

## Technical Note

# A Novel Technique for Treating Cartilage Defects in the Hip: A Fully Arthroscopic Approach to Using Autologous Matrix-Induced Chondrogenesis

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**Abstract:** Microfracture is the standard of care for the treatment of small cartilage defects in the hip. Autologous matrix-induced chondrogenesis (AMIC) is a novel, 1-step approach that combines microfracture with a type I/III collagen matrix (Chondro-Gide; Geistlich Pharma AG, Wolhusen, Switzerland) to cover the microfractured defect area. The AMIC procedure has been successfully established for treating cartilage defects in the knee and talus, and we report, for the first time, its application in the hip. More importantly, at our center, we have developed a fully arthroscopic approach for the use of AMIC in the hip. Arthroscopic procedures are more desirable than open surgery because they are less invasive and hence reduce the risk of complications, such as infection or avascular necrosis of the femoral head, and allow for a shorter recovery time, resulting not only in lower overall treatment costs but also higher patient satisfaction. The arthroscopic AMIC procedure as described in this report, though surgically challenging, represents a viable, cost-effective treatment option for the repair of chondral lesions of the hip, especially when compared with autologous chondrocyte implantation.

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Chondropathies of the acetabulum and the femoral head are a frequent cause of pain and functional limitation. Moreover, if cartilage defects in the hip are not adequately repaired, then progression of the damage and arthritic changes may occur. Several treatment options are available for the repair of chondral defects, such as debridement, microfracture, and autologous chondrocyte implantation (ACI). Partial-

thickness defects are generally treated with chondroplasty, involving debridement of the defect to remove any damaged cartilage and create a smooth surface.<sup>1</sup> For full-thickness chondral defects, microfracture is the current standard of care.<sup>1</sup> Microfracture involves penetration of the subchondral bone to release blood and bone marrow into the defect, initiating cartilage repair. This technique is easy to perform, is cost-effective, and has produced good clinical results, particularly for smaller defects (<2 cm<sup>2</sup>).

In the knee, ACI has been used increasingly for the repair of larger chondral defects. Chondrocytes are harvested from a healthy site, expanded in vitro, and injected in solution under a periosteal flap or collagen membrane. Alternatively, the chondrocytes may be seeded onto a collagen matrix, which is either sutured or glued over the lesion (matrix-induced ACI). ACI requires 2 surgical procedures: an arthroscopy to harvest chondrocytes and a cell implantation step, which is often performed as open surgery, exposing the pa-

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The author reports the following potential conflict of interest or source of funding in relation to this article: Medical writing was supported by nspm ltd, Meggen, Switzerland, with funding directly to nspm ltd by Geistlich Pharma AG, Wolhusen, Switzerland.

Received May 17, 2011; accepted February 24, 2012.

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2212-6287/11307/\$36.00

doi:10.1016/j.eats.2012.02.003



**FIGURE 1.** Arthroscopic access portals for hip: (a) proximal trochanteric portal, (b) anterior paratrochanteric portal, and (c) posterior paratrochanteric portal. (GT, greater trochanter.)

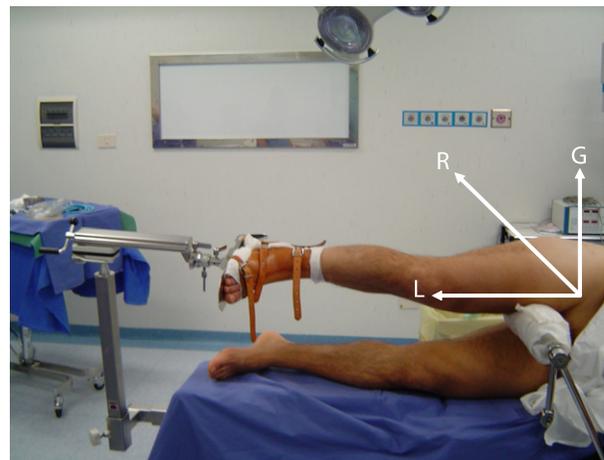
tient to a risk of infection and requiring a long recovery period. Obtaining a sufficient number of cells for implantation requires external laboratory support for in vitro culturing of chondrocytes, making this a cost-intensive procedure. Despite frequent use in the knee, experience with ACI for treatment of damaged cartilage in the hip is limited.

Debridement and microfracture remain the standard treatment for cartilage defects in the hip. Autologous matrix-induced chondrogenesis (AMIC) is a novel approach in which the microfracture technique has been enhanced by the use of a type I/III collagen matrix (Chondro-Gide; Geistlich Pharma AG, Wolhusen, Switzerland).<sup>2</sup> In this single-step procedure, the Chondro-Gide matrix is placed over the defect to stabilize the fragile blood clot that arises from microfracture and to provide infrastructure for repair tissue formation.

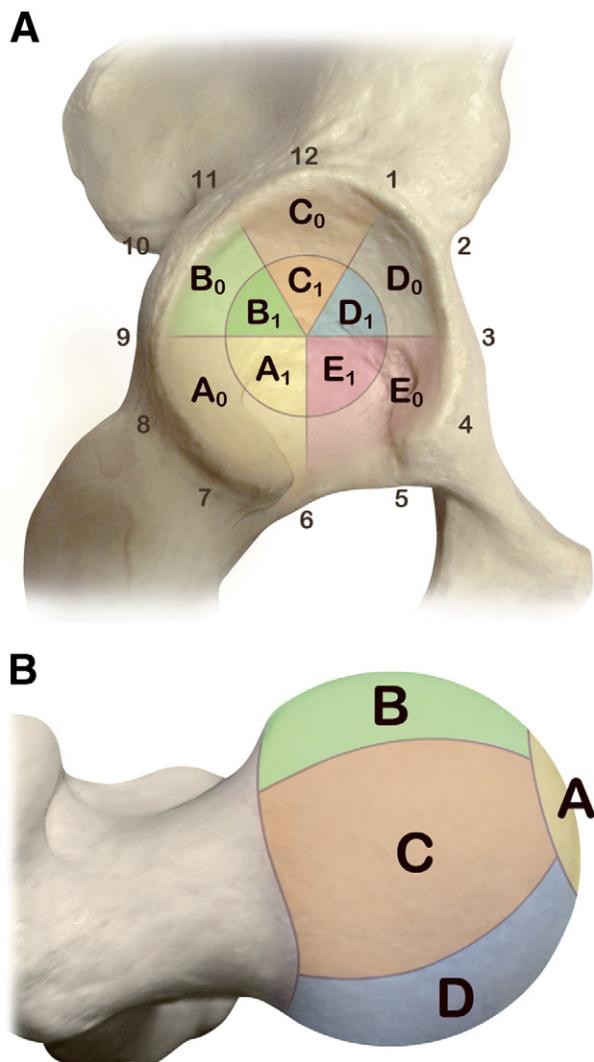
AMIC may offer several potential advantages to patients with medium to large chondral defects. With AMIC, no cells have to be harvested, cultured, and reimplanted and, therefore, no harvest-site morbidity occurs, and the operation can be performed as a single procedure with potential time and cost savings. Furthermore, AMIC does not require complex and costly cell expansion techniques. Encouraging outcomes for the treatment of cartilage defects in the knee with AMIC have been reported.<sup>2,3</sup>

AMIC has been previously performed as an open procedure,<sup>3</sup> raising issues associated with all arthrot-

omies, such as the risk of infection and prolonged recovery time. These could be minimized by performing the procedure arthroscopically. Treating hip pathologies arthroscopically is challenging and often reserved for specialists. Increasing use has been fueled by greater understanding of hip pathology, advances



**FIGURE 2.** Patient positioning for hip arthroscopy. With the patient on his left side in the lateral decubitus position, traction to the groin is applied following 2 forces: longitudinal (L) and lateral (G). The resulting force (R) is a force along the femoral neck that allows an appropriate distraction of the femoral head from the acetabulum (1.5 to 2.0 cm). The created space is just enough to safely insert the arthroscopic instruments under image intensifier control without damaging the hip.



**FIGURE 3.** Mapping system for cartilage lesions of hip joint. (A) Mapping of acetabulum. (B) Mapping of femoral head. Evaluation of the cartilage defect is performed according to the Outerbridge classification, and the localization of the defect is determined and recorded with the mapping system. Accurate mapping and documentation in the patient record are helpful for follow-up of the patient.

in techniques and instruments, and appropriate physician training. We describe, for the first time, technicalities of a fully arthroscopic approach to performing AMIC in the hip.

### TECHNIQUE

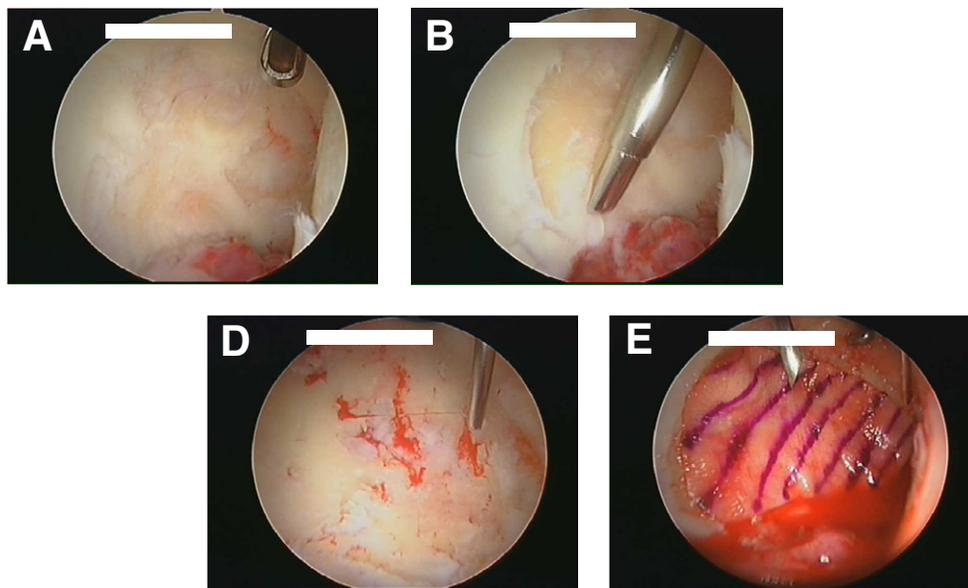
To undergo arthroscopically performed AMIC of the hip, the patient is placed in the lateral decubitus position. The hip is accessed through the proximal

trochanteric and anterior paratrochanteric portal. The posterior paratrochanteric portal is used when the anterior paratrochanteric portal does not give sufficient access to the defect location (Fig 1). Longitudinal and inguinal traction is applied (Fig 2), and two 18-gauge and 15-cm-long needles (Smith & Nephew, Memphis, TN) are inserted into the main portals under image intensifier control. With the help of guidewires, a 70° arthroscope (Smith & Nephew) is inserted in the proximal trochanteric portal and a 12-cm arthroscopic cannula with a 5-mm diameter (Smith & Nephew) in the anterior paratrochanteric portal. Arthroscopic evaluation of the cartilage defect is performed with an arthroscopic probe (Smith & Nephew) according to the Outerbridge classification,<sup>4</sup> and the localization of the defect is determined and recorded by the mapping system shown in Fig 3. AMIC is indicated for the treatment of chondral lesions that are grade III or IV according to the Outerbridge classification with a defect size between 2 and 8 cm<sup>2</sup> in patients aged 18 to 55 years. Chondral lesions of the hip joint can be treated with AMIC if the defect is located on the acetabulum or femoral head. In case of corresponding cartilage defects, so-called kissing lesions, AMIC is performed only on the acetabulum whereas the femoral head is treated only with microfracture (Table 1).

If arthroscopic AMIC treatment is indicated for the evaluated cartilage lesion (Fig 4A), the defect is accurately debrided. Chondrectomy is performed with angled curettes or motorized shavers (Stryker, Kalamazoo, MI) to expose the subchondral bone to create clear margins between the healthy cartilage and cartilage lesion (Fig 4B). In some cases a 90° angled radiofrequency probe (ConMed, Utica, NY) is also used during chondrectomy (Video 1). Measurement of the chondral defect is carried out with the arthroscopic probe.

**TABLE 1.** Indications and Exclusion Criteria for Arthroscopic Hip AMIC

Indications
Grade III or IV chondral lesions (Outerbridge classification)
Acetabulum or femoral head
AMIC on acetabulum and microfracture on femoral head for kissing lesions
Defect size of 2.0-8.0 cm <sup>2</sup>
Age of 18-55 yr
Exclusion criteria
Metabolic arthropathy
Chronic inflammatory systemic disorder
Axial malalignment (concomitant realignment procedure required)
Allergy to porcine collagen



**FIGURE 4.** AMIC for treatment of chondral defect in hip. (A) A third-/fourth-degree chondral defect is located on the anterior area of the acetabulum. (B) Debridement and chondrectomy of the area are performed to expose the subchondral bone. (C) Once the subchondral bone is fully exposed, microfracturing is performed. (D) Bleeding of the area is checked after microfracturing. (E) The Chondro-Gide matrix is inserted and applied to cover the defect. The smooth surface of the matrix is marked with lines to ensure that the rough surface faces the subchondral bone.

Microfracture is carried out using well-established previously reported techniques and involves penetration of the subchondral bone plate and the consequent outflow of bone marrow blood, containing a cell and growth factor mix, which is able to initiate new tissue formation. The subchondral bone is penetrated approximately 2 to 4 mm deep with an arthroscopic awl (Smith & Nephew) (30° and 45° angles are preferable because of the sphericity of the hip) to create V-shaped holes measuring 1.5 to 2 mm in diameter (Fig 4C). It is generally suggested to begin the microfractures at the periphery and to proceed toward the center at a distance of 5 mm. It is important to penetrate the subchondral bone perpendicularly, which can be particularly difficult in the hip, specifically in the superoanterior areas of the acetabulum. In these cases microfracture is carried out by scratching the subchondral bone (Video 1). Bone marrow bleeding from the holes can be verified after reduction of the water pressure (Fig 4D, Video 1).

The dry Chondro-Gide matrix is trimmed to be slightly smaller than the shape of the defect, to compensate for the approximately 10% increase in size after moistening. Before introduction into the joint, the smooth layer of the matrix is marked with a few lines with a surgical marker pen to distinguish the layers and aid insertion. Then, the matrix is inserted

with a grasper (Smith & Nephew) with the porous layer facing the bone surface, directly into the articular space, using an arthroscopic cannula to prevent its loss in the surrounding tissues. It is then adapted with arthroscopic probes to cover the chondral defect (Fig 4E, Video 1).

Accurate chondrectomy creating very sharp edges, the concavity of the acetabulum itself, and the pressure of the femoral head against the acetabulum once the traction is released give the implanted matrix sufficient stability. Nevertheless, the loss of fixation between the implant and the bone is a potential concern and must be carefully controlled. After having positioned the implant on the cartilage defect, the surgeon can introduce a size 10 urinary catheter into the articular space and inflate it. The balloon should properly press against the matrix to support stabilization of the matrix. It is recommended to release the traction and to perform a series of 4 to 6 extension and rotation movements. Traction must then be reapplied, and the position of the transplant must be arthroscopically verified. Fibrin glue can be used to fix the matrix if it does not show acceptable stability.

Postoperative management begins on the first postoperative day with isotonic and isometric quadriceps exercises. Continuous passive motion at 60° of hip flexion is also applied. Patients are discharged from

**TABLE 2.** *Postoperative Rehabilitation After Arthroscopic Hip AMIC*

	1 d Postoperatively	2 d to <4 wk Postoperatively	4 wk to <6 mo Postoperatively	6 mo to <1 yr Postoperatively	1 yr Postoperatively
Load bearing	None	None	Partial load bearing up to 7 wk; afterward, full	Full	Full
Mobilization	Continuous passive motion at 60° of hip flexion	Regain step-wise full range of motion	No restriction	No restriction	No restriction
Physiotherapy and sport	No sporting activities Isotonic and isometric quadriceps exercises	No sporting activities Active and passive physiotherapy	Light sporting activities (e.g., swimming and cycling)	Jogging	Full return to sports

the hospital on the second day and are subject to both active and passive physiotherapy—without putting weight on the articulation—for 4 weeks to regain full range of motion. Partial loading is allowed after 4 weeks, when exercises on a stationary bike and swimming are recommended. After 7 weeks, crutches are no longer required, and patients may return to normal work activity. Jogging is only allowed after 6 months, and a complete return to competitive sporting activities is only recommended at least 1 year after surgery (Table 2).

## DISCUSSION

Microfracture is currently the standard of care for the treatment of small (<2 cm<sup>2</sup>) chondral defects in the hip. The choice of treatment for larger defects depends on a number of factors, including patient's preference, physician's expertise, and the cost of the procedure. To adapt the microfracture technique to larger defects, AMIC has been used in the knee with good results. The use of Chondro-Gide in AMIC helps create a more stable blood clot and provides a bioactive chamber to encourage stem cell differentiation.

There have been no published reports of AMIC in the hip until now, and only 2 case studies and 1 pilot study of ACI have been published.<sup>5-7</sup> AMIC has several potential benefits over ACI. It is a 1-step procedure, with microfracturing and implantation of the Chondro-Gide matrix taking place during the same operative procedure. Because the chondrocyte culturing step is no longer needed, there is no need for specialized centers and laboratory support; as a result, AMIC may be more cost-effective than ACI.

In the hip, access to the joint is difficult, necessitating the need for arthrotomies and dislocations, which puts the patient at a high risk of postoperative

complications, such as infection or avascular necrosis of the femoral head, and prolongs recovery time. For these reasons, various arthroscopic diagnostic and treatment techniques have been developed in recent years. As described in this report, we have developed and established an arthroscopic approach to performing AMIC in the hip at our center. In our method the entire AMIC procedure is carried out arthroscopically, which may have a number of benefits. Compared with open procedures, arthroscopic techniques result in less blood loss, shorter hospitalization, and easier visualization of intra-articular pathology, without trochanteric osteotomy.<sup>8</sup> Furthermore, arthroscopic surgery, when performed by a skilled and experienced surgeon, has been shown to result in excellent outcomes, with faster rehabilitation compared with open procedures.<sup>9</sup> This technique, however, requires considerable training and expertise on the part of the surgeon.

Encouraging results have been reported on the use of AMIC in the knee. For example, in a recent clinical study of 27 patients,<sup>3</sup> all patients showed significant improvement in 5 different scores at 12 months and up to 24 months after the procedure. Given these findings, the AMIC procedure may also represent a viable alternative for treatment of chondral lesions of the hip. The development of a fully arthroscopic procedure for the use of AMIC in the hip represents a major advance with potential associated advantages, which are summarized in Table 3. In an ongoing clinical study at our center, AMIC is being used in this way in patients with femoroacetabular impingement of the hip. Long-term clinical data are being collected from 142 patients, of whom 62 are undergoing AMIC, and will provide information on the clinical utility of AMIC as a cost-effective, 1-step arthroscopic procedure for the treatment of chondral lesions of the hip.

**TABLE 3.** *Advantages and Limitations for Arthroscopic Hip AMIC*

Advantages
Minimally invasive, 1-step arthroscopic surgical technique
Established first-line treatment based on microfracture
Protection of blood clot and “bioactive chamber” provided by Chondro-Gide matrix
Shorter hospitalization and faster rehabilitation
Cost-efficient
Limitations
Limited to skilled and experienced surgeons
Considerable training and expertise required (10-20 procedures)
Limited indications
Long-term clinical data not yet available

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