Viability assessment of the chondral flap in patients with cam-type femoroacetabular impingement: a preliminary report

Brad Meulenkamp, MD
Denis Gravel, MD
Paul E. Beaulé, MD

From the Ottawa Hospital, Ottawa, Ont.

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Correspondence to:
B. Meulenkamp
Division of Orthopaedic Surgery
The Ottawa Hospital, General Campus
501 Smyth Rd., Room W1636, Box 502
Ottawa ON K1H 8L6
brad.meulenkamp@gmail.com

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Background: Delaminated acetabular cartilage is a common finding in patients undergoing surgical dislocation or hip arthroscopy in the treatment of cam-type femoroacetabular impingement. Current treatment involves resection of the free cartilage flap with or without acetabular rim trimming. The viability of the delaminated cartilage flap is not known. We sought to examine if the acetabular cartilage still has viable cartilage cells and, if so, what type of cartilage is present.

Methods: We examined the delaminated cartilage flaps from patients undergoing surgical dislocation and osteochondroplasty for symptomatic cam-type impingement. We performed hematoxylin and eosin staining and histological analysis using light microscopy to determine cartilage viability and cartilage type.

Results: We examined 12 delaminated cartilage flaps from 11 patients (10 men, 1 woman, average age 30.1 yr). Ninety percent chondrocyte viability was confirmed in 11 of 12 flaps. Six of 12 flaps were composed predominantly of hyaline cartilage, 4 were a mixed population of fibrocartilage and hyaline cartilage and 2 were predominantly fibrocartilage.

Conclusion: Our findings suggest that the delaminated cartilage flap in patients with femoroacetabular impingement may retain a large amount of viable chondrocytes. Development of surgical techniques focusing on refixation of this flap as an alternative to excision and microfracture should be considered.

Contexte : La présence d'un cartilage acétabulaire délaminé s'observe souvent chez les patients qui subissent une dislocation chirurgicale ou une arthroscopie de la hanche pour le traitement du conflit fémoro-acétabulaire de type came. Le traitement actuel repose sur la résection du lambeau articulaire libre, avec ou sans résection du rebord acétabulaire. La viabilité du lambeau de cartilage délaminé est inconnue. Nous avons voulu vérifier si le cartilage acétabulaire conserve des cellules de cartilage viables et le cas échéant, quel type de cartilage est présent.

Méthodes : Nous avons examiné les lambeaux de cartilage délaminés provenant de patients soumis à une dislocation et ostéochondroplastie chirurgicales pour un conflit de type came symptomatique. Nous avons procédé à une coloration à l'hématoxyiline et à l'éosine, ainsi qu'à une analyse histologique par microscopie optique pour déterminer le type de cartilage et sa viabilité.

Résultats : Nous avons examiné 12 lambeaux de cartilage délaminé provenant de 11 patients (10 hommes, 1 femme, âgés en moyenne de 30,1 ans). La viabilité des chondrocytes a été confirmée à 90 % pour 11 lambeaux sur 12. Six lambeaux sur 12 se composaient surtout de cartilage hyalin, 4 étaient un mélange de fibrocartilage et de cartilage hyalin et 2 étaient principalement du fibrocartilage.

Conclusion : Selon nos observations, le lambeau de cartilage délaminé chez les patients qui présentent un conflit fémoro-acétabulaire peut conserver une forte proportion de chondrocytes viables. Il faut envisager la mise au point de techniques chirurgicales axées sur la « refixation » de ce lambeau comme solution de rechange à l'exérèse et à la microfracture.

Femoroacetabular impingement (FAI) is a spectrum of hip pathology that is characterized by abnormalities on both the femoral and acetabular side of the hip joint.[1–3] Femoroacetabular impingement is proposed to be a structural etiology causing the hip joint to fail prematurely, similar to developmental dysplasia of the hip, Legg–Calvé–Perthes syndrome and slipped capital femoral epiphysis.[1,4,5]

Cam-type FAI is characterized by abnormal proximal femoral anatomy with a decreased femoral head–neck offset. The resultant nonspherical head and anterolateral "bump" impinges on the acetabular rim, resulting in "outside-in" damage through repetitive compressive and shear stresses, most commonly in the anterosuperior aspect of the acetabulum. These stresses have been shown to result in delamination of the acetabular cartilage at the chondrolabral juntion.[6,7] Cartilage delamination flaps have been documented at the time of surgery for FAI, with an incidence of 44%–75% (Fig. 1).[8–13] Most flaps are classified as being either type 3 (carpet phenomenon) or 4 (cleavage), as per the Beck Classification (Table 1).[14] The current preferred treatment is flap excision, followed by subchondral microfracture[15] for fibrocartilage fill. More recently, some have proposed cartilage refixation using a fibrin adhesive.[16]

While the cartilage flaps seem to be macroscopically normal, the viability of the cartilage flaps has yet to be investigated. The purpose of this study was to determine if the acetabular cartilage still has viable cartilage cells and, if so, what type of cartilage is present.

Methods

We performed a retrospective review of a consecutive sampling of cartilage flaps from patients undergoing osteochondroplasty for symptomatic cam-type FAI between September 2008 and November 2010. Cartilage flaps were excised as encountered in this patient population. Demographic data were retrospectively reviewed from a prospectively collected database. The Ottawa Hospital Research Ethics Board approved our study protocol, and patients provided informed consent to participate.

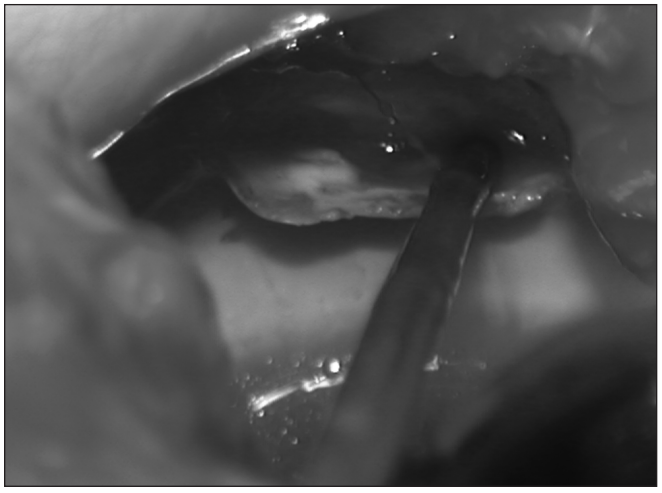

Fig. 1. Intraoperative photograph demonstrating cartilage delamination at the anterosuperior acetabulum.

All patients underwent surgical dislocation and osteochondroplasty for symptomatic cam-type FAI. Diagnosis of FAI was based on a clinical history of persistent hip pain for more than 6 months, limited internal rotation on physical examination at 90° of hip flexion and a positive impingement sign. All patients had a standardized medical imaging workup with an anteroposterior radiograph and specialized lateral radiograph, and hips were given a Tonnis grade of osteoarthritis[17] based on the most recent radiographs before surgery. All patients had a labral tear diagnosed using magnetic resonance inaging with gadolinium arthrography (MRA). To quantify the cam deformity, a senior musculoskeletal radiologist measured the α angle using preoperative magnetic resonance imaging (MRI).

All surgeries were performed by the senior author (P.E.B.) in an academic institution. A lateral approach with trochanteric flip was used to approach the hip, which was dislocated anteriorly. Osteochondroplasty was then performed to restore appropriate femoral head–neck offset. The acetabulum was visualized and a grading was given to the acetabular cartilage damage according to the criteria of Beck and colleagues[14] (Table 1). Labral tears were either debrided to a stable edge or taken down and refixed to the acetabular rim using suture anchors. Fibrin refixation of the remaining chondral flap was performed in cases of lesions extending to the fovea.

Cartilage flaps were excised when encountered at the time of surgery if they were deemed unstable after inspection and probing (Beck grade 3 minimum). They were oriented and sent to a single musculoskeletal pathologist (D.G.) in 10% buffered formalin and embedded in paraffin. The samples then underwent sectioning and staining with hematoxylin and eosin. The musculoskeletal pathologist then assessed the cartilage viability under light microscopy. The percent of viable chondrocytes was determined by the proportion of lacunae-containing viable cells with a nucleus, and absence of degenerative features of

Table 1. Beck classification of acetabular cartilage damage[7]

Stage	Description	Criteria
0	Normal	Macroscopically normal cartilage
1	Malacia	Surface roughening and fibrillation
2	Pitting malacia	Roughening, partially thinning and full-thickness defects or deep fissuring to the bone
3	Debonding	Loss of fixation to the subchondral bone, macroscopically sound cartilage, carpet phenomenon
4	Cleavage	Loss of fixation to the subchondral bone, frayed edges, thinning of the cartilage
5	Defect	Full-thickness defect

necrosis, karyorrhexsis or karyolysis. This was performed by identifying the least viable area of the sample, and counting viable and nonviable cells over 10 high power fields. For cartilage characterization, full sections were scanned under light microscopy to determine the predominant cartilage matrix as either hyaline (homogenous matrix), fibrocartilage (fibril matrix) or mixed. Owing to matrix overlap, samples were assigned to 1 of 3 subgroups; predominant hyaline cartilage, predominant fibrocartilage or mixed cartilage.

Statistical analysis

We performed 2-sided Student *t* tests and χ^2 tests to identify differences between groups.

Results

During the study period, 141 patients (114 men, 37 women, mean age 38.6 [range 16–59] yr) were treated surgically for FAI. A consecutive sampling of 12 cartilage flaps was excised from 11 of these patients, 1 of whom underwent a bilateral procedure. Our sample consited of 10 men and 1 woman with a mean age of 30.1 (range 21.5–42.4) years. The demographic and clinical characteristics of the sample are summarized in Table 2. No patients had undergone prior hip surgery. Labral tears were débrided to a stable edge for 9 hips and taken down and refixed to the acetabular rim using suture anchors for 3 hips. One patient underwent fibrin refixation of the remaining chondral flap owing to the lesion extending to the fovea.

Eleven of 12 flaps contained more than 90% viable chondrocytes, whereas the other flap contained 40% viable chondrocytes (Fig. 2). Six of 12 (50%) flaps contained predominantly hyaline cartilage (Fig. 3), 4 (33%) contained mixed hyaline and fibrocartilage and 2 (17%) contained predominantly fibrocartilage (Fig. 4). Age (p = 0.69), body mass index (p = 0.81), α angle (p = 0.69) and Tonnis grade (p = 0.57) were not significant risk factors for a predominance of one cartilage type over another.

Table 2. Demographic and clinical characteristics of our study sample

Patient	Sex	Age, yr	Side	BMI	α angle	Tonnis grade	Beck grade
1	Male	21.5	Right	25.0	60.3	0	4
2	Male	26.1	Right	25.2	60.5	1	4
3	Male	24.0	Right	20.8	66.0	0	3
4	Male	37.1	Right	27.1	72.0	1	4
5	Male	23.5	Right	24.6	70.3	0	4
6	Male	31.8	Right	28.1	68.5	1	4
	Male	31.8	Left	28.1	75.0	1	4
7	Male	35.2	Left	25.0	72.3	1	4
8	Male	24.6	Right	30.9	80.0	0	4
9	Female	42.4	Left	25.3	64.3	0	5
10	Male	30.8	Right	26.8	58.0	1	4
11	Male	32.0	Right	25.6	73.0	1	4

BMI = body mass index.

Discussion

Femoroacetabular impingement is a structural abnormality of the hip joint that may result in early osteoarthritis.[1,4,5] The goals of surgical management of FAI are to provide symptomatic relief in the short term and to prevent progression of osteoarthritis in the long term.[18] Surgery has been shown to improve pain and function scores in 65%–96% of patients at short-term follow up.[19,20] Risk factors for poor outcome have been found to include patients with advanced arthrosis (Tonnis grade 2 or 3) on preoperative imaging[21,22] and either chondral or labral disease identified intraoperatively.[23] Cam-type impingement is associated with cartilage delamination.[8,9,12,13] Usual management strategies for cartilage flaps include cartilage resection and subchondral microfracture and acetabular rim-trimming with labral advancement.[18,24,25] Intuitively, the capacity to preserve native cartilage would be preferable, as formation of fibrocartilage can be unpredictable, and a zone completely devoid of cartilage leads to eccentric wear and progression of arthritis. As such, the purpose of this study was to determine if the acetabular cartilage flap still has viable chondrocytes and, if so, what type of cartilage is present, permitting us to hypothesize the possible success of cartilage refixation.

Limitations

Limitations of the study include the small sample size, which unfortunately did not allow for identification of patient subgroups with risk factors for either nonviable

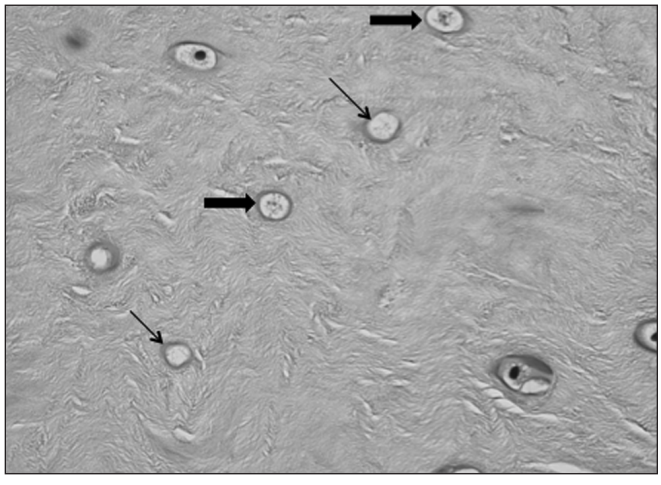

Fig. 2. Light microscopy image of hematoxylin and eosin stain of cartilage from patient 6, right hip. Nonviable chondrocytes are represented by either empty lacunae (thin arrows) or lacunae containing nuclear debris (thick arrows). Viable chondrocytes are seen with darkly stained nucleus within the lacuna.

cartilage or inferior fibrocartilage. In addition, hematoxylin and eosin staining provides only a "snapshot" of the cartilage, demonstrating signs of viability. However, the degeneration process is dynamic, so it is possible to overestimate true viability with this method. A more direct intraoperative assessment of the cartilage flap viability would be the most efficient means of deciding on the appropriate management: refixation or excision. Surgical tools are currently being developed to assess cartilage viability in real time as well as preoperatively using quantitative MRI techniques.[26] Despite the limitations, our results raise the possibility of using flap refixation as an alternative to excision. This may present surgeons with another tool to slow progression of osteoarthritis in patients with cam-type FAI.

Our findings are in keeping with recently reported histological findings in acetabular cartilage biopsies at the acetabular rim in patients with cam-type, pincer or mixed FAI.[27] This group's findings included a mixed population of fibrocartilage and hyaline cartilage in hips with cam-impingement with overlying degenerative changes and tangential tears of the cartilage. Hips with pincer impingement demonstrated focal areas of severe damage, radial tears in the cartilage with mixed populations of viable and nonviable cells. Hips with mixed type of impingement demonstrated histological features of both types. Our results corroborate these findings, indicating that there is a large number of viable chondrocytes in the delaminated acetabular cartilage. The variable amounts of hyaline and fibrocartilage likely represent cartilage repair in response to repetitive microtrauma in the zone of impingement. A single hip in our group (patient 6) had less than 90% chondrocyte viability. This patient was the only one undergoing a bilateral procedure. We were unable to identify any hip-specific factors associated with this deviation by reviewing the α angle, Tonnis grade and Beck grade. Of note, this sample was from the first of his 2 hips undergoing osteochondroplasty, and as such was delayed in its transfer to the formalin solution. We may infer that this delay could have resulted in desiccation and further degeneration of the sample; however, we are unable to provide a definitive explanation for the discrepancy.

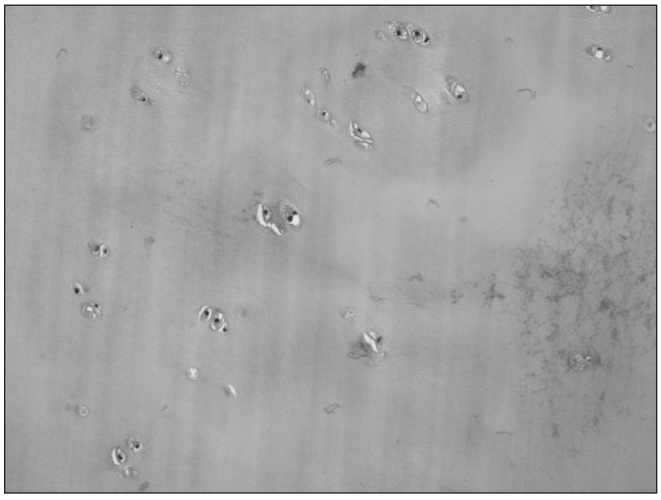

Fig. 3. Light microscopy image of viable hyaline cartilage. Darkly stained nuclei are seen within the lacunae, embedded in the homogenous matrix of hyaline cartilage.

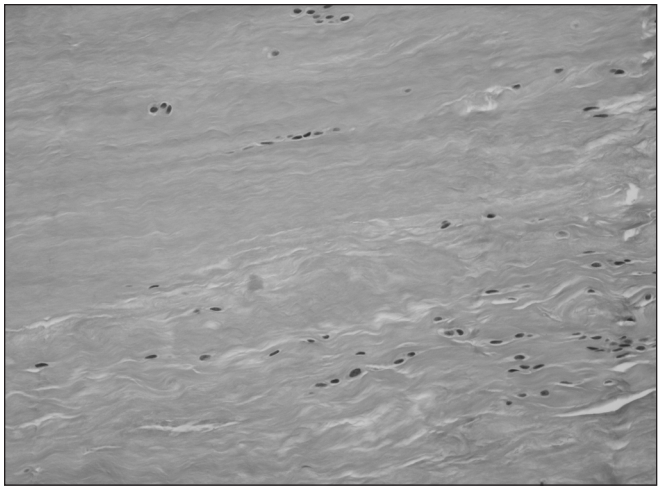

Fig. 4. Fibrocartilage image under light microscopy. Viable chondrocytes embedded in the heterogenous, fibrillated matrix characteristic of fibrocartilage.

The strength of our study is that we performed an objective assessment that demonstrated consistent results for cartilage viability. Recent literature suggests that refixation of the cartilage flap with a fibrin adhesive could provide the most favourable result in regards to joint preservation.[16] Harris hip scores for pain and function were found to be significantly better at midterm follow up. Our results provide more evidence that refixation could indeed be reasonable to consider when flaps are encountered in surgery, although further viability assays are needed. Work must now focus on determining what techniques are optimal for chondral refixation and how to better identify patients with severe chondral disease.

Conclusion

Confirming that the acetabular flap in patients with cam-type FAI contains histologically viable cartilage further validates primary repair rather than resection of these lesions when encountered. The work by Stafford and colleagues[16] has demonstrated promising results with flap refixation at midterm follow-up. Conducting longer term repair outcome studies and developing tools to better identify these patients may allow the clinician to further prevent progression of hip osteoarthritis in this select population.

Competing interests: None declared.

Contributors: B. Meulenkamp and P.E. Beaulé designed the study and wrote the article. All authors acquired and analyzed the data, reviewed the article and approved the final version for publication.

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