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ORIGINAL STUDY

Prevalence of acetabular cartilage lesions and labral tears in femoroacetabular impingement

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The goal of this study was to determine the prevalence of associated acetabular cartilage lesions and labral tears in patients with cam-type femoro-acetabular impingement (FAI). We evaluated acetabular cartilage lesions and labral tears found during hip arthroscopy in 52 patients with radiological signs of cam-type FAI. We found a high prevalence of associated lesions (86.5%) in patients with cam-type FAI. They were graded according to the morphology, extent, and location of the lesion. Forty-one patients (78.8%) had an acetabular cartilage lesion. Labral tears were found in 31 patients (59.6%). There was a high correlation between age and the presence and extent of acetabular cartilage and labral lesions ($r = 0.70$; $p < 0.0001$ and $r = 0.45$; $p < 0.001$ respectively). There was also a high correlation between the extent of the acetabular cartilage lesion and the presence of labral lesions ($r = 0.62$; $p < 0.0001$). Despite the recognized consequences of associated lesions on treatment and outcome, no classification system includes this aspect of FAI. Based on our findings, we developed a system to grade acetabular cartilage lesions according to their morphology and extent. This information can help to define the natural history of cam-type FAI, and to determine appropriate treatment.

Keywords : femoro-acetabular impingement ; cam type ; cartilage lesions ; labral tears.

INTRODUCTION

Hip pain in younger individuals has been associated with abnormal morphology of the hip joint. More attention is currently being paid to acetabular and femoral morphology and abnormal contact between the proximal femur and the acetabular rim during terminal motion of the hip (*10*) causing femoroacetabular impingement (FAI). Two types of FAI can be distinguished : cam impingement by abutment of an abnormal femoral head or head-neck junction onto the acetabulum during flexion (*14*) and pincer impingement because of contact between the acetabular rim, with general or local over-coverage, and the femoral head-neck junction (*10*).

Both types of impingement may lead to labral and chondral damage although different patterns are described according to the type of impingement. In cam impingement shear forces produce outside-in abrasion of the acetabular cartilage and/or its avulsion from the labrum and the subchondral bone

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in the anterosuperior rim area. In pincer impingement the first structure to fail is the acetabular labrum. Persistent abutment with leverage of the head in the acetabulum can result in cartilage damage at the posteroinferior aspect of the acetabulum (*10*). Osteoarthritis develops when damage at the labral-cartilage junction extends to the articular cartilage and subchondral bone. This damage extends by shearing of the adjacent articular cartilage from the underlying subchondral bone (*1,21*).

There are different treatment options for patients with cam-type FAI, including nonoperative treatment with modification of activity, restriction of athletic pursuits, and reduction of excessive motion (*17,18*). Because young patients are frequently involved, compliance with nonoperative treatment is often jeopardized and nonoperative treatment will not eliminate the pathomechanics of the structural deformities (*5,11*). Operative treatment focuses on improving the clearance of motion and alleviating femoral abutment against the acetabular rim. This can be accomplished via an arthoscopic (*11,12,25,27,28,33*), limited open (*7*), or open operation with surgical dislocation which is currently considered the criterion standard (*2,3,9,17*).

Acetabular cartilage lesions are frequently encountered in FAI. The absence of joint space narrowing, osteophyte formation, subchondral sclerosis, and cystic changes on conventional radiographs does not exclude these lesions. Asymmetric, focal chondral degenerative changes, particularly in the anterior or anterosuperior aspect of the femoral head or acetabulum, may appear normal on anteroposterior (AP) pelvic radiographs (*1*). These lesions can be detected by magnetic resonance arthrography (*3,4*), but arthroscopic examination will identify the exact extent and location of chondral degeneration and exclude other pathology. Accurate staging of the lesions is useful when subsequent surgical procedures are considered (*19*). When there is cartilage damage it is permanent and may compromise the result of operative treatment (*6,11,24,27,28,32*).

To our knowledge, there are no specific reports on the prevalence and extent of acetabular cartilage lesions and labral tears in cam type FAI. Treatment of these lesions is anecdotal and no controlled studies exist that report specifically on its results. The presence of such lesions may compromise the outcome and may be an important confounding factor when comparing the results of different centers and/or methods of treatment. The goal of this study was to accurately describe and report these associated lesions and thus to provide a standard for reporting injury, management, and outcome. Our study hypothesis is that there is a high incidence of associated lesions in patients with cam-type FAI.

MATERIALS AND METHODS

We reviewed the data of hip arthroscopies performed from 2000 till 2007 in 52 patients with a painful cam impingement not resolving with non-operative treatment. There were 32 male and 20 female patients. Their mean age at the time of the surgery was 28.5 years (range : 18-46).

The diagnosis of cam impingement was made by clinical examination, plain radiographs, computed tomography and/or magnetic resonance imaging. Based on the criteria by Nötzli *et al* (*22*) only patients with an alpha angle of more than 55° were included. Data regarding the acetabular cartilage lesion were gathered prospectively by the leading author. Patients with moderate and severe osteoarthritic changes on plain radiographs (Tönnis grade II and III) were excluded from this study (*31*). Pincer FAI cases (patients with excessive bone along the rim of the acetabulum or radiographic signs of acetabular retroversion) were not included in this study. Patients with previous hip surgery were not included in this study.

All arthroscopic procedures were done in the supine position on a traction table (Maquet, Rastatt, Germany) with a well padded perineal post. An anterior paratrochanteric and an anterior portal were used in every case to inspect the central compartment. When necessary, a posterior paratrochanteric portal was made for further inspection. Capsulotomy was done with a cutting radiothermal device or a beaver blade to facilitate access to the central compartment.

Acetabular cartilage lesions were graded and the location of the acetabular cartilage damage was noted. Grade 1 is softening of the cartilage at the labral-cartilage junction, which correlates to the "wave sign" as previously reported by Philippon and Schenker (*26*). Grade 2 to 4 indicate acetabular cartilage delamination which invariably starts at the labral-cartilage junction. Grading is based on the extent of the lesion (table I and figure 1 a-d). Grade 2 is a lesion < 1/3 of the distance between the

Table I. — Classification of acetabular cartilage lesions

grade	cartilage	treatment	n	%
0	normal	osteochondroplasty	11	21.2
1	softening	grade 0 + vaporization	14	26.9
2	ACD* < 1/3	grade 0 + vaporization or microfracturing	17	32.7
3	ACD* 1/3-2/3	grade 0 + microfracturing	6	11.5
4	ACD* > 2/3	debridement and/or arthroplasty	4	7.7
			52	100.0

* extent of acetabular cartilage delamination, distance between the acetabular rim and the cotyloid fossa.

acetabular rim and the cotyloid fossa. Grade 3 is a lesion of 1/3-2/3 and grade 4 a lesion > 2/3 of this distance. Associated labral lesions were also recorded. These were classified according to the morphology classification described by Lage *et al* (*16*).

Following treatment of the central compartment pathology, the peripheral compartment was inspected through an anterior paratrochanteric portal. An arthroscopic osteochondroplasty was performed with a burr via the anterior portal. In case of an extensive cartilage lesion the central compartment was debrided.

Correlations between age, gender, labral lesions and acetabular cartilage lesions were determined using the Spearman correlation matrix. This was done with the use of Graphpad PRISM 5.00 (Graphpad, San Diego, USA). A p value of < 0.05 was considered to be significant.

RESULTS

All the acetabular cartilage lesions were located at the anterosuperior rim. Eleven of the 52 patients (21.2%) had normal cartilage. Softening of the cartilage was seen in 14 patients (26.9%). Twenty-seven patients had an acetabular cartilage defect of grade 2 in 17 (32.7%), grade 3 in 6 (11.5%) and grade 4 in 4 (7.7%) (table I). All the patients with grade 4 lesions were 35 years of age or older. Of the 41 patients that had acetabular chondral damage, 29 (70.7%) had a labral tear as well. The 12 patients without an associated labral tear had a more benign cartilage lesion grade, 9 had a grade 1 and 3 had a grade 2 acetabular cartilage lesion.

An osteochondroplasty was done in every case . In cases of softening of the cartilage or limited delamination (grade 1 or 2), the cartilage was stabilised by vaporisation. If there was a moderate lesion of the acetabular cartilage (grade 2 or 3) the cartilage was debrided back to stable cartilage, and microfracturing was done. If the lesion reached the cotyloid fossa (grade 4) the cartilage was debrided. Three out of those four patients were subsequently treated with a hip arthroplasty because of residual pain.

Table II. — Classification of labral lesions

labrum	n	%
normal	21	40.4
radial fibrillated	26	50.0
radial flap	2	3.8
peripheral longitudinal	2	3.8
unstable bucket handle	1	1.9
	52	100.0

Labral tears were found in 31 out of 52 patients (59.6%) (table II). Radial fibrillation of the labrum was found in 26 patients (50%). Two patients had incomplete peripheral longitudinal tears at the base and two had a radial flap tear. In one additional patient the handle of a complex and unstable bucket handle tear was resected. Labral tears at the base were smoothed with the vaporizer. In all the other cases debridement and/or partial resection of the labrum was undertaken. Of the 31 patients that had a labral tear, 29 (93.5%) had an associated acetabular cartilage lesion. The two patients that did not have a lesion of the cartilage had radial fibrillation of the labrum.

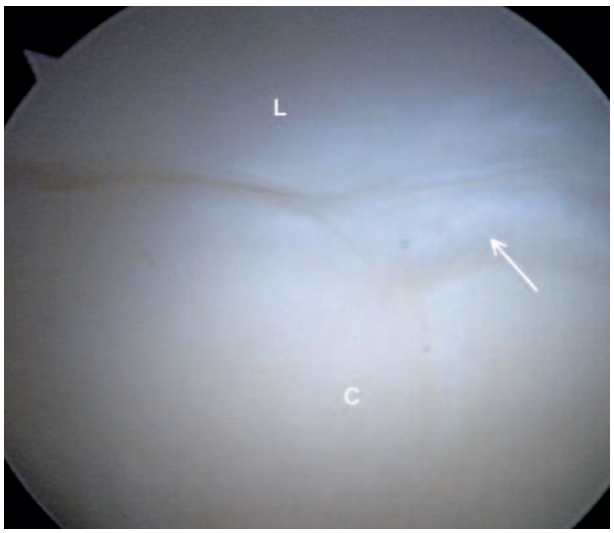

Fig. 1a. — Softening of the cartilage at the labro-chondral junction with a "wave sign" (grade 1) (arrow).

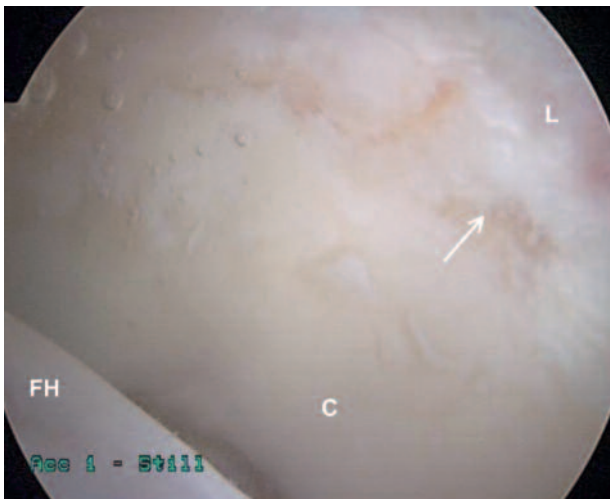

Fig. 1b. — Extent of the cartilage delamination < 1/3 of the distance between the acetabular rim and the cotyloid fossa (grade 2).

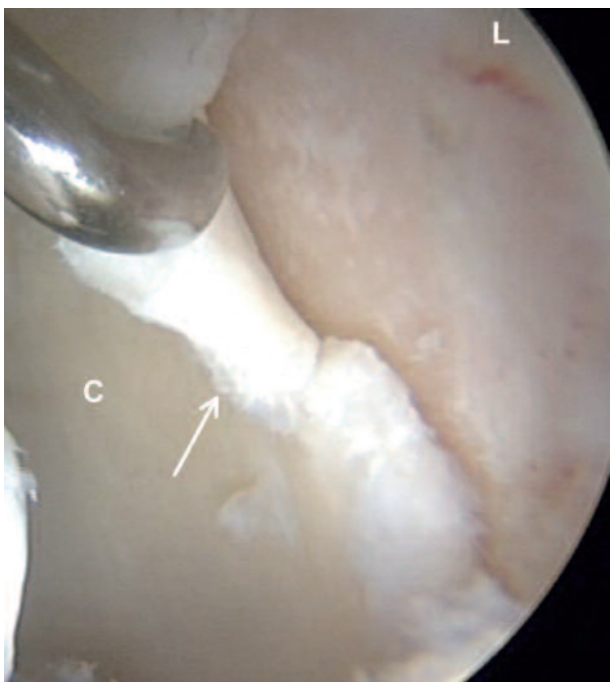

Fig. 1c. — Cartilage delamination between 1-2/3 of the distance between the acetabular rim and the cotyloid fossa (grade 3).

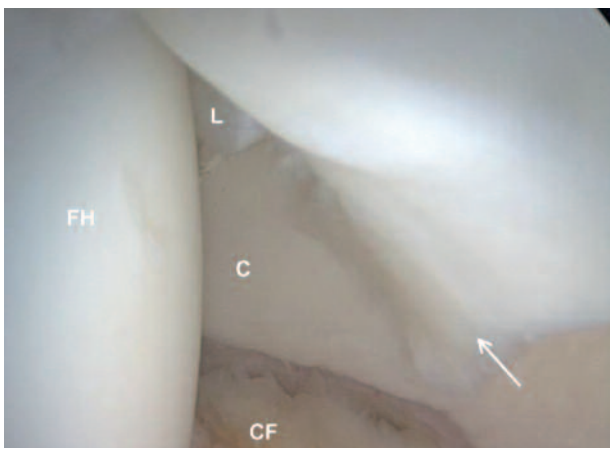

Fig. 1d. — Cartilage delamination > 1/3 of the distance between the acetabular rim and the cotyloid fossa (grade 4). L indicates labrum ; C, normal acetabular cartilage ; FH, femoral head ; acetabular cartilage lesion (arrow) ; CF, cotyloid fossa.

Only 7 patients (13.5%) had no acetabular cartilage lesion nor labral tear. Statistical analysis demonstrated a high correlation between age and the presence and extent of acetabular cartilage and labral lesions ($r = 0.70$; $p < 0.0001$ and $r = 0.45$; $p < 0.001$ respectively) (fig 2). We found a high correlation between the extent of the acetabular cartilage lesion and the presence of labral lesions ($r = 0.62$; $p < 0.0001$). No significant correlation was found between gender and acetabular cartilage and labral lesions ($r = 0.03$; $p = 0.83$ and $r = 0.17$; $p = 0.24$ respectively).

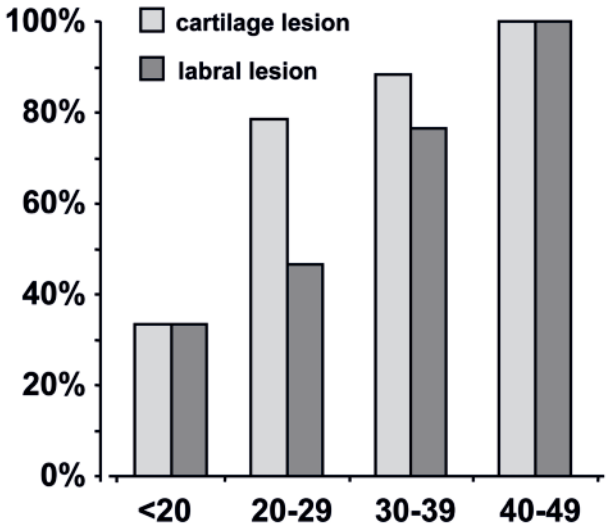

Fig. 2. — Incidence (in percent) of the presence of associated lesions per age group.

DISCUSSION

Surgical treatment of FAI focuses on improving the clearance of hip motion. Traditionally this has been performed by an open surgical dislocation technique with very encouraging clinical results (*2,6,8,20,24*). However, the morbidity and prolonged rehabilitation time of open surgical dislocation cannot be ignored (*9*). There is also a relatively high risk of reoperation directly related to the surgical dislocation approach (*2*). The minimally invasive nature of hip arthroscopy makes it a very attractive alternative to treat FAI, both for the surgeon and the patient (*12*). Some recent reports show promising short-term follow-up results (*12,25,27,33*) with good restoration of the femoral offset (*28*). Arthroscopic techniques have been able to achieve adequate decompression of the head-neck junction with results comparable to those of the open procedure (*29*). However, experience in arthroscopic techniques for the hip joint is mandatory to avoid either insufficient resection with insufficient correction or too extensive resection with a risk of femoral neck fracture (*12,27*).

Associated lesions in FAI have recognised consequences on outcome. Although two authors have not found a correlation between cartilage damage and outcome (*2,8*), most reports demonstrate poorer results with more advanced cartilage damage (*6,11,24,27,28,32*). Histological investigations of resected labra showed that the tip of the labrum remains uninvolved in FAI and that the interface between the border of acetabular cartilage and the base of the labrum showed substantial degeneration (*13*). A recent study demonstrated superior results for patients treated with labral refixation compared to labral resection (*15*). Lage *et al* (*16*) described a classification system for labral tears in terms of aetiology and morphology.

Currently, different staging systems for cartilage lesions in FAI are used (table III). Normal radiographs lack the sensitivity to assess subtle changes associated with early osteoarthritis secondary to FAI and do not exclude the existence of cartilage lesions. However the Tönnis radiographic staging system (*31*) is still frequently used to compare outcomes after osteochondroplasty (*6,8,25,29*). The majority of previous authors who evaluated cartilage damage in FAI intraoperatively used the Outerbridge classification to grade the lesions (*12,20,25,26,28*) ; this classification was originally developed to grade cartilage lesions of the knee caused by hyperpressure (*23*). However, acetabular cartilage damage in FAI is caused by abutment of the femoral neck against the superolateral rim, causing a localised cartilage lesion (*6*). Fluid penetration between the cartilage and the exposed subchondral bone will lead to delamination of the acetabular cartilage which is progressive over time. Johnston *et al* used the Outerbridge classification for chondral damage along with the size of the lesion in reference to an arthroscopic probe (*15*). Beck *et al* modified the Outerbridge classification to describe the lesions specific to FAI (*2,6*), but the extent of the lesion which is an important aspect of the treatment and outcome is not included in this evaluation.

Although in our study only patients with Tönnis grade 0 and I were included, a significant number (27 of 52 patients) had extensive chondral damage with a delamination type injury. Labral tears were less commonly found, but were still present in more than 50% of our patients (29 of 52 patients). We found a high correlation between age and acetabu-

Table III. — Reports on acetabular cartilage lesions in FAI

Technique	Author(s)	Year (Journal)	No. of Patients	Classification cartilage lesions	Treatment	Comments
Open surgical dislocation of hip	Beck *et al*	2004 (*Clin Orthop*)	19	Beck and Tönnis ; 18 patients with cartilage lesion	not specified	5 patients converted to THA, 4 had Grade 2
	Espinosa *et al*	2006 (*J Bone Joint Surg Am*)	141	Tönnis and depth of cartilage lesion	debridement	no correlation between Tönnis and Merle d'Aubigné
	Peters *et al*	2006 (*J Bone Joint Surg Am*)	30	Tönnis and Outerbridge ; 2 grade 0, 8 grade I or II, 20 grade III or IV	varied	8/10 patients with progression Tönnis had grade III or IV
	Beaulé *et al*	2006 (*J Bone Joint Surg Am*)	37	Beck ; 2 type 3, 20 type 4, 6 type 5	debridement back to stable cartilage	no correlation between cartilage damage and clinical outcome
Arthroscopic	Sampson	2005 (*Tech Orthop*)	158	Outerbridge	debridement back to stable cartilage	poorer results and longer recovery with grade III
	Guanche *et al*	2006 (*Arthroscopy*)	10	not specified	drilling or microfracture	patients without cartilage damage did significantly better
	Wettstein *et al*	2006 (*Orthopäde*)	15	Noyes ; 3 central grade II, 11 anterolateral Grade I-II, 2 anterolateral Grade III with delamination	debridement and or microfracture	
	Philippon *et al*	2007 (*Knee Surg Sports Traumatol Arthosc*)	45	Outerbridge ; 17 grade I-III, 21 grade IV	chondroplasty and or micro-fracturing	3 patients with diffuse OA did not return to professional sport
	Ilizaliturri *et al*	2008 (*Arthroscopy*)	19	Outerbridge ; 16 grade III or IV	resection unstable cartilage and microfracture	
	Stahelin *et al*	2008 (*Arthroscopy*)	22	not specified ; 14 chondromalacia, 7 delamination	debridement and or microfracture	poorer results Tönnis grade I or II
Combined arthroscopic and limited open	Clohisy *et al*	2005 (*Iowa Orthop J*)		not specified	debridement	

lar cartilage lesions or labral lesions. The high correlation between acetabular cartilage lesions and labral lesions has been reported previously (*6,19*), but this could be due to the relation between age and both variables. However, this does suggest that the acetabular cartilage lesions and labral tears are part of a continuous spectrum with increasing extent according to age. This theoretically means that if FAI is found earlier, there is a greater chance of less extensive cartilage lesions and a better outcome (*6,11,24,27,28,32*). A recent study has demonstrated that patients with a higher offset alpha angle have greater acetabular cartilage damage and labral injury. In this study patients were included based on clinical findings, but the majority of them had no radiological signs of cam-type FAI with an alpha angle $< 55°$. Because associated injuries are so important to determine treatment or provide input to suggest prognosis, we developed a system to grade acetabular cartilage lesions according to their extent. The proposed treatment methods are based on our personal experience and treatment options discussed in the literature (table III). This provides the surgeon with a standardised tool to better describe the full extent of the injury and treat it accordingly.

The proposed method of cartilage lesion description was designed to be intuitive, thus minimising the need for formal memorisation. The system is comprehensive but not all inclusive to avoid adding to the complexity of the proposed system. Therefore, we describe labral tears and femoral cartilage damage separately according to the classification of Lage *et al* (*16*) and Outerbridge (*23*) respectively. This system for acetabular cartilage lesions provides a basis for evaluation and communication, to define the natural history, and to compare treatment modalities and results.

In the future, a prospective evaluation of proposed treatment methods and comparison of the results according to the grade of cartilage lesion is planned. It has been generally agreed that FAI can cause a progressive degenerative process and lead to early osteoarthritis (*14,30*), so long term follow-up studies are needed to further evaluate the result of surgical intervention on the prevention of early osteoarthritis. We believe our classification system offers a valuable basis and foundation for future treatment recommendations and follow-up studies.

CONCLUSION

There is a high prevalence of associated injuries in patients with cam-type FAI. Despite the recognized consequences of associated lesions on treatment and outcome, no classification system includes this aspect of FAI. Based on our findings, we developed a system to grade acetabular cartilage lesions according to their morphology and extent. This information can help to define the natural history of cam-type FAI, to determine appropriate treatment, and to compare results.

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