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Why do subchondral cysts occur at the medial aspect of the femoral head in hip dysplasia?

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Abstract

Introduction: Osteoarthritis in dysplastic hips should develop from the lateral side of the acetabulum and the femoral head just below. However, the existence of subchondral cysts located more on the medial side contradicts the weight-loading theory. The aim of this study was to confirm the presence of medial cysts at the femoral head and to investigate the relationship between medial cysts and injuries of the ligamentum teres in hip dysplasia.

Methods: A retrospective analysis was conducted on 257 cases of hip dysplasia. All patients had x-rays and 3-dimensional computed tomographies (3D CT) preoperatively and 123 patients had magnetic resonance arthrographies. A comparison was performed between cases with and without medial cysts according to the severity of damage to the ligamentum teres, the presence of bony spurs around the fovea capitis, and the Tönnis grade.

Results: Medial subchondral cysts around the fovea capitis were found in 100 cases. Mild osteoarthritis (Tönnis grade 0 or 1) was present in 89% of cases in the medial cyst group. A significant difference between the groups was observed in the incidence of bony spurs around the fovea capitis ($p < 0.05$) and injuries of the ligamentum teres ($p < 0.05$).

Conclusions: The formation of subchondral cysts at the medial femoral head in hip dysplasia may be related to damage in the ligamentum teres. Considering that subchondral cysts develop in early osteoarthritis, the progression of arthritis in hip dysplasia appears to correlate with damage to the ligamentum teres, as well as compressive pressure on the joint.

Keywords

Ligamentum teres, hip dysplasia, osteoarthritis, subchondral cyst

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Introduction

Hip dysplasia is a condition in which the acetabulum does not fully develop to cover the femoral head. As a result, hypertrophy of the acetabular labrum commonly occurs to compensate for the shortage. About 20–40% of patients with hip disease require total hip arthroplasty (THA) due to secondary arthritis caused by hip dysplasia.[1,2]

The acceleration of degenerative changes is considered to result from more contact stress on the relatively narrow articular surface of the acetabulum.[3,4] Jacobsen[5] suggested that arthritis frequently occurred in the anterolateral quadrant of the hip joint, consistent with the mechanism stated above. However, in some cases of hip dysplasia in our study, more subchondral cysts were found at the more medial

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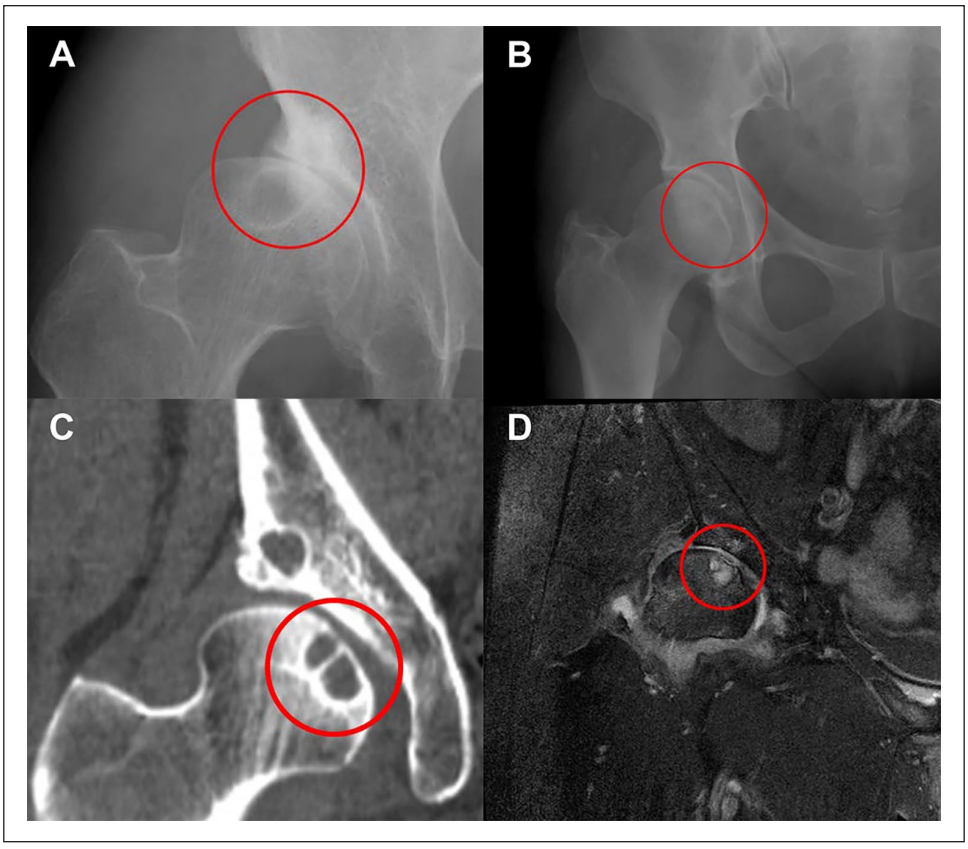

Figure 1. (A) Typical cyst at the lateral aspect of the femoral head, (B) Subchondral cyst at the medial aspect of the femoral head in hip dysplasia on x-ray, (C) CT, and (D) MRI.

aspect on the femoral head than at the lateral weight-bearing portion (Figure 1), particularly in the early stages of osteoarthritis. We assumed that other mechanisms of secondary arthritis were involved because the cyst locations could not be explained only by increases in load-weight.

While its role as the blood supplier to the femoral head is unclear, the ligamentum teres,[6] is considered to help spontaneous reduction by the ball-and-chain mechanism and eversion of the acetabular labrum in the developmental of hip dysplasia.[7] In early studies on the role of the ligamentum teres Howe et al.[8] assumed that the ligamentum teres resisted dislocation of the hip and Li et al.[9] reported that hip dislocation rates were low if the ligamentum teres was intact in animal studies. Many authors have also reported that micro instability may lead to pain and symptoms when the ligamentum teres is injured, such as in post-traumatic patients with anterior cruciate ligament (ACL) ruptures showing radiographic changes consistent with bony spurs.[10–12] Hence, we hypothesised that instability represented by a tear in the ligamentum teres or a bony spur around the fovea capitis might contribute to the occurrence of subchondral cysts at the medial aspect of the femoral head in the early stage of osteoarthritis.

In this study, we reviewed the preoperative records of 257 hips in 135 patients who had had surgery due to hip dysplasia. This study had 2 purposes: (1) to evaluate the frequency of medial cysts and the relationship between medial cysts and injuries to the ligament teres; and (2) to demonstrate that subchondral cysts at the medial aspect of the femoral head occurred at the early stage of degenerative changes.

Methods

Patients

A retrospective review of the medical records of patients who had had surgery due to hip dysplasia was conducted at our institution from January 2000 to December 2014. A total of 135 patients were reviewed. If a patient had hip dysplasia on both sides, then both sides of the hip were analyzed. 2 patients had already undergone total hip arthroplasties on the contralateral side, 3 patients had normal hip joints on the other side, and 8 patients had hip joints with advanced osteoarthritis on the other side where the fovea capitis could not be distinguished due to the progression of osteoarthritis. Hence, 13 hip joints were excluded and a total of 257 hip joints in135 patients were analysed.

The operative treatments were either a periacetabular osteotomy (PAO) or a total hip arthroplasty (THA). PAOs

Table 1. Demographic characteristics.

Characteristic	Value
Number of hips	257
Age (years)	50.5 (20–77)
Gender (male/female)	21/114
Type of surgery	
PAO	92
THA	43
Image work-up	
3D CT	257
MRA	123

PAO, periacetabular osteotomy; THA, total hip arthroplasty; 3D CT, 3-dimensional computed tomography; MRA, magnetic resonance arthrography.
Note: The values are expressed as numbers of cases or means (range).

were performed in most patients aged under 60 with mild osteoarthritic hip joints, whereas THAs were performed in most patients aged over 60 with progressive osteoarthritis. Regardless of their age, we decided on surgery according to the patient's symptoms, status, and disease progression. Among 135 patients, 92 patients underwent PAO and 43 patients underwent THA. The mean age of the patients was 50.5 years (range 20–77 years), of whom 21 patients were male and 114 were female (Table 1).

Imaging and statistical analysis

All patients had a simple x-ray, including anteroposterior and translateral images, as well as a 3-dimensional computed tomography (3D CT). Although a magnetic resonance arthrography (MRA) was recommended for all patients, it was performed preoperatively in only 123 hips of patients who agreed to the procedure. Damage to the ligamentum teres was checked through MRI scans. Subchondral cysts were defined as a radiolucent area that was distinguishable in at least 2 different planes (coronal, axial, and/or sagittal) in CT or MRA. Medial cysts were defined as subchondral cysts located in the medial half of the femoral head.

In patients without MRIs, bony spurs around the fovea capitis were checked on CT to evaluate instability of the hip joint caused by ligamentum teres injuries. A prominent spur was defined if the length was more than half the depth of the fovea capitis (Figure 2).

The extent of damage to the ligamentum teres was evaluated on MRA by Devitt et al.[13] and classified into four categories (Figure 3). We also evaluated the progress of osteoarthritis based on the Tönnis grade on anteroposterior x-rays.

The patients were divided into 2 groups based on the existence of cysts, the medial cyst group and the remainder. We compared the groups based on Tönnis grades, spurs around the fovea capitis, and the extent of damage to the ligamentum teres. Correlation analysis and the chi-square test were performed to compare the 2 groups and evaluate the relationship between spurs around the fovea capitis and the extent of damage to the ligamentum teres.

Figure 2. Prominent spur at the fovea capitis.

P-values < 0.05 were considered statistically significant and all tests were performed using SPSS version 18.0 (SPSS Inc., Chicago, IL, USA).

Results

Imaging study

Subchondral cysts at the medial aspect of the femoral head were found in 100 out of 257 cases. Thirty-nine cases were Tönnis grade 0, 150 cases were grade 1, 41 were grade 2, and 27 cases were grade 3. In 3D CTs of the hip, prominent spurs on the fovea capitis were detected in 152 cases.

The ligamentum teres in 28 cases was intact on MRA, 13 cases had hypertrophy, 64 had partial tears, and 18 cases had complete tears (Table 2).

Analysis of cysts at the medial aspect of the femoral head

The subchondral cyst cases (100 cases) were classified into the medial cyst group and the cases without medial cysts (157 cases) were classified as the remainder group. Tönnis grades 0 and 1 were regarded as mild osteoarthritis and grade 2 and 3 were regarded as advanced osteoarthritis. In the medial cyst group, 89 cases had mild osteoarthritis and 11 cases had advanced osteoarthritis. In the remainder group, 100 cases had mild osteoarthritis and 57 cases had advanced osteoarthritis. The proportion of mild

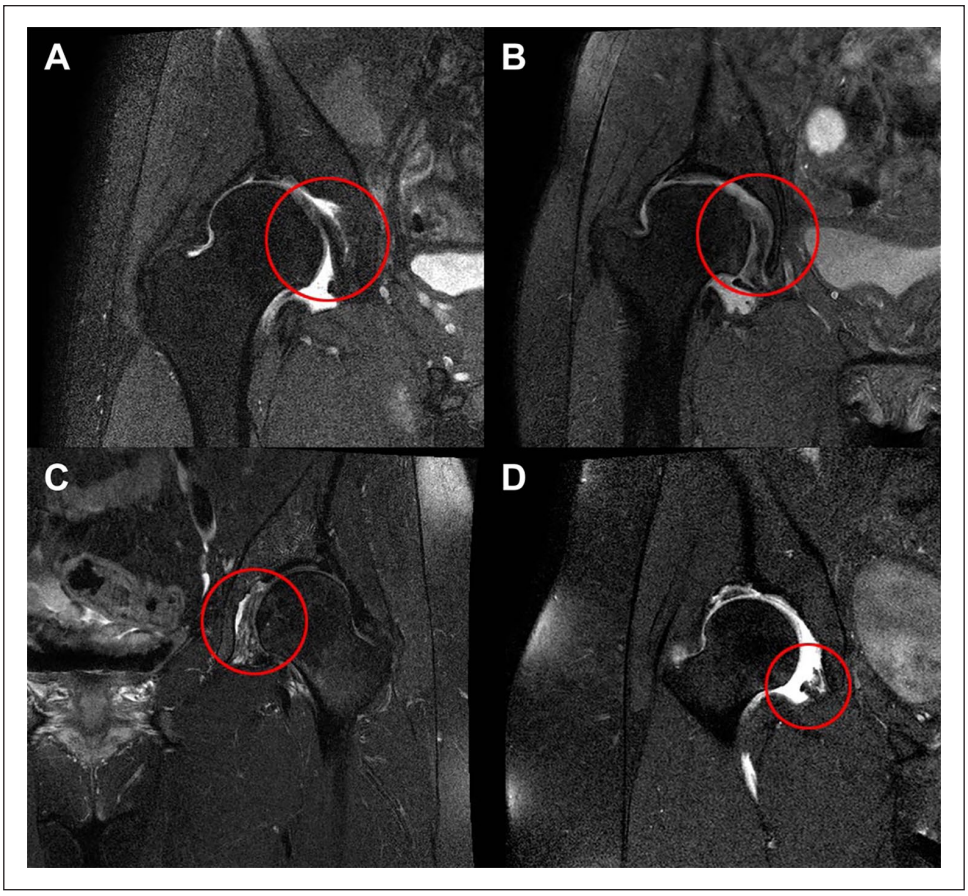

Figure 3. Ligamentum teres (LT) on MRA. (A) Intact LT, (B) hypertrophied LT, (C) partial tear, and (D) complete tear.

Table 2. Radiographic parameters.

Parameter	Number of cases (%)
Medial subchondral cysts ($n=257$)	100 (38.9)
Tönnis grade ($n=257$)	
Grade 0	39 (15.2)
Grade 1	150 (58.4)
Grade 2	41 (15.9)
Grade 3	27 (10.5)
Spur around fovea ($n=257$)	
No spur	105 (40.9)
Prominent spur	152 (59.1)
Injury to the ligamentum teres ($n=123$)	
Intact	28 (22.8)
Hypertrophy	13 (10.6)
Partial tear	64 (52.0)
Complete tear	18 (14.6)

osteoarthritis in the medial cyst group was significantly higher than in the remainder group ($p<0.05$, odds ratio [OR] = 4.612) (Table 3).

Prominent spurs were observed in 95 cases in the medial cyst group and 57 cases in the remainder group and the difference was statistically significant ($p<0.05$, OR = 33.333). Partial or complete tears of the ligamentum teres were observed in 58 cases in the medial cyst group and 24 cases in the remainder group. The difference was statistically significant ($p<0.05$) (Table 3).

Additionally, there was a significant correlation between bony spurs around the fovea capitis and damage to the ligamentum teres. Therefore, we assumed that bony spurs could represent damage to the ligamentum teres ($p<0.05$, OR = 53.958) (Table 4).

Discussion

Many studies have described the frequent finding of subchondral cysts in patients with hip dysplasia. Inui et al.[14] reported that subchondral cysts occurred in the early stage of osteoarthritis in hip dysplasia and confirmed that cysts communicated with joint spaces using 3D-CT analysis. Nakamura and Mechlenburg[15] argued that contact stress and the increased pressure on a relatively narrow joint space resulted in subchondral cysts. They insisted that the cysts could be aggravated by inflammation during osteoarthritis progression and could be cured by PAO through the distribution of pressure. However, there was

Table 3. Comparison between the medial cyst and remainder groups.

	Medial cyst group ($n = 100$)	Remainder ($n = 157$)	p-value
Age (years)*	49.4 (20–77)	50.6 (21–76)	0.526
Gender (male/female)	12/88	26/131	0.315
Tönnis grade†			<0.05
Grade 0, 1	89 (34.6)	100 (38.9)	
Grade 2, 3	11 (4.3)	57 (22.2)	
Spur around the fovea†			<0.05
Prominent	95 (36.9)	57 (22.2)	
Not prominent	5 (1.9)	100 (38.9)	
Injury to the LT†			<0.05
Grade 1, 2	0 (0)	41 (33.3)	
Grade 3, 4	58 (47.2)	24 (19.5)	

LT, ligamentum teres.
*The values are expressed as means (range).
†The values are the number of cases (%).

Table 4. Correlation between spurs around fovea and injury to the ligamentum teres.

	Prominent spur	Not prominent	p-value
Injury to the LT			<0.05
Grade 1, 2	35	6	
Grade 3, 4	8	74	

LT, ligamentum teres.
Note: The values are the number of cases.

no mention in their study of subchondral cysts in the medial aspect of the femoral head and there are no studies on it in the literature.

The mechanism of subchondral cyst formation in the femoral head is still unknown, but there are 2 hypotheses. The "synovial fluid intrusion theory" states that a calcified tissue barrier between the cartilage and subchondral bone is broken by cartilage injuries and synovial fluid intrudes into the bone marrow space of the subchondral bone and forms a cyst.[16,17] The "bone contusion theory" explains that excessive mechanical stress damages trabecular bones and the area is absorbed and replaced by a cyst.[16,18] However, there has been no mention of subchondral bone cysts located in the femoral head in previous studies.

This study demonstrated that subchondral cysts in the medial aspect of the femoral head often occurred in the early stages of osteoarthritis. Therefore, we concluded that not only an increase in contact stress but also other external factors related to damage of the ligamentum teres could apply stress to the cartilage in the medial aspect of the femoral head in the early stages. The damage of the ligamentum teres may cause microinstability[10,11,19] and result in damage to the articular cartilage.[10,11,19–21] In this study, we could not check the MRA of all the cases. However, there was a significant correlation between bony spurs around the fovea capitis and damage to the ligamentum teres. Therefore, we assumed bony spurs could represent damage to the ligamentum teres. Chiba et al.[22] also reported that bone sclerosis, such as bone spurs around bone cysts in the fovea capitis, might be reactive bone formation under areas of cartilage loss, as in our study.

There are limitations to this study. First, selection bias could have affected the results because 3D CTs or MRAs were performed on patients who needed surgery. This might represent populations with more advanced degenerative hip joint diseases. Secondly, we were not able to follow up on the natural history of the subchondral cysts and ligamentum teres tears because our study was on preoperative patients. Previous studies reported that periacetabular osteotomies resulted in decreased size or healing of cysts.[15] Therefore, follow-up data after periacetabular osteotomies in this study would not reflect the natural progression of degenerative changes. Thirdly, this study enrolled relatively high numbers of partial ligamentum teres tears. Devitt et al.[13] reported that the sensitivity and specificity of MRI for diagnosing partial tears of the ligamentum teres were 91% and 9%, respectively. Thus, there were measurement errors because of the inaccuracy of the MRIs. We also assumed that bony spurs could represent damage to the ligamentum teres. Although a correlation between the bony spurs around the fovea capitis and damage to the ligamentum teres has been proven, bony spurs do not necessarily indicate damage to the ligamentum teres. Lastly, multiple MRA interpreters, including radiology specialists, are required for more accurate analyses.

Conclusion

The formation of subchondral cysts at the medial aspect of the femoral head in hip dysplasia may be related to damage to the ligamentum teres. In the early stage, a damaged ligamentum teres may contribute to secondary osteoarthritis in hip dysplasia.

Declaration of conflicting interests

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