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Arthroscopic Treatment of Acetabular Cartilage Lesions in Cam-Type Hip Impingement with Membrane Induced Chondrogenesis versus Microfracturing

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Abstract: We report on a consecutive series of patients with cam type FAI (femoro-acetabular impingement) with acetabular cartilage rim lesions larger than 150 mm^2 that were treated with an arthroscopic AMIC (Autologous Matrix Induced Chondrogenesis) procedure and compared these patients to a matched cohort of patients who underwent an arthroscopic microfracturing. The AMIC group consisted 16 patients with a mean age of 34. Mean follow up is 38 months. Sixteen age and sex controlled patients who underwent an arthroscopic microfracturing of a similar size cartilage lesion were used as a comparative study group with a mean follow up of 41 months. No complications and no adverse reactions were seen, and all patients would have the same surgery again. We report 2 failures in the AMIC group with conversion to THR (Total Hip Replacement) at 8 and 36 months, respectively. In the microfracturing group, there were 3 conversions to THR after 12, 14 and 24 months. The HHS (Harris Hip Score) was 96.5 in the AMIC group and 93.5 in the microfracturing group. Patients had significantly less symptomatic synovitis postoperatively in the AMIC group and more athletes could resume their activities to the pre-injury level in this group. In conclusion, AMIC offers promising results in the treatment of cartilage lesions in patients with cam-type FAI.

Key words: FAI, cartilage lesions hip, arthroscopy, AMIC.

1. Introduction

Cam-type FAI (Femoro Acetabular Impingement) typically produces acetabular cartilage lesions that can be quite extensive in young and active patients. These cartilage lesions start at the periphery and are typically located anterosuperiorly in the area of impingement. The end stage of the pathology can be generalised osteoarthritis, and cam-type FAI has been recognised as the leading cause of hip osteoarthritis in young adults [1]. Other types of impingement (pincer and mixed type) and hip dysplasia confound the treatment algorithm and make comparison of cartilage treatment results difficult. The treatment of cam-type FAI has been established over recent years, and both open and arthroscopic femoroplasty lead to a successful clinical outcome in the short term, if performed adequately. The treatment of the acetabular cartilage lesions is much debated, and not clearly established at present. The golden standard in the hip is still microfracturing or icepicking as reported by Philippon et al. [2]. Many advances have been made in the treatment of cartilage lesions in recent years. ACI (Autologeous Chondrocyte Implantation) with Chondrogide® was first described in the knee joint by Haddo [3], and only few cases were reported in the hip joint. The procedure necessitates 2 surgeries and is extremely costly. Again in the knee joint, AMIC (Autologeous Membrane Induced Chondrogenesis) was reported to be equally successful to ACI by Anders et al. [4]. The AMIC procedure combines the ease and reproducibility of the technique described by Steadman et al. [5], and the advantages of using a collagen membrane to fill the cartilage defect as in the ACI technique with Chondrogide membrane impregnated with chondrocytes, but with a lower cost

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due to the absence of chondrocyte culture. The Chondrogide® membrane is a biodegradable collagen membrane that is CE-marked for the use in cartilage repair, and reported to be safe in the human body. There are no reports to date of adverse reactions to the membrane, and it is in clinical use since 2004. The membrane is fabricated from porcine collagen and produced and marketed by Gheistlich, Switzerland. In 2012, Fontana reported the use of the AMIC procedure in the hip joint [6]. He reported similar results with ACI and AMIC. We started using the technique in 2011 and used the technique described by Fontana.

We present a prospective consecutive series of 16 patients who underwent an arthroscopic AMIC procedure and femoroplasty for isolated cam-type FAI and compare these results to an age and cartilage size matched cohort of 16 patients from our database who underwent a standard microfracturing procedure. Outcome measures were HHS, UCLA Activity Score, Oxford Hip Score, conversion to THR and patient satisfaction. Secondary outcome measures were return to sports, radiographic signs of osteoarthritis, and the need for adjunctive medical therapy for hip synovitis during the first postoperative year.

2. Material and Methods

2.1 Patient Selection

In 2012, we performed the AMIC procedure with Chondrogide® membrane in 16 consecutive patients with cam-type FAI (Group A). Patients with mixed or pincer type FAI were excluded from the study. Patients older than 18 and younger than 50 were included. We defined the following contra-indications for the AMIC procedure: generalised osteoarthritis of the hip (presence of osteofytic reaction in the fossa acetabuli, extensive cartilage lesions in more than one zone combined with generalised cartilage thinning and/or breakdown, radiographic signs of osteoarthritis), metabolic arthropathy, chronic inflammatory systemic disease and patient allergy to porcine collagen. Inclusion criteria for the study were full thickness isolated full thickness acetabular cartilage lesions greater than 150 mm^2 and smaller than 450 mm^2, as measured and calculated intra-operatively with a calibrated teaser after debridement of the lesions and stabilisation of the articular margins. On radiographic examination the hip had to be Tönnis grade < 2, CE-angle measured on AP X-ray > 25° and < 35°, absence of cross-over sign, and presence of cam-type FAI. The presence of cam impingement was confirmed on AP Hip and cross-table lateral X-Rays, with alfa-angle being > 65°. Intra-operatively the cartilage lesion had to be isolated and limited to the periphery of the acetabulum, absence of femoral cartilage lesions, intact ligamentum teres on visual inspection, and intact labrum or anatomically and functionally equivalent labrum after repair. Hips not meeting all inclusion criteria were excluded from the study. Patients typically presented with hip pain, reduced range of motion typically in internal rotation measured with the hip in 90° of flexion, and all had positive hip impingement tests. Sixteen patients (3 female, 13 male) were included in this series. Average age at the time of surgery was 34 years (range 20-48).

An age- and pathology- matched control group of patients treated with a microfracturing procedure was selected from our database of patients (Group B). In this control group, 16 patients (3 female, 13 male) with an average age of 36 years (range 24-49) at the time of surgery were included. Inclusion criteria were identical to group A. Exclusion criteria for this control group were the same as for the AMIC group, except for the allergy to porcine collagen. All procedures were executed by the same experienced hip surgeon (JS).

All patients in both groups were examined clinically by the same examiner (SG) and had standard radiographs of the pelvis (standing) and hip (AP and cross table lateral views). Patients were clinically scored preoperatively, at 1 and 2 years and at final follow-up. They had X-rays preoperatively, at 3 weeks postop and at final follow-up. They were also clinically evaluated at 3, 10 and 24 weeks after surgery. Reoperations with conversion to THR (Total Hip

Replacement) were regarded as failures and were not scored at final FU. All patients in both groups were assessed with the HHS (Harris Hip Score) and the UCLA-activity score preoperatively and at final follow-up. Hip range of motion was assessed, and internal and external rotation was measured with the hip flexed to 90 °. Patient reported subjective outcome was obtained using the Oxford Hip Score and evaluated "would have/have not surgery again". Patients were graded preoperatively and at FU for their pre-injury sporting activities: recreational sport, competition sport and high-level competition athletes. Competition and high-level athletes were graded at FU as "same-level" or "lower-level" as compared to pre-injury level. Traction times and complications were noted.

Statistical analysis was performed in SPSS using standard student *t*-test with two-sample equal variances in a two-tailed distribution. *P*-values were calculated; significance limit was < 0.05.

Ethical approval for this study was obtained, and consent was obtained from all patients, according to the guidelines of the Ethical Committee of the hospital.

2.2 Surgical Technique

Patients received one dose of 2 grams of cefazoline intravenously before surgery. All surgeries were performed under general anaesthesia with the patient supine on a traction table. Central compartment was addressed first. Traction times were recorded. All surgery was performed through 2 conventional portals: the anterolateral and midanterior portal as described by Philippon. Cartilage lesions were delineated and debrided. The calcified layer on the subchondral bone was removed using a curette, and microfracturing was performed using a large picker (Smith & Nephew, Andover). Typically 4-5 small holes were made per cm^2. The labrum was addressed; if deemed necessary it was repaired using BioRaptor knotless anchors (Smith & Nephew, Andover). It was verified that the acetabular cartilage defect was surrounded with stable and healthy cartilage centromedially and with a well-functioning labral seal on the periphery. The cartilage defect was measured with a calibrated curved teaser and the Chondrogide® membrane was sized accordingly to have a complete fill of the defect, but without any overhang over remaining cartilage. Typically a medium size membrane can be used. The membrane was marked with a surgical pencil on the articulating side, to help correct placement in the joint. For placement of the membrane into the joint, we advocate to use an anterolateral viewing portal with a sleeved cannula in the midanterior portal. A suction drain was placed into the joint and the joined was aspirated dry, allowing air inflow from the viewing cannula. The membrane was introduced and placed correctly into the defect with the use of a curved grasper. A Fowley catheter was introduced into the joint and inflated with 10 cc air, hereby compressing the membrane onto the subchondral bone. One can verify this process by placing the camera lens against the balloon of the catheter and viewing through the catheter. The catheter was then removed and it was verified that the membrane was well adhering to the underlying bone. Cadaver work by Fontana has confirmed the membrane adheres well to the concave acetabulum, without the need of glue or sutures (personal communication). Traction was then released. Saline inflow was re-established and the peripheral compartment addressed. Femoroplasty was performed through the same portals, after locating the subcapital perforating vessels laterally. The hip was dynamically checked through a full ROM (range of motion), ensuring that the impingement was adequately addressed. Fluoroscopy was used during the femoroplasty to increase accuracy of this procedure. After lavage, the hip joint was distracted again and a final view was established onto the membrane. In all cases, the membrane was *in situ* and a nice fibrin clot had formed (Fig. 1).

2.3 Postoperative Management

Patients were allowed to regain full ROM from day 1

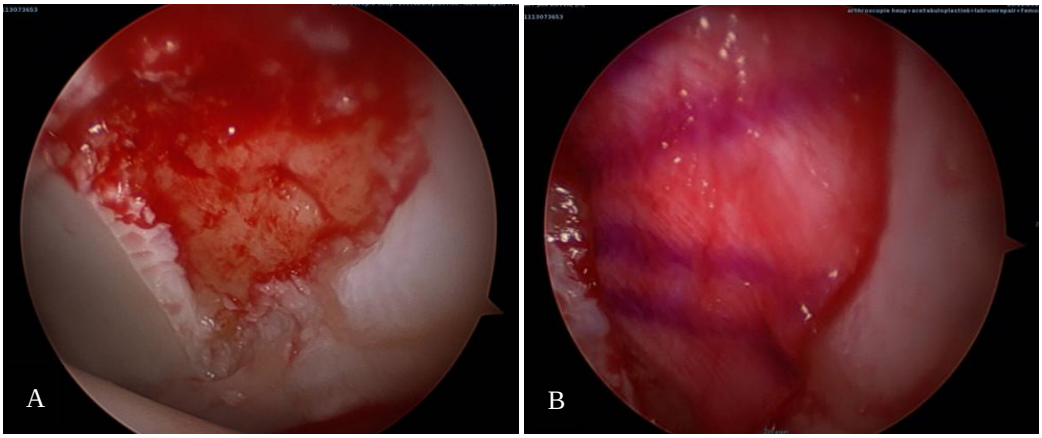

Fig. 1 Hip arthroscopy view of acetabular cartilage lesion after debridement and icepicking. (A) Dry view showing bleeding of the subchondral bone; (B) Same view after application of Chondrogide® Select membrane.

after surgery. They were kept on crutches for 6 weeks, allowing touch down weight-bearing. They received one dose of indomethacine 100 mg on day 0, and ibuprofen 600 mg 3 times daily for one week. No narcotics were given. Patients had mechanical foot pumps on the day of surgery; no pharmacological agents were used for VTE (Venous Thrombogenic Embolus) prophylaxis. Cycling on a stationary bike was started on day 1, and patients were instructed to gradually increase the duration of their aerobic exercises. At 4 weeks, rowing was allowed; at 6 weeks, swimming was allowed without restriction. Open chain exercises were not allowed during the first 3 months. Sport specific rehab was started between 8 and 12 weeks; running was not allowed until 6 months postoperatively. If patients presented with a painful hip joint during the first six months and a significant joint effusion was confirmed on ultrasound, they received intra-articular 20 mg (2 cc) HA (hyaluronic acid) (Ostenil Plus, TRB Chemedica AG, Germany).

3. Results

The 2 patient groups were matched for age, sex and similar cartilage defect size, but there was a tendency to larger defects in the AMIC group: average defect size was 298 mm^2 (range 200-425 mm^2) in group A vs 267 mm^2 (range 150-450 mm^2) in group B ($P = 0.38$) (Fig. 2). The mean follow-up in group A was 38 months (range 30-45 months) and 41 months (range 28-53 months) in group B (standard deviation 8.39-4.09; $P = 0.257$). The average traction time was 48 minutes for group A (range 39-54 min) and 39 minutes for group B (range 24-48 min) ($P < 0.05$). The additional traction time to apply the membrane decreased substantially over time (highest 35 min; lowest 10 min).

There was no loss to follow-up and the fate of all hips is known. No surgical complications were observed in either group. There were no VTE-events in this series. There were no infections. One patient (group B) died during the study period, 16 months after the index surgery, to the consequences of an aggressive neurotumour. At one year postoperatively, he had returned to recreational athletics and was graded as a perfect result (UCLA 10; WOMAC 100). Subjectively all patients in both groups would have the same surgery again. Oxford Score was 96/100 in group A (range 90-100) and 91/100 (range 79-100) in group B ($P = 0.25$).

One patient in group A was converted to THR within the first year after surgery in another centre, although he was pain-free in daily life and with cycling at his 6 month visit. Apparently he got symptomatic upon starting jogging exercises 7 months after surgery. Another patient was converted to THR after 3 years because of increasing pain in the hip. At the 2 year visit, she was slightly symptomatic and achieved the lowest clinical score of her group. At final follow-up, 3 patients in group B have been converted to THR:

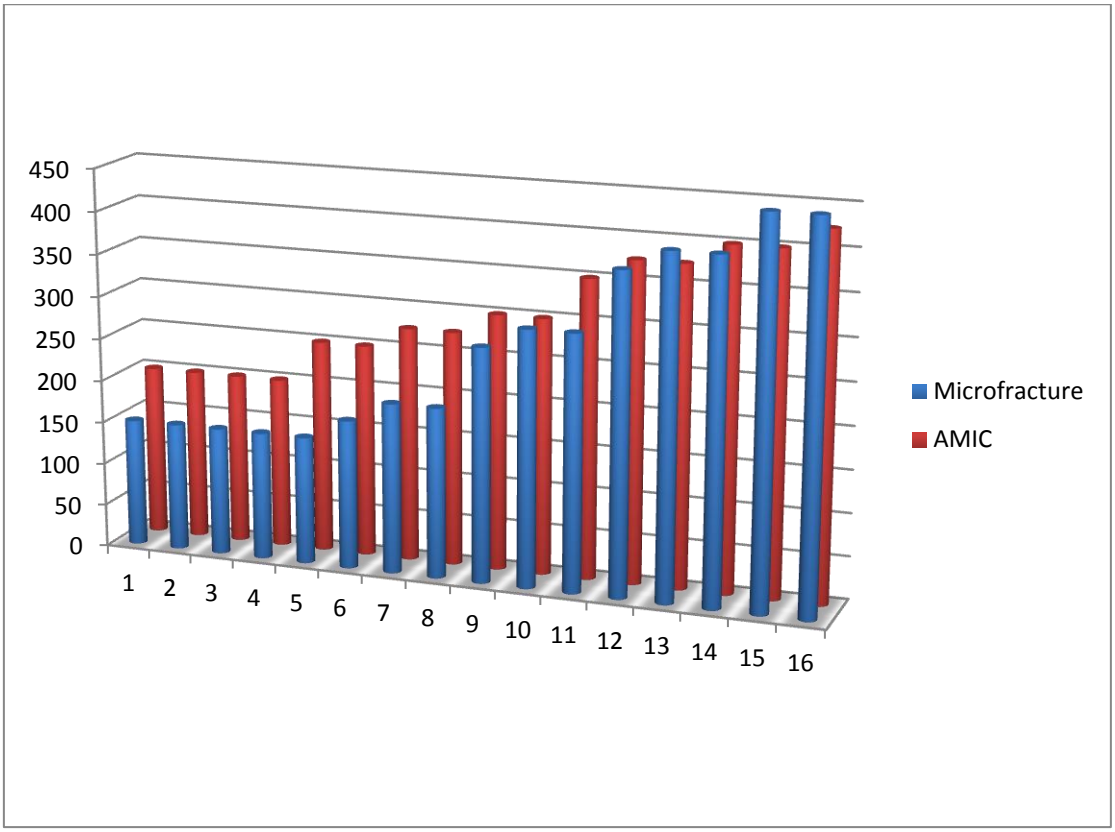

Fig. 2 Comparison of defect size of group A and group B. X-axis represents patients 1-16 and Y-axis shows size of defect in mm^3.

respectively at 12, 14 and 24 months after surgery.

Preoperative HHS was 83 in both groups and improved significantly with surgery in both groups to 94 (group A) and 93 (group B) ($P < 0.01$) at 2 years. At final FU, there was further improvement in group A to HHS 96.5. Preoperative UCLA score was 6 in both groups and improved significantly in both groups ($P < 0.01$) at 2 years (Table 1). UCLA activity score at final FU remained high at a mean of 8.9 in group A and 8.2 in group B. Although clinical scores were higher in group A, statistically no differences were found in comparing both postoperative HHS and UCLA score in between both groups (HHS $P = 0.07$; UCLA $P = 0.150$).

Internal rotation improved equally well in both groups, reflecting adequate treatment of the impingement problem. Internal rotation was between 0 and 5 ° for all patients before surgery. At final follow-up, average internal rotation was 28 ° for group A (range 20-40 °) and 27 ° (range 20-35 °) for group B. No patient in any group showed signs of stiffness. All patients in both groups regained full external rotation, flexion and extension compared to the preoperative values, within 3 months after surgery. There was no difference in range of motion between the 2 and 3 year results.

Return to sports activities was different for both groups (Table 2). No statistic correlation is shown in sports resumption because these groups are too small to compare statistically.

There was a significant difference in the presence of a painful hip with joint effusion in the first 3 months post-surgery when comparing the two groups. In group A 3 patients received an average of 2 (range 1-3) intra-articular injections with HA. In group B, 10 patients received an average of 3 (range 2-6) injections with HA ($P = 0.002$).

X-Ray evaluation at final FU showed that all surviving

Table 1 HHS and UCLA score pre-and postoperatively.

AMIC (group A)	Pre operative	2 yrs	3 yrs	*P*-value
HHS	83	94	96.5	< 0.01
UCLA	6	8.8	8.9	< 0.01
Control (group B)	Pre operative	2 yrs	3 yrs	*P*-value
HHS	83	94.2	93.5	< 0.01
UCLA	6	8.2	8.1	< 0.01

Table 2 Sports activity grading pre- and postoperatively.

	AMIC (group A)		Control (group B)	
	Preop	Postop	Preop	Postop
Failed/No Sports	0	2	0	3
Recreational Sports	3	4	4	7
Competition Sports	9	7	10	5
Same Level		*6*		*2*
Lower Level		*1*		*3*
High Level Competition	4	3	2	1
Same Level		*2*		*1*
Lower Level		*1*		
Total	16	16	16	16

hips had remained in their preop Tönnis stage, and none had signs of osteoarthritis. All patients had Alfa-angles < 65° in both planes. Of the failed hips with conversion to THR, 2 hips from group B showed signs of osteoarthritis before THR. The other failed hips showed no signs of osteoarthritis and no deterioration in Tönnis grade before THR. All 5 failed hips had Alfa-angles < 65° post surgery without signs of residual bony impingement.

4. Discussion

The treatment of cartilage lesions in the presence of cam-type FAI is challenging. These lesions are located in the anterosuperior rim of the acetabulum and tend to be quite extensive. Full thickness lesions have been treated traditionally with microfracturing, following the principles published by Philippon et al. [2]. Our results over a period of 10 years have however been varying. The difficulties and variability of results in the treatment of cartilage lesions in general has led to newer techniques. There are very few reports of treatment of cartilage lesions in the hip joint.

Fontana described the use of AMIC with Chondrogide® for the first time in the hip [6]. He showed favourable results in a mixed group of patients. He compared the results with an historic group of patients treated with ACI, but groups were not matched. He indicated that the use of the Chondrogide membrane was safe and he achieved comparable results to ACI. There is no other report in the arthroscopic literature, and no comparison has been made to the treatment with microfracturing only. Leunig et al. [7] reported the use of AMIC in the treatment of FAI by open surgical dislocation. In this clinical report, there was no comparison group, but results were favourable. We confirm that the use of the Chondrogide® membrane is safe, and technically feasible by arthroscopy. The present study shows good results with the AMIC technique in the short term with more than 80% success at 3 years. Significant improvement in clinical scores is consistent and statistically proven, as with the microfracturing only technique. The HHS and UCLA scores tended to be higher in group A, although the cartilage lesions were slightly larger. The return to sports in the AMIC group was better in comparison with the control group. This could not be proved statistically however due to the small number of patients. Patients in the AMIC group

also needed statistically less postoperative infiltrations during the initial healing period (first 3 months postoperatively), indicating less postoperative joint effusion and arthritis. This could mean that the healing process of the cartilage is faster. Interestingly, the clinical results were better at the final FU compared to the 2 year results. It seems that improvement can be expected up to 3 years after surgery. This stresses the importance to give time to healing. The unfortunate revision in another centre of one patient in group A within one year of surgery shows that patient selection and coaching of patients during rehab is important. In the absence of radiographic deterioration, it is important to know that healing can take up to 2 years and more! There were fewer failures in the AMIC group, but due to the small numbers could not be proved statistically. Therefore, we cannot prove to date that cartilage repair is better. Nevertheless, it seems plausible that repair is possibly better, since healing was faster and load tolerance (competitive sports) was higher in the AMIC group versus the microfracturing only group. Since these results suggest a difference in the healing process after both procedures and a tendency to faster recovery after AMIC procedure, second look arthroscopy would be ideal to evaluate this effect. This presents a clear ethical problem. We have had the opportunity to re-evaluate 4 hips with arthroscopy over the past years. One of these patients belongs to the present study group A. This patient had a new trauma 2 years after surgery playing soccer, where he sustained a minor labral lesion. Relook arthroscopy showed good fill of the cartilage defect (Fig. 3A). Another relook of a patient that was not part of the present study group is shown in Fig. 3B. Here the cartilage lesion is filled with a labral-looking tissue, with continuous chondrolabral junction. Philippon published a series of second look arthroscopies in patients who underwent a previous microfracturing procedure in the hip [2]. He presents a grade 1-2 repair product in 8 out of 9 patients with a nice filling of the previous defect, illustrating the effectiveness of microfracturing in cartilage lesion treatment. At this time, no similar series with second look hip arthroscopy in AMIC patients has been published. The only histology report of AMIC is from Gigante et al. [8], who describe the results in the knee joint. MRI studies would be more practical, but results are extremely difficult to interpret. We have used d-GEMRIC (delayed Gadolinium Enhanced Magnetic Resonance Imaging of Cartilage) techniques for many years, and some of the patients in both groups have been examined with both pre- and post- treatment MRI-studies. Although we have seen patients with a nice “cartilage fill” on postoperative images, we have insufficient data to make any comment in this regard. It is also extremely difficult to exactly measure the cartilage

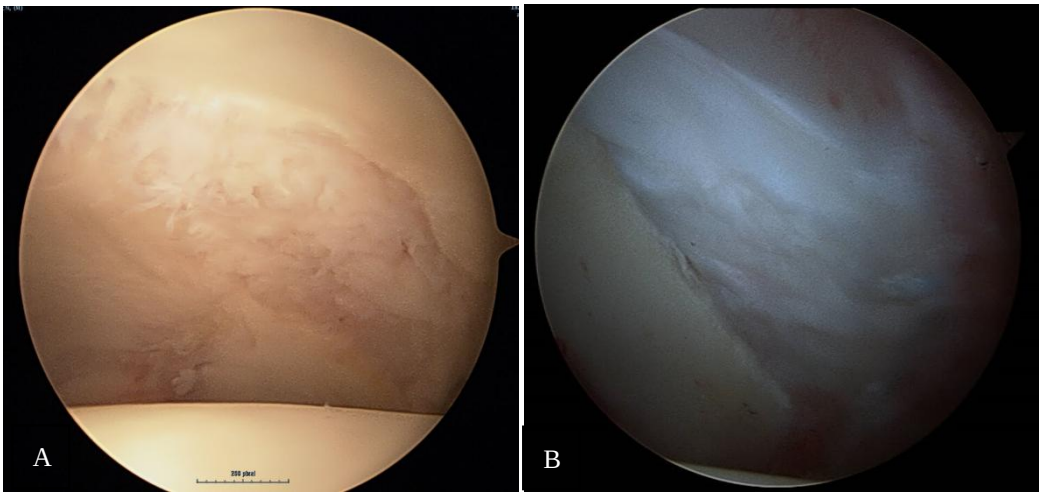

Fig. 3 Relook arthroscopy. (A) 2 years after AMIC with full filling of defect with fibrocartilage; (B) 1.5 years after surgery with labral repair.

fill and quality of the repair tissue on these images. At present, there is insufficient technological knowledge to set up a study using sequential MRI studies (with or without d-GEMRIC study). We are therefore left with clinical measurements, and we believe that medium to long term data are of particular value. The present study also compares favourably with open techniques to treat cam-type FAI. The results in the short term are at least as good as those reported by Ganz et al. [7], and this without the disadvantages and complications of open surgical dislocation. This finding has been reported previously by other authors. We noted no infections and no complications in both series. Although we used no pharmacological VTE-prophylaxis, we observed not a single VTE-event (symptomatic and asymptomatic deep venous thrombosis + pulmonary embolism).

Limitation of this study is the relative small patient sample size. The non-controlled use of HA viscosupplementation in the postoperative period, can be a confounding variable.

There are however several strengths of this study. Although this study is using a matched cohort for comparison, we believe we have controlled for all possible confounding variables. Groups were matched for age, sex and pathology. Both patient groups had similar demographics and similar hip scores before surgery. We also limited the variability of cartilage defect size, eliminating small and very large cartilage defects. Small cartilage lesions tend to heal well and usually don't have a major clinical impact. Very large lesions in cam-type FAI don't do well generally, both due to long standing hip disease and to unfavourable mechanical environment for cartilage healing. The femoral head tends to sink into the defect and prevent cartilage regeneration. Usually hips with these larger defects have already generalised cartilage disease. Also we proved that both groups were treated equally regarding their etiology. Radiographically all patients showed no residual impingement, and clinically all regained internal rotation. This was reflected in identical objective scores for ROM. Also we excluded all other forms of impingement, particularly mixed type impingement or dysplasia. Only pure cam-type FAI was included. All surgeries were performed by the same experienced hip surgeon, eliminating surgeon bias. The treating surgeon was also not involved in the data collection, and patients were clinically evaluated by an independent surgeon (SG).

In conclusion, AMIC with Chondrogide® membrane shows promising results in the treatment of cartilage lesions in the young athletic population with cam-type FAI, with excellent return to sports. Clinical results improve up to 3 years after surgery. Longer follow-up is needed to see if these results can be maintained over a longer period of time.

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