Technical Note

Single-Stage Arthroscopic Minced Cartilage Implantation for Focal Cartilage Defects of the Glenoid Including Glenolabral Articular Disruption Lesions: A Technical Note

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Abstract: Anterior shoulder dislocations often are associated with cartilage defects of the anterior glenoid (glenolabral articular disruption, or GLAD lesions). However, the importance of GLAD lesions for shoulder stability is usually greatly underestimated. Moreover, glenoid cartilage defects may have a high clinical relevance as the result of persistent pain and possible progression to osteoarthritis. Therefore, surgical treatment appears to be necessary. Although in older patients prosthetic arthroplasty is a useful treatment option for progressive symptomatic cartilage defects, there is still disagreement about the ideal joint-preserving method for the treatment of isolated glenoid cartilage defects, especially in younger and more active patients. In recent years, autologous chondrocyte implantation has been established as a promising treatment option for focal cartilage defects. However, most autologous chondrocyte implantation techniques have the disadvantage of requiring 2 surgical procedures and the availability of specialized laboratories, making the techniques complex and expensive. In contrast, the AutoCart procedure (Arthrex, Munich, Germany) is a cost-effective one-step procedure in which the cartilage defect is filled with a mixture of minced autologous cartilage and autologous conditioned plasma and has already shown good clinical results in the knee joint. We present an arthroscopic technique for use in glenoid cartilage defects.

The importance of cartilage defects of the anterior glenoid (glenolabral articular disruption, or GLAD lesions) is usually greatly underestimated, as they play a substantial role in shoulder stability[1,2] and can lead to persistent shoulder pain.[3] Therefore, surgical treatment appears necessary. The focus in younger patients is usually placed on joint-preserving options such as arthroscopic debridement, microfracturing, osteochondral autografting, and autologous chondrocyte implantation (ACI).[4]

A newer technique that is gaining interest is minced cartilage implantation. Especially in knee surgery, initial clinical studies have shown promising results.[5] In contrast to ACI, this technique has an important advantage in that only one procedure is necessary. Autologous hyaline cartilage is harvested from the defect area, minced, and finally inserted into the defect to achieve a hyaline-like cartilage repair.[6]

Surgical Technique

We describe an arthroscopic technique for treatment of a GLAD lesion with minced cartilage and simultaneous refixation of the labrum. However, this technique can also be used for all other glenoid full cartilage defects. Table 1 and Video 1 provide an overview of the steps of surgery. This study was performed in line with the principles of the Declaration of Helsinki. Informed consent was obtained from all individual participants included in the study.

The preoperative radiologic examinations consist of conventional radiographs and magnetic resonance imaging to determine the extent and location of the cartilage defect as well as possible concomitant pathologies. In our clinic, AutoCart (Arthrex, Munich,

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Table 1. Overview of the Different Steps of Operation

1. Preoperative venous blood sampling for the production of ACP
2. Production of autologous thrombin solution with part of the ACP for later fixation
3. Thorough debridement of degenerative or defective cartilage in the defect
4. Harvesting, collecting, and mincing of vital cartilage for later transplantation
5. Refixation of the labrum with suture anchors
6. Mixing of the minced cartilage with ACP in a ratio of 3:1
7. Drying of the cartilage defect
8. Filling the defect with the chip-ACP paste via application cannula
9. Fixation of the cartilage chips in the defect with thrombin solution
10. Sealing of the lesion with an additional layer of fibrin

ACP, autologous conditioned plasma.

Germany) is used for isolated chronic or acute symptomatic International Cartilage Repair Society grade III or IV lesions.

The surgery can be performed with the patient under general or regional anaesthesia. It is recommended to apply single-shot antibiotics. The later implantation of the cartilage chips is performed together with ACP, which serves as a biological agent. For this, venous blood is taken from the patient and converted using the ACP Double-Syringe System (Arthrex) (Fig 1). Part of the ACP is further processed in the Thrombinator System (Arthrex) according to the manufacturer's instructions to produce an autologous thrombin solution, which can later be used to improve the fixation of the cartilage chips. The Thrombinator uses the blood coagulation cascade to produce an autologous thrombin solution from 3 mL of ACP after 10 to 15 minutes of incubation.

The patient is placed in the lateral position and the arm is suspended, distracting the glenohumeral joint and increasing the glenohumeral space (Fig 2). In addition, this positioning offers a significant advantage over the beach-chair position because later filling of the defect is much easier when the glenoid is in a horizontal position. The arthroscopy can be performed completely dry. Alternatively, the procedure can be started wet and then switched to a dry procedure for the implantation of the cartilage chips.

First, a diagnostic arthroscopy is performed via the standard posterior portal (Fig 3 A and B), with particular attention to the extent and location of the cartilage damage. Afterwards, the additional necessary arthroscopy portals are created. In our practice, we use an anterior and a suprabicipital portal for this purpose (Fig 3C). Subsequently, the cartilage defect is prepared. For this, degenerative or defective cartilage should be removed using a ringed curette, a sharp spoon, or a shaver (Fig 4 A-C). Afterwards, cartilage is circumferentially harvested from the chondral walls of the defect edge to create vertical defect edges while preserving vital cartilage for transplantation (Fig 4 D-F). In our practice, we use a 3- or 4-mm shaver device for this purpose, which is connected to a collection device (GraftNet; Arthrex). This has the advantage that the cartilage is collected and already minced. Alternatively, single fragments can be carefully grasped with forceps. The collected cartilage is then transferred to a small metal tub.

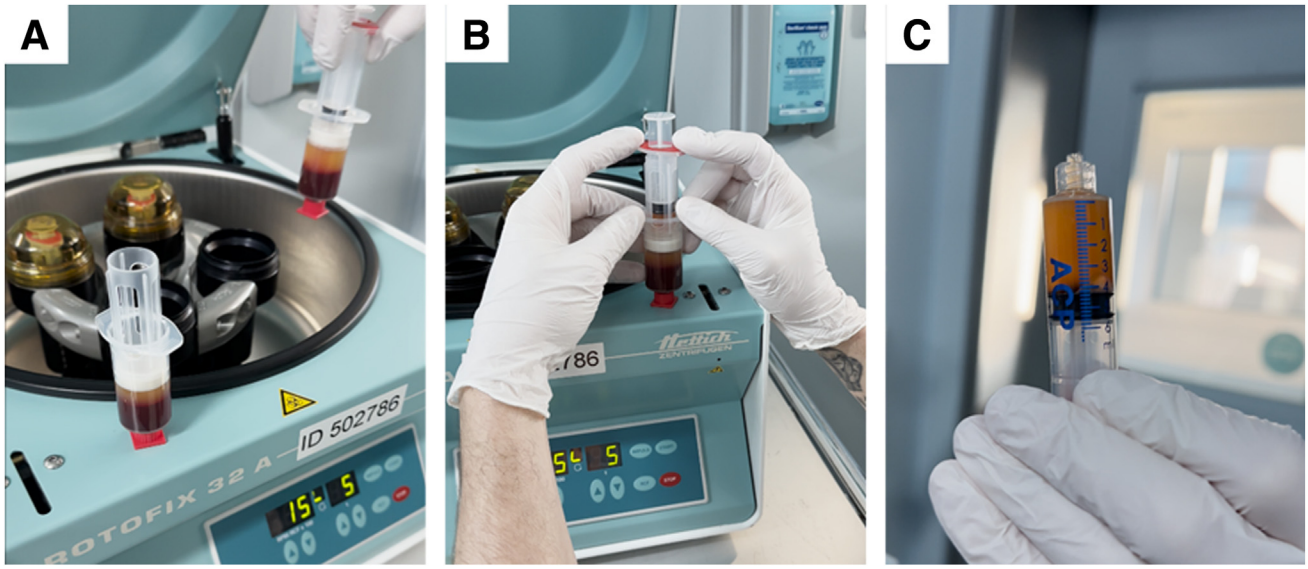

Fig 1. The later implantation of the cartilage chips into the defect is done together with autologous conditioned plasma (ACP), which serves as a biological agent. For this, venous blood is taken from the patient under sterile conditions and converted using the Arthrex ACP Double-Syringe System (Arthrex) (A-C).

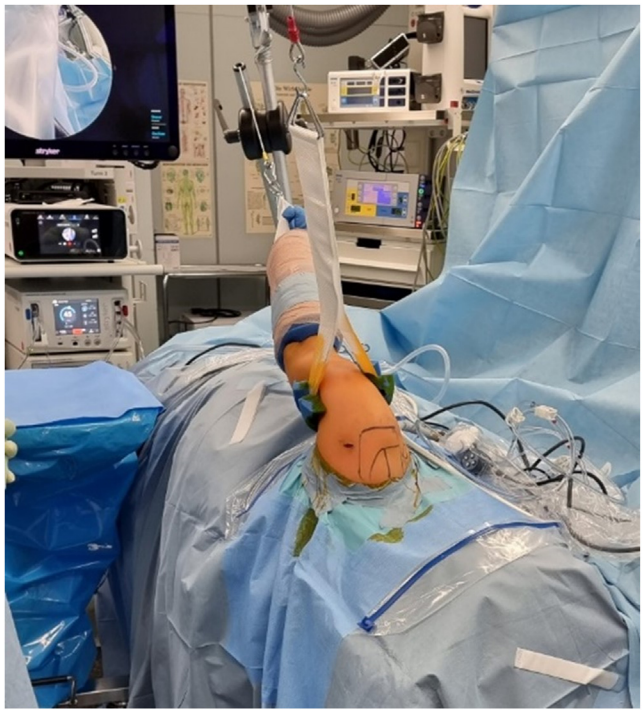

Fig 2. Arthroscopy in a left shoulder. The patient is placed in the lateral position and the index arm is suspended, distracting the glenohumeral joint and increasing the glenohumeral space. In addition, later implantation of the cartilage chips into the defect is much easier when the glenoid is in a horizontal position.

Afterwards, the calcifying layer is also removed from the exposed bone. Care is taken not to damage the subchondral bone. If there are larger bone defects, they can be filled with spongiosaplasty before implantation of the minced cartilage.

If simultaneous labral refixation is necessary, the next step is to mobilize the labrum using a Bankart knife (Fig 5A) followed by placement of the suture anchors (Fig 5 B and C). The aim of positioning the anchors is to achieve adequate stabilization, reduce the size of the cartilage defect, and use the labrum to form a stable border for the later implantation of the minced cartilage. The number and exact position of the anchors therefore depend on the tear configuration.

For implantation, cartilage fragments of about 1 mm^3 or smaller are recommended. Cartilage removed with the 3-mm shaver and connected GraftNet system (Fig 6 A and B) already is the required size. Cartilage removed with a forceps must still be minced to the appropriate size, for example, by coarse shredding with a 10- or 15-mm blade in the metal tub, followed by finer shredding with a 3-mm shaver blade or complete mincing using a scalpel. In either case, a careful approach to mincing is crucial. In animal models, there is a significant loss of chondrocyte viability when the cartilage is comminuted with blunt methods.[7] In contrast, it has recently been shown that chondrocytes in cartilage tissue harvested and minced using an arthroscopic shaver retain their viability and proliferative capacity.[8]

The minced cartilage chips (Fig 6C) are then combined with the previously prepared ACP in a ratio of 3:1 to obtain a paste-like substance (Fig 6D). There are 2 variants of this procedure. Using a female-to-female adapter, a syringe containing the cartilage chips can be connected to a syringe containing the ACP and both components can be mixed together. Alternatively, the cartilage chips can be mixed with the ACP directly in the metal tub and the mixture then transferred to the application cannula (Fig 6 D-F).

The defect area must then be completely dried. If the arthroscopy was performed wet, the fluid must now be

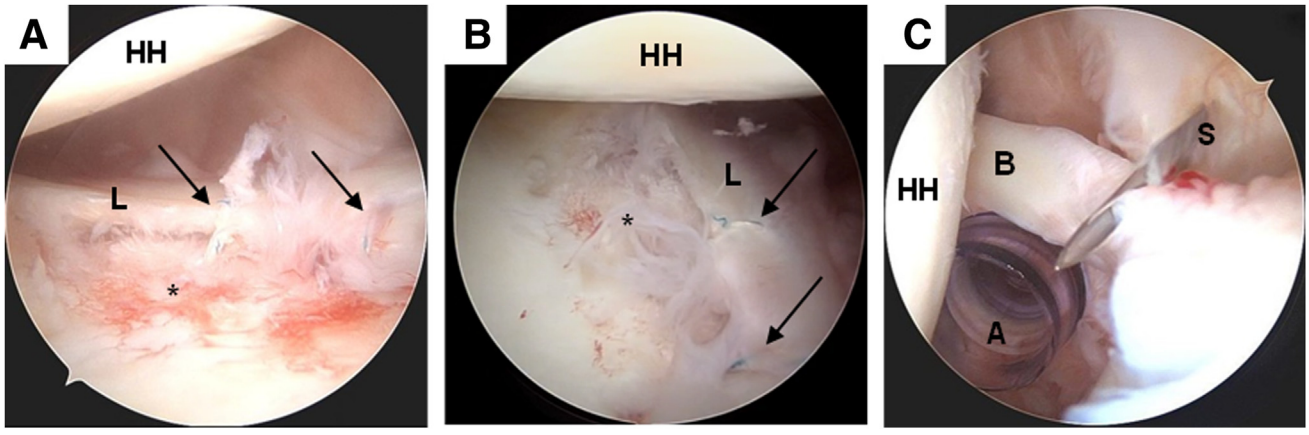

Fig 3. The arthroscopic visualization from the posterior portal (A) and from the suprabicipital portal (B) in a left shoulder with the patient in the lateral position shows a large GLAD lesion with visible suture material after Bankart repair and recurrence instability (A and B). After the standard diagnostic arthroscopy, the additional necessary portals are created. In our practice, we use an anterior and a suprabicipital portal for this purpose (C). Black arrows show suture material; asterisk shows glenoid chondral defect. (A, anterior portal; B, long biceps tendon; HH, humeral head; L, anterior labrum; S, suprabicipital portal.)

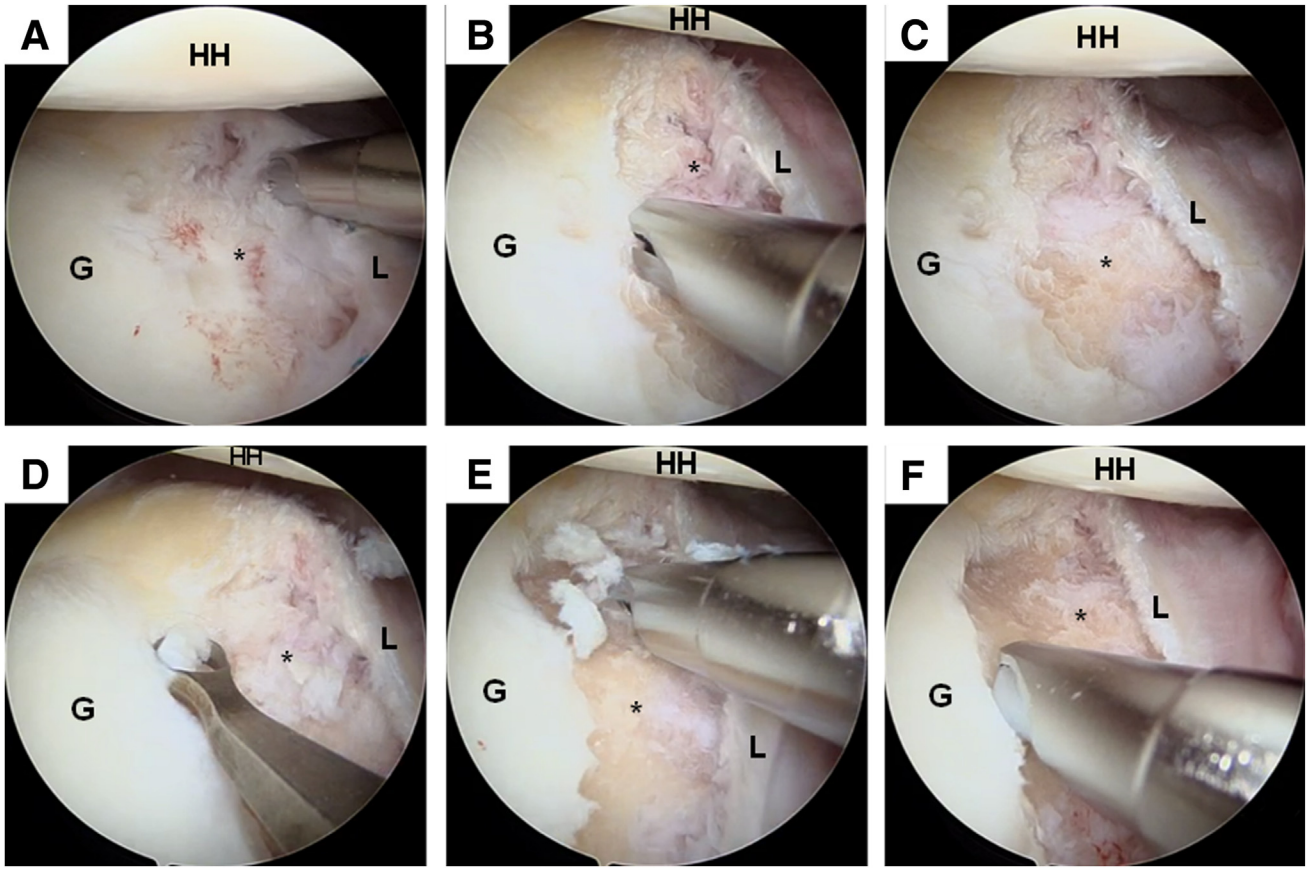

Fig 4. Arthroscopic visualization from the suprabicipital portal in a left shoulder with the patient in the lateral position. First, degenerative and defective cartilage is removed using a shaver (A-C). Subsequently, cartilage can be circumferentially harvested from the chondral walls of the defect edge with a curette (D) or a shaver (E and F). The goal is to create vertical defect edges while preserving and harvesting vital cartilage for transplantation. The removed cartilage must be preserved for later implantation. For that reason, the shaver is connected to a collection device (GraftNet; Arthrex). Asterisk shows glenoid chondral defect. (G, glenoid with intact cartilage; HH, humeral head; L, anterior labrum.)

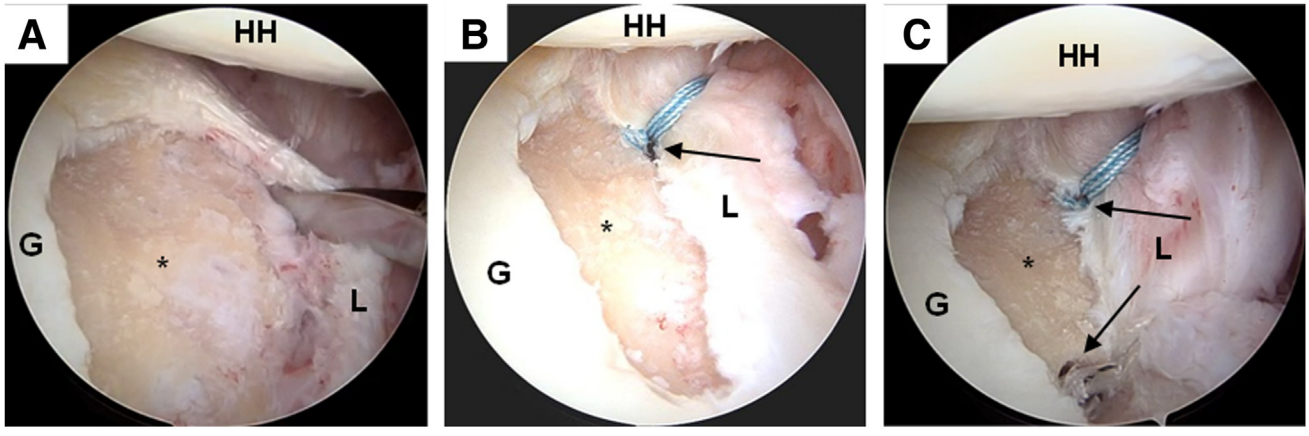

Fig 5. Arthroscopic visualization from the suprabicipital portal in a left shoulder with the patient in the lateral position. Before refixation of the labrum, it is first mobilised with the Bankart knife (A). Then the suture anchors are placed (B and C). The aim of positioning the anchors is to achieve adequate stabilisation, reduce the size of the cartilage defect and use the labrum to form a stable border for the later implantation of the minced cartilage. Black arrows show the suture anchor; asterisk shows glenoid chondral defect. (G, glenoid with intact cartilage; HH, humeral head; L, anterior labrum.)

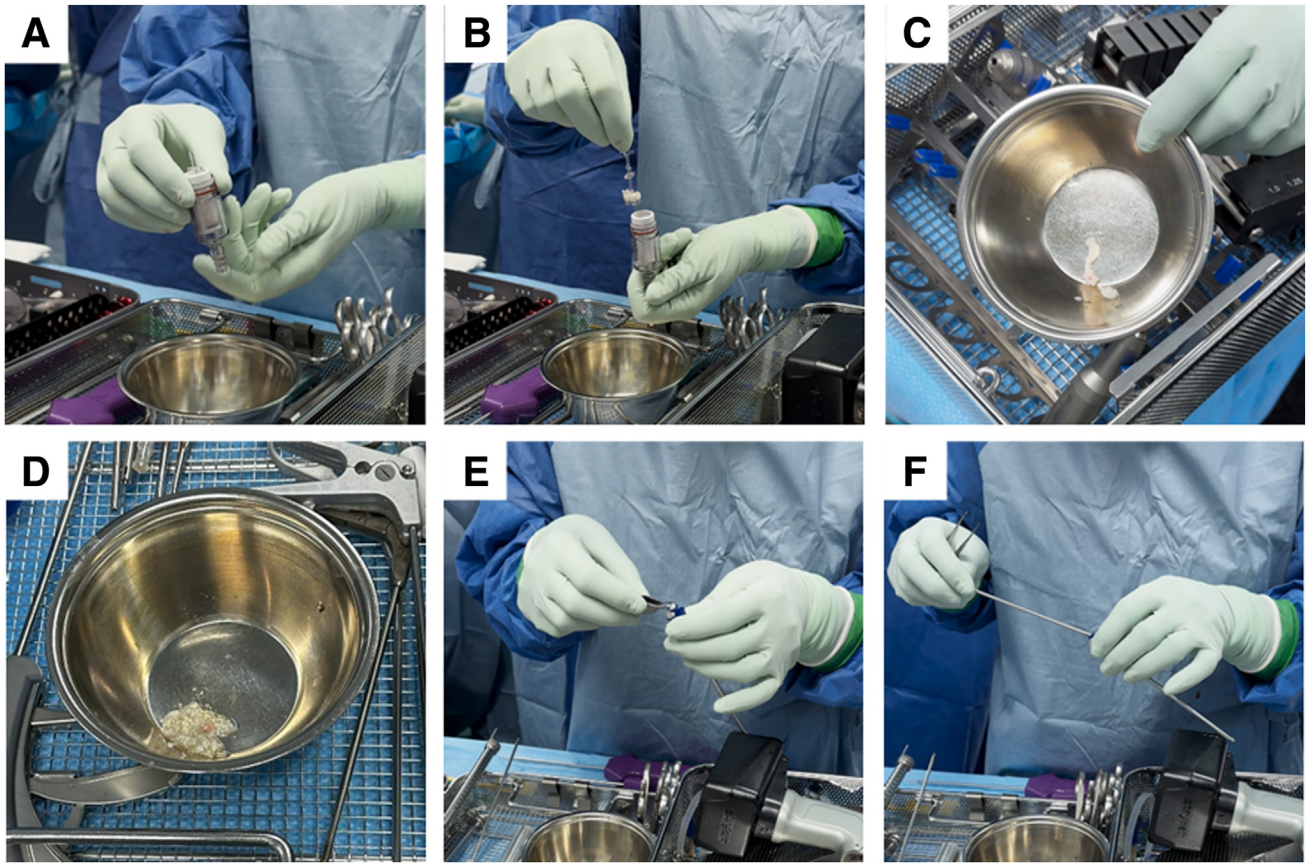

Fig 6. To preserve the harvested cartilage, the shaver device is connected to a collection device (GraftNet; Arthrex), which has the advantage that the cartilage fragments are collected and already minced. Afterwards, the GraftNet tissue collector can be disconnected from the shaver, opened and the collected cartilage transferred to a small metal tub (A-C). The minced cartilage chips are then combined with the previously prepared ACP in a ratio of 3:1 to obtain a paste-like substance (D) and are transferred to the application cannula (E and F).

removed from the joint (eg, using a shaver or syringe) (Fig 7A). The remaining fluid in the defect can then be carefully dried with a swab or a buttoned cannula (Fig 7B). The application cannula is then inserted via a portal and the defect should be filled evenly to 80% to 90% with the chip-ACP paste (Fig 7C). The initial stability will be provided by the paste's consistency. Fine distribution can be done after complete application with the back of the Bankart knife or a probe before covering the mixture drop by drop with the previously prepared thrombin solution (Fig 7 D and E). The thrombin reacts with the fibrinogen contained in the chip-ACP paste to form fibrin, which fixes the chips in the defect (Fig 7F). The lesion can then be sealed with an additional layer of fibrin. For this purpose, thrombin and ACP are mixed in a 1:1 ratio and quickly dripped onto the inserted chip-ACP paste. The operation can be terminated after an application time of approximately 2 minutes.

Postoperative Procedure

The shoulder is first immobilized in a brace for 48 hours in an internally rotated position. Subsequently, the follow-up treatment is carried out in accordance with our in-house anterior shoulder stabilization scheme.

Discussion

As already mentioned in the introduction, the technique for implanting minced cartilage described in this Technical Note is currently gaining in popularity, mainly because of the fact that this alternative joint-preserving approach to treat symptomatic chondral lesions offers many advantages compared with other procedures. Although this technique has already been used in knee surgery for some time and the first clinical successes have now been published,[5] the first applications in other joints are increasingly being described, such as the ankle joint,[9] the metatarsophalangeal joint of the big toe,[10] and the shoulder joint.[11,12]

The aim is to form new hyaline cartilage by using "minced" pieces of autologous hyaline cartilage. Chondrocytes play a decisive role in this process, because they have the ability to produce matrix and

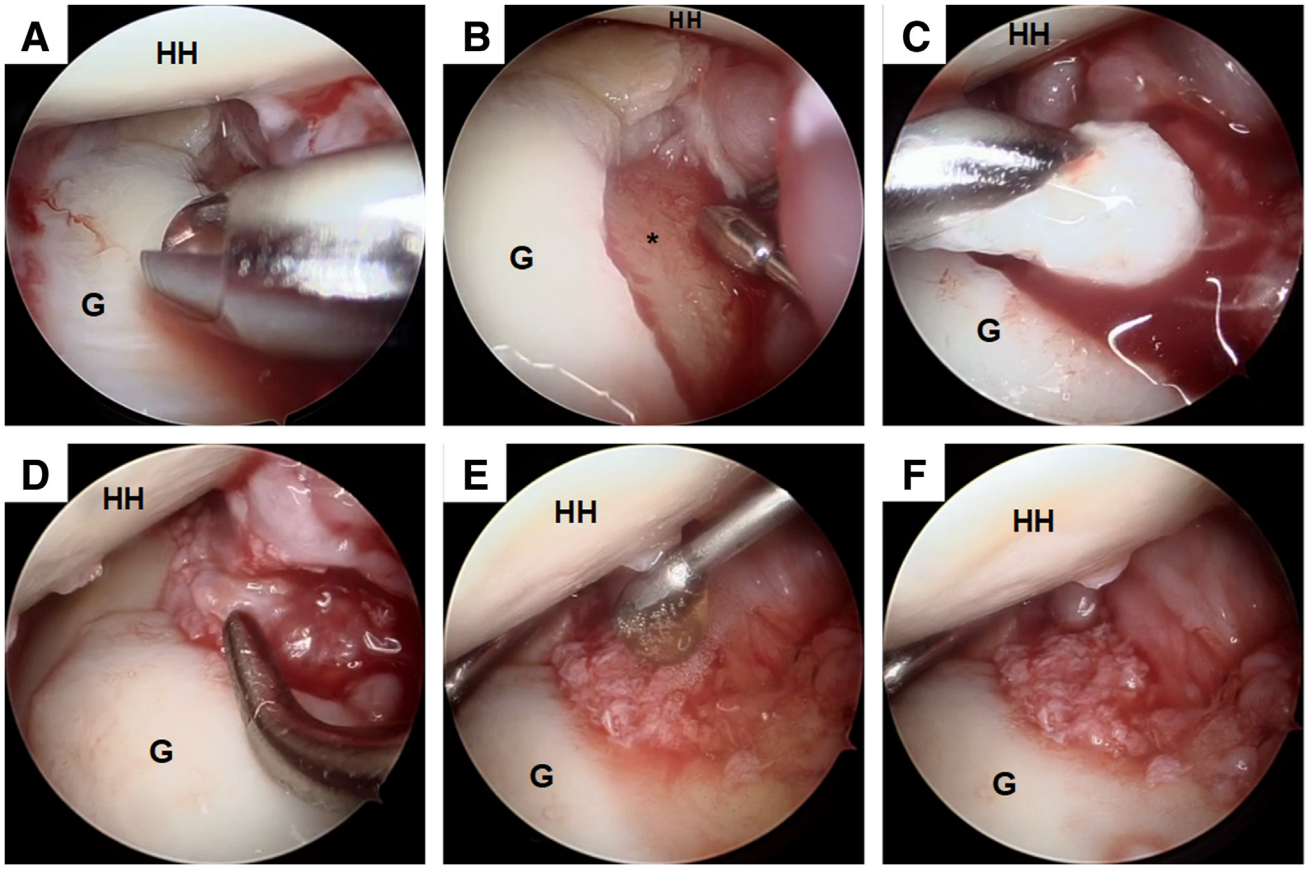

Fig 7. Arthroscopic visualization from the suprabicipital portal in a left shoulder with the patient in the lateral position. For implantation of the minced cartilage, the fluid must now be removed from the joint—for example, using a shaver (A). The remaining fluid in the defect can then be carefully dried with a swab or a buttoned cannula (B), because the defect area must be completely dried. The application cannula is then inserted via a portal, and the defect should be filled evenly to 80% to 90% with the chip-ACP paste (C). The initial stability will be provided by the chip paste's consistency. After fine distribution with a probe (D), the mixture is then covered drop by drop with the previously prepared thrombin solution (E). The thrombin reacts with the fibrinogen contained in the chip-ACP paste to form fibrin, which fixes the cartilage chips in the defect (F). The lesion can then be sealed with an additional layer of fibrin. (ACP, autologous conditioned plasma; G, glenoid with intact cartilage; HH, humeral head; asterisk, glenoid chondral defect.)

collagen.[13] They are found in the cartilage fragments and can be transferred with them to the defect in a single surgery without the need for prior cultivation of the cells in a special laboratory.[14] In contrast to the ACI technique, the chondrocytes in the minced cartilage technique remain in the normal microenvironment, which seems to play a crucial role in the vitality of the chondrocytes.[15] Several studies have shown that the cartilage formed by this technique is equivalent to the standard ACI procedure and even superior to microfracturing.[16-19]

The cartilage required for minced cartilage implantation can be obtained from the periphery of the defect, which contains many viable chondrocytes suitable for implantation.[20] In addition, the size of the cartilage chips is decisive for good and adequate function of the implanted chondrocytes[21] and should be about 1 mm^3, which provides the optimal biological environment for the chondrocytes.[22] This can be achieved quickly and efficiently by using a 3-mm shaver, which allows standardized fragmentation of the cartilage without significantly compromising the viability of the chondrocytes.[8,23]

By subsequently mixing of the minced cartilage with ACP, the contained fibrinogen is converted into fibrin by thrombin, which forms a stable clot and already ensures a certain primary stability.[24] In addition, ACP can lead to activation of the chondrocytes, which results in an increase in the cell number and metabolic activity.[25]

So far, there has been limited research on the use of minced cartilage, and long-term follow-up is not yet available. However, the few studies published to date show promising results with good cartilage repair and general improvement with no difference in the number of adverse effects compared to other

Table 2. Advantages and Disadvantages of the Minced Cartilage Technique

Advantages
One-step procedure
More cost-effective than ACI
Use of autologous cartilage
Hyaline-like cartilage repair
Fully arthroscopic procedure possible
Disadvantages
No long-term follow-up available
Fixation of the minced cartilage is more difficult than on the knee joint due to the thinner glenoid cartilage

ACI, autologous chondrocyte implantation.

cartilage repair procedures.[5,26,27] As such, it seems to be a safe technique, with the advantage of being a single-step procedure and using autologous cartilage. Table 2 provides an overview of the advantages and disadvantages of the minced cartilage technique.

Disclosures

All authors (A.P., A.D., F.F., and M.S.) declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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