Complete Circumferential Osseous Extension in the Acetabular Rim Occurs Regardless of Acetabular Coverage

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Abstract

Background Complete circumferential osseous extension in the acetabular rim has been reported to occur in the deep hip with pincer impingement. However, this phenomenon occasionally is observed in dysplastic hips without pincer impingement, and the degree to which this finding might or might not be associated with hip pain, and how often it occurs bilaterally among patients, are not well characterized.

Questions/Purposes (1) To determine the proportion of patients with complete circumferential osseous extension in the acetabular rim using three-dimensional (3-D) CT in patients with and without hip pain who had CT scans obtained for various reasons. (2) To elucidate how often this complete circumferential osseous extension occurred

bilaterally among those patients. (3) To investigate the relationship between the proportions of patients with complete circumferential osseous extension observed on CT scans among three different acetabular coverage groups: dysplasia, normal, and overcoverage. (4) To determine how often the finding of hip pain was associated with complete circumferential osseous extension.

Patients and Methods Between September 2011 to July 2016, we evaluated 3788 patients with pelvic complaints such as hip, groin, thigh, buttock, or sacroiliac joint pain. We obtained consent from 26% (992 of 3788) of them, and obtained 3-D CT scans as part of that evaluation. For the current retrospective study, we excluded patients younger than 20 years or 80 years or older (181 patients), patients who had previous hip surgery (185 patients), patients with severe osteoarthritis with Tönnis Grades 2 or 3 (301 patients), and patients who could not have an accurate lateral center-edge (LCE) angle measured owing to poor-quality radiographs (24 patients), leaving 301 patients (602 hips) for this analysis. In this study population, patients reported pain in 131 hips (22%), defined as all types of hip pain except for trauma, including activity pain, pain with sports, pain on motion, and impingement pain; the others did not report hip pain. The mean age of the patients was 56 ± 16 years, and the mean LCE angle was $26^\circ \pm 8^\circ$ (range, -9° to 47°). We first determined the proportion of patients with complete circumferential osseous extension in the acetabular rim using 3-D CT for those with and without hip pain who had CT obtained for various reasons. We next elucidated how often this complete circumferential osseous extension occurred bilaterally among the patients, and finally we investigated the relationship between the proportion of patients with complete circumferential osseous extension observed on CT scans among the three groups: dysplasia (defined as LCE angles of 22°

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or smaller), normal, and overcoverage (defined as LCE angles of 34° or larger) groups. We finally determined how often the finding was associated with hip pain attributable to complete circumferential osseous extension. **Results** The proportion of patients with complete circumferential osseous extension was 6% (18 of 301 patients). Eighty-nine percent (16 of 18) of the patients had bilateral complete circumferential osseous extension. There were no differences in the proportions of patients with complete circumferential osseous extension among the three groups: 5.3% (odds ratio [OR], 1.02; 95% CI, 0.45–2.31; $p = 0.97$), 5.3%, and 7.4% (OR, 0.70; 95% CI, 0.28–1.73; $p = 0.44$) in the dysplasia, normal, and overcoverage groups, respectively, with the numbers available. Eighteen percent (six of 34) of the hips with complete circumferential osseous extension had pain.

Conclusions Complete circumferential osseous extension in the acetabular rim is relatively uncommon. When it occurs, it usually is bilateral, it occurs regardless of acetabular coverage, and it is associated with pain in a minority of patients.

Level of Evidence Level III, prognostic study.

Introduction

Osseous extension in the superolateral portion of the acetabulum, also known as roof osteophyte or osseous metaplasia, occasionally is observed in acetabular dysplasia. A possible cause of this is a traction force through the articular capsule or synovial tissue attachment [3]. In diffuse idiopathic skeletal hyperostosis, large paraacetabular osteophytes develop from the articular capsule attachment [14] and also contain intralabral ossifications. Labral ossifications are thought to result from labral damage [2, 10]. This mechanism of labral ossification was postulated by Seldes et al. [15] in 2001. Labral injury may lead to minor abnormal motion of the femoral head and cause a traction force from the acetabular attachment with subsequent ossification formation in the damaged labrum. However, several theories regarding the nature of labral ossification have been reported. Ninomiya et al. [13] and Byrd et al. [4] suggested it might be the result of enchondral ossification; however, Corten et al. [5] suggested it might result from bone apposition from the acetabular rim. Although labral ossifications are partial (noncircumferential) in most patients, others have osseous extension around the complete circumference of the acetabular rim.

A possible mechanism of complete circumferential osseous extension has been reported to be pincer impingement causing linear contact between the acetabular

rim and the head–neck junction [2]. However, complete circumferential osseous extension is observed not only in the deep hip but also in dysplastic hips without pincer impingement. To our knowledge, there have been no published reports regarding the proportion of patients with complete circumferential osseous extension in the acetabular rim, and how often it occurs bilaterally. We also do not know the relationship between the proportions of patients with complete circumferential osseous extension among three different acetabular coverage groups: dysplasia, normal, and overcoverage. In addition, although resection surgery of the painful ossified labrum has been reported [2, 4, 13], the frequency of pain in patients with complete circumferential osseous extension has not been clarified.

Therefore, we sought (1) to determine the proportion of patients with complete circumferential osseous extension in the acetabular rim using three-dimensional (3-D) CT in patients with and without hip pain who had CT obtained for various reasons; (2) to elucidate how often this complete circumferential osseous extension occurred bilaterally among the patients; (3) to investigate the relationship between the proportions of patients with complete circumferential osseous extension observed on CT scans among three different acetabular coverage groups; and (4) to determine how often the finding of hip pain was associated with complete circumferential osseous extension.

Patients and Methods

Study Design and Setting

We retrospectively examined the records of patients seen from September 2011 to July 2016 at Saitama Medical University Hospital in Japan. We evaluated 3788 patients with pelvic conditions such as hip, groin, thigh, buttock, or sacroiliac joint pain. We obtained consent from 26% (992 of 3788) of them, and obtained 3-D CT scans of the pelvis as part of our evaluation.

Participants and Study Subjects

Patients 20 to 79 years old with no surgical history and Tönnis Grade 0 or 1 [18] disease of their bilateral hips were included (Fig. 1). Patients were excluded if an accurate lateral center-edge (LCE) angle could not be measured owing to poor-quality radiographs. A total of 301 patients (602 hips) fulfilled the inclusion criteria of this study (Fig. 1). The mean age of the patients was 56 ± 16 years (Table 1). One hundred thirty-eight patients were male and 163 were female. Only 22% (131 of 602) of the hips had

Fig. 1 The inclusion algorithm of this study is shown. *Patients with no surgical history in the bilateral hips; †patients with Tönnis Grades 0 or 1 disease in their bilateral hips.

associated pain judged by the main presentation obtained from review of the patients' medical records, and was defined as all types of hip pain except for trauma, including activity pain, pain with sports, pain on motion, or impingement pain. Hip pain was not reported for the other 78% of the hips. Ninety-four percent (563 of 602) of the hips had Tönnis Grade 0 disease, and only 39 hips had Grade 1 disease. The mean LCE angle obtained from standardized supine AP pelvis radiographs was $26^\circ \pm 8^\circ$ (range, -9° to 47°). Hip and pelvic trauma were the most-prevalent diagnoses for all patients (34%; 101 of 301 patients) (Table 2). Lumbar spine disease was the second most-prevalent diagnosis. Patients with ankylosing spondylitis [19] or diffuse idiopathic skeletal hyperostosis [14] were excluded from the study.

Description of Experiment, Treatment, or Surgery

Complete circumferential osseous extension of the acetabular rim was defined as the ossification shading the entire circumference of the acetabular rim on 3-D CT scans. "Complete" was defined as a hip with osseous

extension observed on all slices, and on 360° scanning in 3-D CT. Even if a small gap was seen on 360° scanning, we defined it as "incomplete". Three-dimensional CT images were obtained using a 16-slice, 64-slice, or 128-slice multidetector CT scanner system (SOMATOM® Emotion 16; SOMATOM® Perspective; and SOMATION® Definition Flash, respectively; Siemens Healthcare, Forchheim, Germany) using the same protocol. When patients had two or more CT scans during the study period, we assessed the first one.

The LCE angle was measured on pelvic radiographs using OP-A software (FUJIFILM Medical Co, Ltd, Tokyo, Japan). Patients were divided in three groups according to the coverage of the acetabulum: dysplasia, normal, and overcoverage, with LCE angles of 22° or smaller, 23° to 33° , and 34° or larger, respectively [16].

Variables, Outcome Measures, Data Sources, and Bias

All hips were evaluated independently by two orthopaedic specialists (KW and FK). The patient selection was performed with discussion and agreement of these two

Table 1. Characteristics of all patients

Parameter	Value
Patients (number)	301
Hips (number)	602
Age, mean $\pm$ SD (years)	56 $\pm$ 16
Age group (number of patients)	
20–29 years	18
30–39 years	38
40–49 years	56
50–59 years	43
60–69 years	70
70–79 years	76
Gender (patients: number)	
Male	138
Female	163
Hip pain (percent positive)*	22
Tönnis grade (hips: number)	
Grade 0	563
Grade 1	39
Lateral center-edge angle	
Mean $\pm$ SD ($^{\circ}$)	26 $\pm$ 8
Range ($^{\circ}$)	–9 to 47

*Hip pain in patients without trauma.

specialists. The study was approved by the institutional review board of Saitama Medical University Hospital (No. 13-045-3), and was performed in compliance with the Helsinki Declaration. Informed consent was waived because the study is retrospective.

Statistical Analysis and Study Size

Statistical analyses were performed using Mann–Whitney U or chi-square tests using a bell curve with Excel Statistics Version 2.03 (Social Survey Research Information Co, Ltd, Tokyo, Japan). A *p* value less than 0.05 was considered statistically significant. The proportions of hips among the dysplasia, normal, and overcoverage groups were compared.

Results

Complete circumferential osseous extension in the acetabular rim was observed in 6% (18 of 301 patients) of patients with and without hip pain who had CT scans (Fig. 2; Table 3).

Eighty-nine percent (16 of 18) of the patients had bilateral complete circumferential osseous extension. The

Table 2. Diagnoses of all patients

Diagnosis or symptom	Patients (number)
Hip or pelvic trauma	101
Lumber spine disease	64
Osteonecrosis	47
Acetabular dysplasia	37
Labrum tear or femoroacetabular impingement	16
Diffuse idiopathic skeletal hyperostosis	5
Benign hip tumor	4
Amyloidosis of the hip	4
Subchondral insufficiency fracture	3
Labral ossification	3
Rheumatoid arthritis	3
Ectopic ossification of the hip	3
Transient osteoporosis of the hip	2
Gout of the hip	2
Other	7

other two patients with complete circumferential osseous extension had partial ossification on the contralateral side.

The proportions in the dysplasia, normal, and overcoverage groups were 5.3% (odds ratio [OR], 1.02; 95% CI, 0.45–2.31; *p* = 0.97), 5.3% (reference), and 7.4% (OR, 0.70; 95% CI, 0.28–1.73; *p* = 0.44), respectively. There were no differences in the proportions among groups, with the numbers available (Table 4). Furthermore, 25% (four of 16) of the patients with bilateral complete circumferential osseous extension did not have their right and left hips in the same coverage group (Table 5).

Eighteen percent (six of 34) of the hips with complete circumferential osseous extension had pain.

Discussion

Although most labral ossification is partial in the damaged labrum in the superolateral portion [2, 10], we observed a few patients with complete circumferential osseous extension of the acetabular rim. Complete circumferential osseous extension of the acetabular rim has been reported to occur in the deep hip with pincer impingement [2]. However, this phenomenon is observed occasionally in dysplastic hips without pincer impingement (Fig. 2A–B). Various subgroups of labral ossification with differing etiologies may exist. There is little knowledge regarding the number of patients with complete circumferential osseous extension of the acetabular rim, how often it occurs bilaterally, whether there is a relationship between the proportion and acetabular coverage, and whether this finding is associated with hip pain. In our study patients, complete circumferential osseous

Fig. 2A–C Bilateral labral resection was performed in a 39-year-old man with bilateral hip pain. **(A)** His AP radiograph showed bilateral osseous extension (arrows) with Tönnis Grade 1 disease. **(B)** The pelvic 3D-CT scan showed complete circumferential osseous extension (arrows) from the acetabular rim in both hips. **(C)** Osseous extension existed in the labrum. A trabecular fracture (arrow) was observed around the articular cartilage-labrum transition zone (Stain, Azan; original magnification, $\times 1.25$).

extension of the acetabular rim, which is relatively uncommon and usually bilateral, was observed. It is associated with pain only in a minority of patients, and it occurs regardless of the acetabular coverage.

Our study had several limitations. First, this was a retrospective study, and we did not have knowledge of the natural course of the ossification. Second, the patient population in this study was 298 Japanese, one Korean, and

Table 3. Patients with complete circumferential osseous extension in the acetabular rim

Variable	Positive	Negative	p Value (OR; 95% CI)
Patients (number)	18	283	
Bilateral complete circumferential osseous extension	16		
Unilateral complete circumferential osseous extension	2		
Proportion of patients (%)	6	94	
Age, mean $\pm$ SD (years)	61 $\pm$ 11	55 $\pm$ 16	0.24*
Range (years)	38–76	20–79	
Age group (number of patients)			
20–29 years	0	18	
30–39 years	2	36	
40–49 years	1	55	
50–59 years	2	41	
60–69 years	10	60	
70–79 years	3	73	
Gender (number of patients)			
Male	12	126	0.07†
Female	6	157	
Hip pain (positive) (%)‡	18	22	0.30† (0.60; 0.23–1.59)
Tönnis grade (number of hips)			
Grade 0	30	533	0.20†
Grade 1	4	35	
Lateral center-edge angle $\pm$ SD (°)	28 $\pm$ 7	25 $\pm$ 8	0.23*

OR = odds ratio; *Mann–Whitney U test; †chi-square test; ‡does not include patients with trauma

Table 4. Prevalence rate of complete circumferential osseous extension according to acetabular coverage

Parameter	Dysplasia	Normal	Overcoverage
Proportion of hips (%)	5.3	5.3	7.4
Complete osseous extension (number of hips)			
Positive	9	18	7
Negative	162	319	87
Odds ratio (95% CI), p value	1.02 (0.45–2.31), 0.97	1	0.70 (0.28–1.73), 0.44

two Chinese patients. Although complete circumferential osseous extension occurs regardless of the acetabular coverage, differences between ethnic populations might exist. Third, the mean LCE angle ($26^\circ \pm 8^\circ$) in our study patients is less than the previously reported mean LCE angles in Japanese men (30° – 35°) and women (28° – 33°) [6, 9, 12, 20]. The reliability of LCE angle measurement is

Table 5. 16 patients with bilateral hip ossification

Age (years)	Gender	Right hip	Left hip
38	M	Dysplasia	Dysplasia
38	M	Normal	Overcoverage
49	M	Normal	Normal
50	F	Dysplasia	Dysplasia
56	M	Overcoverage	Normal
60	M	Dysplasia	Dysplasia
61	M	Dysplasia	Dysplasia
61	F	Overcoverage	Overcoverage
65	M	Overcoverage	Overcoverage
65	F	Overcoverage	Normal
66	M	Normal	Normal
67	M	Normal	Normal
68	M	Normal	Dysplasia
68	F	Normal	Normal
73	F	Normal	Normal
74	F	Normal	Normal

another limitation [8, 11, 17], and subdivision into three groups based on the LCE angle increases this disadvantage. Fourth, although 78% of hips in this study were asymptomatic, 3-D CT was required for reasons other than pain, indicating that our patients did not represent the general population; therefore, the proportion of patients in the general population may be different. In this study, hip pain was judged based on the main presentation on medical record review. Therefore, there is a possibility that pain was underreported, affecting the frequency of hip pain. Fifth, the same model of multidetector CT scanning systems was not used for all patients; however, this may not have greatly affected the results because the same protocol was used. Finally, the lack of statistical significance in the difference between the three groups may be attributable to the relatively small sample size, and actual differences between these groups cannot be ruled out (Table 4).

In 1980, Azuma et al. [1] reported that osteophytes develop from the articular cartilage-labrum transition zone growing in the labrum and that they appear not only in the weightbearing portion but also throughout the complete circumference of the acetabular rim, especially in elderly patients. To our knowledge, that was the first description of complete circumferential osseous extension in the labrum. The precise pathology of labral ossification remains unclear. Some researchers have reported it as the result of endochondral ossification in the labrum [1, 4]. Others [5] postulated that this was not labral ossification, but simply bone apposition superimposed on pincer impingement where the labrum became encased or displaced by new bone formation.

Beck et al. [2] reported five hips with complete circumferential osseous extension and pincer impingement. In our study, complete circumferential osseous extension of the acetabular rim was observed in 6% (18 of 301) of patients and was relatively uncommon. We also found that 89% (16 of 18) of patients had bilateral complete circumferential osseous extension. This is the first report, to our knowledge, on the proportion of patients with complete circumferential osseous extension.

Beck et al. [2] also discussed the relationship between pincer impingement and complete circumferential osseous extension and reported that circumferential osseous extension in the labrum was observed in 31% (five of 16) of hips with pincer impingement. Pincer impingement causes linear contact between the acetabular rim and head-neck junction, and thus, ossification of the labrum develops circumferentially [2, 5, 7, 10]. However, in our study patients, complete circumferential osseous extension of the acetabular rim was observed not only in the overcoverage group with pincer impingement but also in the dysplastic and normal hip groups. According to the power analysis, with power = 0.8, alpha = 0.05, and delta = 0.5, the number of hips in each group was more than needed ($n = 63$) to identify differences between groups. Moreover, in 25% (four of 16) of the patients with bilateral complete circumferential osseous extension, the right and left hips belonged to different acetabular coverage groups. This result indicated that complete circumferential osseous extension could develop independently of acetabular coverage and also suggested the existence of unknown factors other than mechanical stress, including pincer impingement or traction.

Ninomiya et al. [13] reported that an extensive resection of the ossified labrum leads to a reduction in pain. In our study, one patient had a trabecular fracture and fracture callus formation (Fig. 2C), which might have been the result of repeated crushing between the ossified labrum and femoral head. This type of fracture might be a reason for hip pain with complete circumferential osseous extension of the acetabular rim. However, ossification did not cause hip pain in all patients. Only 18% (six of 34) of our study patients experienced pain, which is important for clinicians to know to avoid misjudging the reason for hip pain. Accordingly, the surgical strategy might have to be changed.

In our patient population, complete circumferential osseous extension in the acetabular rim was relatively uncommon, usually bilateral, associated with pain only in a minority of patients, and occurred regardless of the acetabular coverage. It will be important to investigate the natural course and prognosis of complete circumferential osseous extension, such as whether pain appears in

asymptomatic patients or osteoarthritis progresses, by long-term followup of these patients.

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