperatively, and at the time of follow-up. The femoral head position and hip morphology were assessed. The parameters evaluated include CE angle [29], acetabular head index (AHI) [8], and acetabular angle [23]. We also evaluated CE angle and AHI in abduction before surgery (Fig. 2).

All radiographs were performed in the supine position. Anteroposterior radiographs were taken with a source to film distance of 110 cm. The patient's feet were internally rotated with the toes at $15 \pm 5^\circ$ to ensure that the X-ray beam was centred on the superior aspect of the pubic symphysis. For each patient, two conventional pelvic radiographs were taken preoperatively. The first film was obtained in the neutral position and the second film was obtained in abduction [21].

To test the reproducibility of the radiographic measurements, two authors (KO and HE) measured the CE angle, AHI, and acetabular angle in ten randomly selected hips. Each observer measured each hip two times, with a one-week interval between measurements; the values were then

averaged. The data were analysed for intraobserver and interobserver variances and the coefficient of variation was calculated to be less than 5%. Therefore, we considered the reproducibility of the measurements as reasonable. To assess reliability of the osteoarthritic stage at follow-up and preoperative joint congruency in abduction, 20 randomly selected hips were reviewed independently by two authors (KO and HE) and interobserver variability values (kappa statistics) were 0.95 and 0.91, respectively.

We used the Mann-Whitney U test to compare age at surgery and follow-up period between two groups (good and poor groups), and Wilcoxon rank tests to compare preoperative and postoperative CE angles, AHI, and acetabular angle. Kruskal-Wallis tests were used to compare follow-up results among three groups (excellent, good, and fair congruency). Statistical significance was assumed at a *p* value less than 0.05.

Results

All patients had survived at the time of follow-up without any secondary operations. The mean Merle d'Aubigné clinical score improved from 12.6 (7–16) points preoperatively to 16.8 (11–18) points postoperatively ($P < 0.001$), mainly because of increased scores for pain reduction and walking ability. The mean pain score improved from 3.0 (1–5) to 5.7 (3–6) points ($P < 0.001$). The mean mobility score decreased significantly from 5.8 (5–6) to 5.3 (4–6) points ($P = 0.009$), and the mean walking ability score improved from 3.8 (1–6) to 5.8 (3–6) points ($P < 0.001$).

The osteoarthritic stage remained unchanged (early stage) at the time of follow-up in 76 hips and progressed in 16 hips. At the time of follow-up, nine hips were graded as early-advanced stage, five were graded as late advanced stage, and two as end stage. Two of the 16 hips with progression of the osteoarthritis stage had apparent technical failure and were excluded from subsequent comparison. One of the excluded hips had incomplete coverage of the

Table 1 Comparison of radiographic parameters between good (maintained osteoarthritic stage) and poor (progressed osteoarthritic stage) groups

Radiographic parameter	Good (<i>n</i> =76)			Poor (<i>n</i> =14)		
	Preop	Postop	Follow-up	Preop	Postop	Follow-up
Centre edge angle	2.0±11.2 (–20–18)	39.0±11.6* (22–75)	42.1±14.5 (23–75)	–1.7±12.3 (–20–18)	36.6±10.6* (20–55)	47.6±11.4 (37–67)
Acetabular head index	53.0±12.1 (29–76)	94.7±11.4* (83–111)	95.5±15.4 (82–116)	53.4±13.5 (35–74)	90.0±12.3* (83–102)	99.6±12.7 (85–130)
Acetabular angle	50.5±4.1 (43–60)	37.3±6.4 * (25–43)	35.3±6.1 (20–45)	52.3±4.6 (47–60)	37.9±7.0 * (28–44)	34.4±9.3 (18–44)

All values are mean ± SD, with the range in parentheses.

* $P < 0.001$ postop vs. preop (within-group comparison).

Table 2 Relationship between preoperative congruency in abduction, postoperative congruency in the neutral position, and follow-up results in hips treated with RAO

Parameters	Good (<i>n</i> =76)	Poor (<i>n</i> =14)	<i>p</i> value
Preoperative congruency			<i>p</i> <0.001
Excellent (<i>n</i> =20)	18	2	
Good (<i>n</i> =62)	58	4	
Fair (<i>n</i> =8)	0	8	
Postoperative congruency			<i>p</i> <0.001
Excellent (<i>n</i> =19)	17	2	
Good (<i>n</i> =62)	59	3	
Fair (<i>n</i> =9)	0	9	

RAO rotational acetabular osteotomy

The values are given as the number of hips. The results at follow-up were compared in patients with excellent, good, and fair congruency (Kruskal-Wallis test)

femoral head (AHI 70%) and the other had intra-articular damage from the chisel. Therefore, we compared the remaining 14 hips with progression of the osteoarthritic stage at follow-up without technical failure (poor group) to the 76 hips with maintained osteoarthritic stage at follow-up (good group). The mean age at surgery and follow-up period was 32.1 (13–54) and 12.0 years for the good group, and 35.2 (32–47) and 13.9 years for the poor group, respectively. There were no significant differences in age at surgery and follow-up period between the two groups.

The CE angle, AHI, and acetabular angle in the neutral position improved after surgery ($P<0.001$) with no significant preoperative, postoperative, and follow-up differences in these parameters between the groups (Table 1).

No hip had poor congruency either preoperatively or postoperatively. Preoperative joint congruency in abduction was excellent in 20 hips, good in 62, and fair in eight. The 20 hips with excellent congruency preoperatively produced 18 hips in the good group and two in the poor group at follow-up. The 62 hips with good congruency preoperatively produced 58 hips in the good group and four in the poor group at follow-up. All eight hips with fair congruency were

in the poor group at follow-up. Postoperative joint congruency was excellent in 19 hips, good in 62, and fair in nine. Excellent or good preoperative congruency in abduction ($P<0.001$) and postoperative congruency in the neutral position ($p<0.001$) were observed more often in the good group at follow-up than in those who had fair congruency (Table 2).

The mean CE angle and AHI in abduction before surgery (Fig. 2) were 34.8° (18–57°) and 88.6% (72–104%) in the good group, and 24.3° (13–32°) and 79.9% (68–89%) in the poor group, respectively. There were significant differences in CE angle ($P<0.001$) and AHI ($P=0.002$) in abduction between the groups. Six hips in the poor group had preoperative excellent or good joint congruency of the hip in abduction, of which five exhibited deformity of the femoral head.

Complications

There were no incidences of deep-tissue infection or major neurovascular complications. Two patients developed transient irritation of the lateral femoral cutaneous nerve. Thrombosis of the deep femoral vein occurred in two patients. Technical failure, as described above, occurred in two patients. Both hips were operated in the early years after the introduction of RAO at our hospital.

Discussion

Preoperative osteoarthritis stage reportedly influences the results of periacetabular osteotomy [16, 28]. For early-stage osteoarthritis, secondary to DDH, satisfactory long-term results of periacetabular osteotomy have been reported [16, 18, 26]. Candidates for periacetabular osteotomy in previous studies were those patients who demonstrated improvement in femoral head coverage and joint congruency with the hip in abduction [2, 13, 27, 33]. Some authors have reported that postoperative CE angle [7] and AHI [22] in patients with good results were significantly larger than those with poor results. Postoperative joint congruency has also been

Fig. 3 Radiographs of a 35-year-old woman. **a** Preoperative early-stage osteoarthritis. The hip score was 10 points. **b** Fair congruency in abduction. **c** Three months postoperatively. **d** Fourteen years post-

operatively; end-stage osteoarthritis associated with the joint space having disappeared on the lateral side. The hip score was 12 points

reported to be a useful predictor of postoperative results [33]. However, to our knowledge, no studies have analysed the relationship between results of periacetabular osteotomy for early-stage osteoarthritis and preoperative congruency in abduction. Postoperative joint congruency is the information obtained on the radiographs just after operation. Preoperative information that can be used in determining indications for periacetabular osteotomy is important to avoid performing osteotomy in young patients with early-stage osteoarthritis who would be unlikely to achieve substantial benefit. In this report, all hips without excellent or good congruency in abduction progressed the osteoarthritis stage at the time of follow-up (Fig. 3).

Even in early-stage osteoarthritis, there is no indication for RAO in hips without good congruency in abduction.

Our study had several limitations. First, six hips developed progressive joint space narrowing at follow-up even with preoperative excellent or good joint congruency of the hip in abduction. Five of these hips had deformity of the femoral head. One possible reason for this radiographic deterioration is that the weight-bearing load was concentrated laterally on the femoral head as a shearing force and resulted in progressive joint space narrowing, even with good joint congruency just after operation over a period of more than seven years. Second, in our series, patients even in their late fifties were included because our indications for RAO included patients under 60 years of age. A previous study showed no significant differences in the results of RAO observed in patients less than 46 years (average, 34.4 years; range 30–45 years) of age and older (average, 50.9 years; range, 46–58 years) [33]. We believe that patients even in their late fifties will have good outcomes if they have round femoral heads, good congruency, and early-stage osteoarthritis.

According to reports that have described the results of intertrochanteric varus osteotomy of the femur for developmental dysplasia of the hip, the indications for this procedure include patients having mild acetabular dysplasia [10, 11, 31]. One author reported observing no significant differences in survival rate between patients treated with periacetabular osteotomy and those treated with intertrochanteric varus osteotomy, if patients with more than five degrees of CE angle were selected preoperatively [31]. In our series, patients with mild acetabular dysplasia (more than five degrees of CE angle) in the neutral position before surgery might have obtained good results by femoral osteotomy alone.

The majority of Japanese patients in Asia are diagnosed with osteoarthritis secondary to developmental dislocation of the hip joint or acetabular dysplasia [15], often associated with a deformed femoral head [9, 15]. Japanese patients with osteoarthritis were reported to have a greater incidence of hip dysplasia when compared with white Americans [9] and Britons [34]. To treat young patients with various degrees of dysplasia and femoral head deformity,

we must refer not only to preoperative joint congruency in abduction but also to the radiological condition of the femoral head [19].

Clohisey et al. [2] reported good short-term results from periacetabular osteotomy with valgus osteotomy of the proximal femur in patients whose hips did not have good congruency because of major aspherical femoral head deformities. Yanagimoto et al. [30] reported good long-term results of Chiari pelvic osteotomy for the dysplastic hip without good congruency. Osteotomy, such as Chiari pelvic osteotomy [1], shelf acetabuloplasty [4], or RAO with additional osteotomy of femur should be selected for patients without good congruency of the hip joint. Resection of the lateral edge of the acetabulum to improve postoperative joint congruency on the radiograph should not be undertaken because poor results have been reported with additional procedures in RAO [20].

In conclusion, patients without preoperative good congruency in abduction may experience progression of osteoarthritis after RAO. Even in early-stage osteoarthritis, there is no indication of RAO for the hips without good congruency in abduction.

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