Technical Note

A Technique Using a Low-Cost, Accessible Cannula to Aid Scaffold Passage in Dry Arthroscopic Cartilage Repair in the Knee

Andrew Chou, B.S., M.D., M.R.C.S. (Edin), and Denny Lie, M.B.B.S., M.R.C.S., F.A.M.S

Abstract: Although autologous matrix-induced chondrogenesis has grown increasingly popular, it can be technically challenging to place the scaffold within the knee efficiently without extending the arthroscopic incisions. To facilitate arthroscopic placement of the matrix into the knee, we developed a technique that involves fashioning a cannula from a standard 5-mL syringe. This technique enables surgeons to conveniently and efficiently place the matrix through the standard arthroscopic ports at minimal cost.

Microfracture for the treatment of cartilage lesions was first described in the 1950s by Pridie and Steadman, and the advent of cell-free biological scaffolds has augmented the efficacy of such cartilage regeneration techniques by providing a biocompatible matrix for multipotent mesenchymal stem cells and growth factors to concentrate at cartilaginous defect sites.[1-6] A variety of scaffolds are available, including porcine-derived collagen membranes, absorbable polyglycolic acid, chitosan, and hyaluronic acid—based scaffolds, although no single scaffold has been shown to be superior to the others.[1,3,4,7,8] Consequently, autologous matrix-induced chondrogenesis (AMIC) has grown increasingly popular as a cost-effective, single-stage option for the treatment of focal osteochondral lesions of the knee.[3-6,8-12]

Placement of the matrix directly onto the defect site can be challenging, particularly as visualization can be limited because of postmicrofracture bleeding, and reaching certain locations within the knee is difficult with an arthroscopic approach. In the case of Hyalofast (Anika Therapeutics, Bedford, MA), a hyaluronic acid—based scaffold, premature wetting of the matrix makes it soft and adherent, which causes it to lose its shape and stick to other structures.[1,7,13] As Hyalofast releases hyaluronic acid upon degradation, has been shown promote formation of hyaline-like cartilage in histological studies, and has good early clinical results, it is particularly attractive as a scaffold in the treatment of osteoarticular lesions of the knee.[3,6,14,15] Although surgeons in the literature have opted to extend the standard arthroscopic portal incisions or perform a mini-arthrotomy to enable direct access to the cartilage lesions, maintaining a fully minimally invasive approach is preferred to avoid excessive wound site morbidity and enable earlier postoperative recovery.

Therefore, there is a need to efficiently and effectively enable scaffold placement into the knee under a fully minimally invasive approach. To overcome the technical difficulties and facilitate scaffold placement, we used a 5-mL 3-part Luer tip syringe (Terumo Europe, Leuven, Belgium) to fashion a cannula for fast and effective scaffold placement.

Surgical Technique

Patient Positioning and Diagnostic Arthroscopy

As previously described in the literature, AMIC is performed as per a standard arthroscopic microfracture procedure.[16,17] After positioning the patient supine, the patient's knee is cleaned and draped. As AMIC is typically performed under general anesthesia, a physical examination of the knee under anesthesia is

From the Department of Orthopaedic Surgery, Singapore General Hospital, Singapore.

The authors report that they have no conflicts of interest in the authorship and publication of this article. Full ICMJE author disclosure forms are available for this article online, as supplementary material.

Received November 22, 2019; accepted February 5, 2020.

Address correspondence to Department of Orthopaedic Surgery, the Academia, 20 College Road, Singapore 169856. E-mail: andrew.chou@alumni.stanford.edu

2212-6287/191452

https://doi.org/10.1016/j.eats.2020.02.009

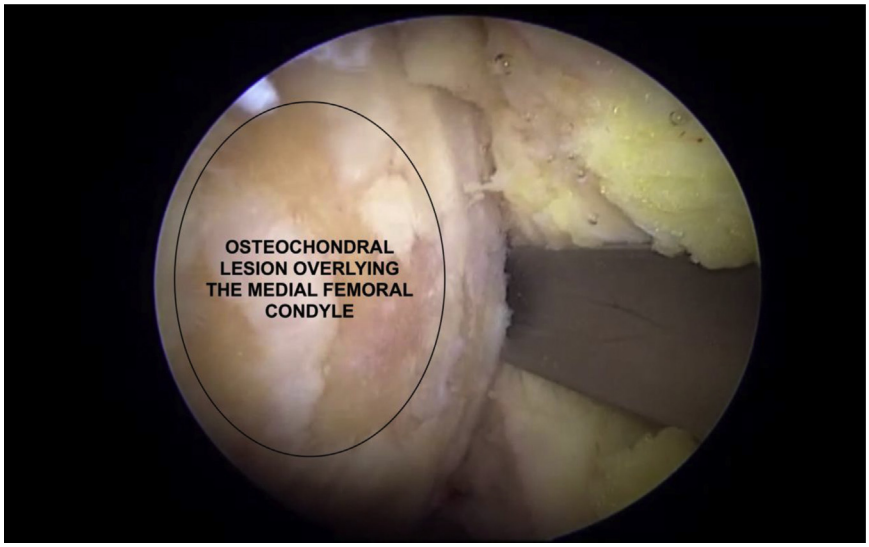

Fig 1. Diagnostic arthroscopy to visualize osteochondral lesions. The procedure begins with a standard diagnostic arthroscopy of the knee, with the arthroscope inserted via the lateral portal with the patient supine, the knee flexed to 90°, and the tourniquet inflated. The image depicts an osteochondral lesion overlying the medial femoral condyle.

recommended to confirm preoperative findings and identify any other pathology, which can help to determine whether concurrent treatment of associated pathology is required. After the tourniquet is inflated, the knee is flexed to 90°, and a routine diagnostic arthroscopy is performed to document the preoperative size, location, and appearance of any osteochondral lesions, as well as to assess for any concurrent ligamentous or meniscal injury, as shown in Figure 1. After all defects have been photographed for documentation purposes, osteochondral lesions are debrided with an arthroscopic shaver and curetted until each defect becomes a contained lesion with vertical circumferential shoulders to facilitate sizing and placement of the Hyalofast scaffold, as shown in Figure 2. Loose bodies and chondral tissue should be removed with arthroscopic tools to improve visualization. If multiple defects are identified as requiring treatment during diagnostic arthroscopy, it is recommended that all defects are debrided and prepared in the same setting to facilitate a smooth operation.

Scaffold Preparation and Microfracture

Each defect is measured using a standard arthroscopic probe or ruler. Based on these measurements, a hyaluronic acid–based cell-free scaffold (Hyalofast) can be trimmed and prepared using a pair of standard surgical scissors to match the size and shape of each defect requiring treatment, as shown in Figure 3. Microfracture is then performed at each of the defect sites using either a handheld awl or 1.1-mm Kirschner wires (K-wires) drilled at regular 5-mm intervals in a

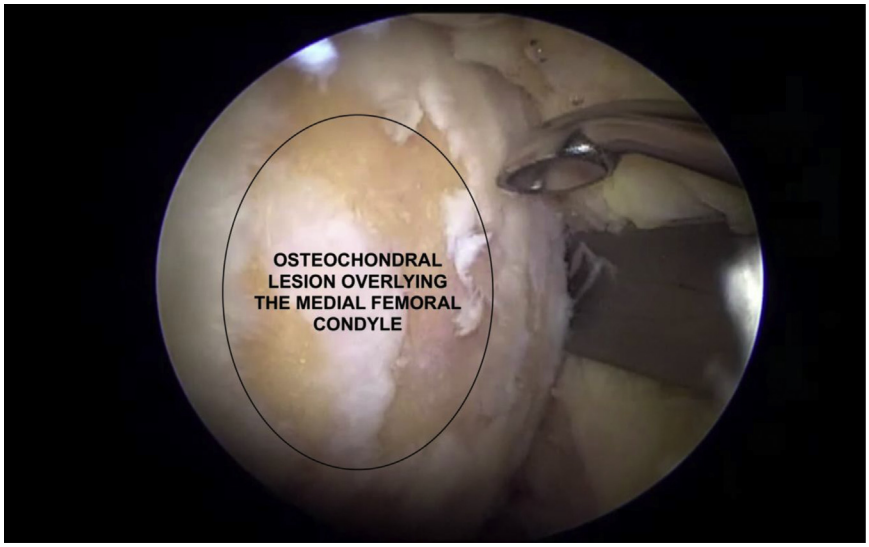

Fig 2. Preparing the lesion. With the patient kept supine, the right knee flexed at 90°, and the arthroscope kept in the lateral portal, a standard handheld curette is used to debride the osteochondral lesion until it becomes a contained osteochondral defect with stable, circumferential vertical shoulders.

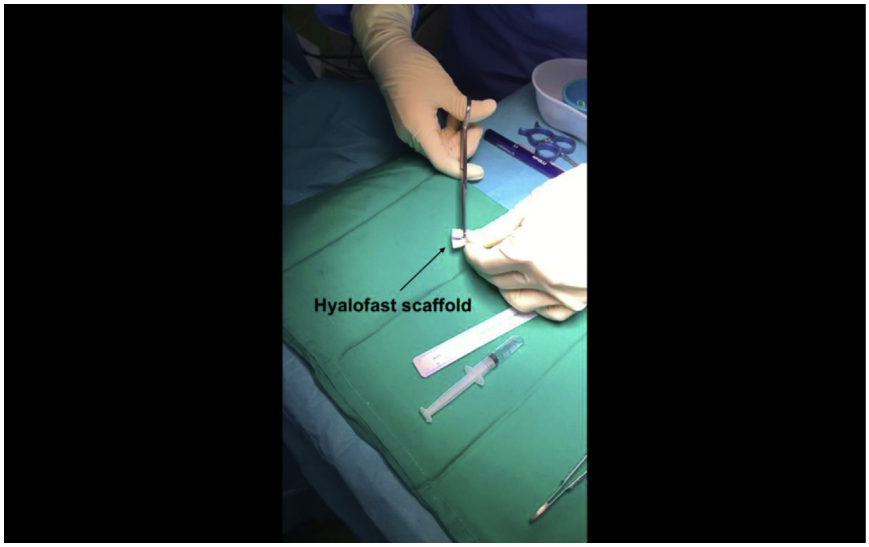

Fig 3. Preparing the Hyalofast scaffold. After preparing the osteochondral lesion, the defect can be measured, and with a pair of standard surgical scissors, the Hyalofast scaffold can be cut in a sterile field to match the defect's size and shape.

grid-like fashion, as shown in Figure 4. If an assistant is available, the assistant can proceed to prepare the scaffolds and cannulas while the surgeon continues with the microfracture.

Cannula Preparation

To facilitate efficient, precise placement of the Hyalofast scaffold into the knee, a simple cannula can be fashioned from readily available medical equipment, as shown in Figure 5. A standard sterile 5-mL syringe is opened into the sterile field. Depending on the location of the osteochondral lesion, the syringe nozzle is cut flat, at a 30° angle, or at a 45° angle to best conform to the femoral edge, as illustrated in Figure 6. Under direct visualization, the cannula is then placed through the closest arthroscopic portal to lie flush against the defect and ensure a good fit. If the cannula does not fit well against the lesion, cuts can be made at the cannula tip to improve conformity to the defect. Conformity between the cannula and femur surface is critical to allow for stable positioning of the cannula during placement of the scaffold. Once the cannula has been prepared and tested, the scaffold is then loaded into the syringe using a pair of forceps, as shown in Figure 7. During this step, it is important not to bunch or crumple the scaffold, as this can lead to an uneven scaffold being placed onto the surface of the defect. The syringe plunger can later be used with the syringe as trocar, allowing the surgeon to gently conform the scaffold onto the knee defect through the cannula.

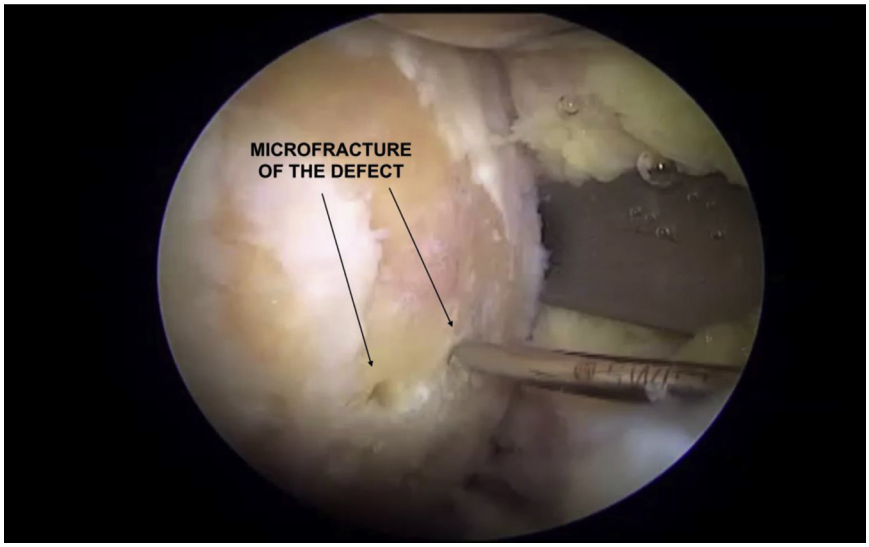

Fig 4. Microfracture of the defect. With the right knee in 90° of flexion, the patient supine, and the arthroscope inserted in the lateral portal, microfracture of the defect can be performed through the medial portal using either a handheld awl or a 1.1-mm K-wire driver in a grid-like fashion spaced 5 mm apart.

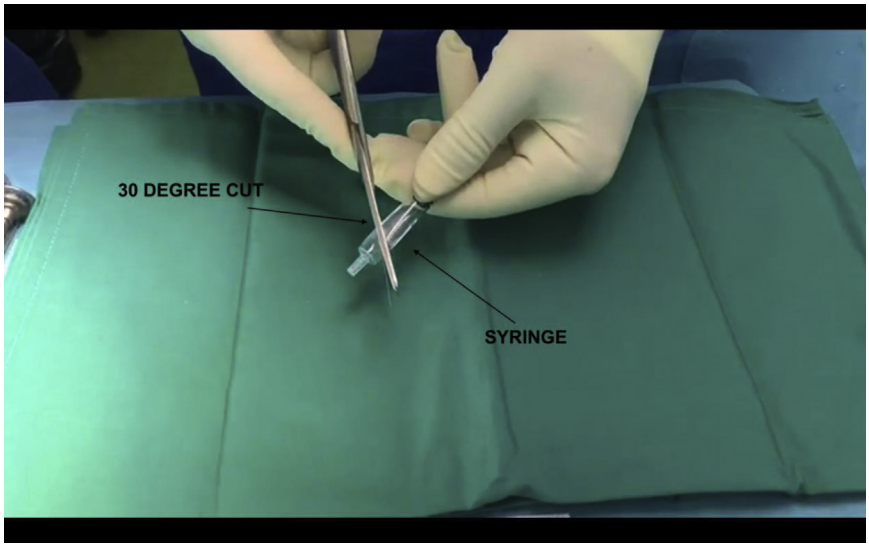

Fig 5. Fabricating the cannula. In a sterile field, a standard 5-mL syringe can be fashioned into a cannula with a standard pair of surgical scissors. The nozzle is cut at an angle depending on the specific location of the defect.

Scaffold Application Technique

Once the scaffold has been loaded into the syringe, the knee is drained of arthroscopic fluid. We recommend dry arthroscopy, as it enables greater visualization of the defect and allows the surgeon to confirm that each defect has been prepared adequately. Furthermore, as the Hyalofast matrix becomes soft and adherent upon contact with fluid, placement under dry arthroscopy avoids premature wetting of the matrix and facilitates easy placement of the Hyalofast scaffold. Under dry arthroscopy, the cannula can be inserted into the closest arthroscopic portal, and the scaffold can be applied and conformed directly to the defect site using the plunger as a trocar, as shown in Figures 8 to 10. Upon contact with fluid at the defect site, the scaffold shrinks slightly and becomes soft and adherent, after which it can be conformed and shaped to fit the size and shape of the defect. If needed, the plunger can be

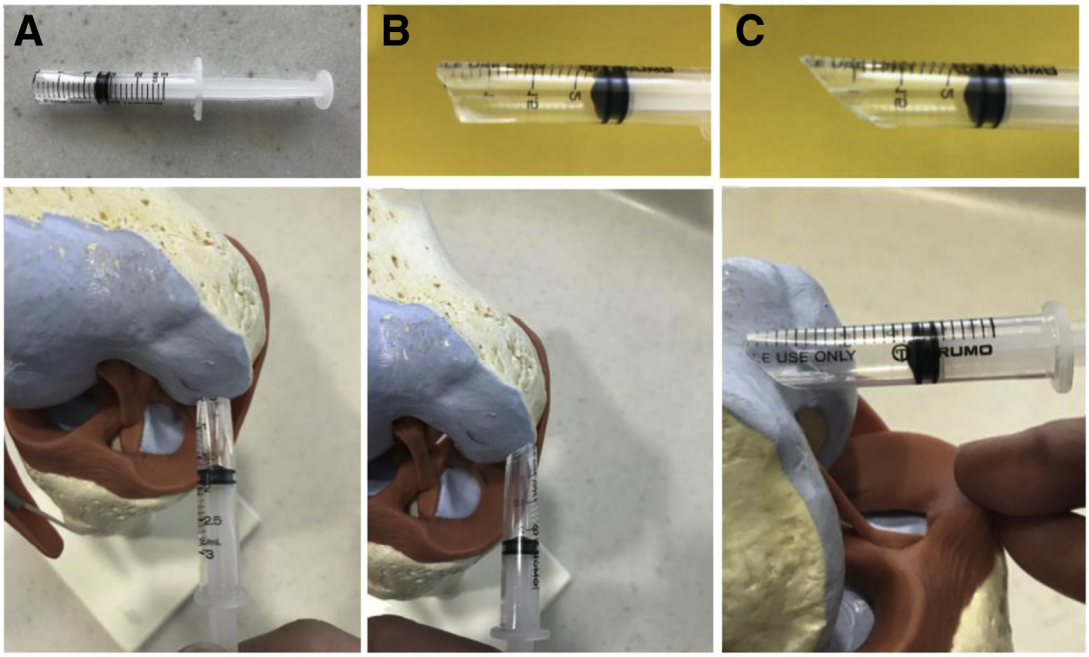

Fig 6. Syringe cut. The standard sterile 5-mL syringe can be cut at 3 different angles to facilitate insertion of the Hyalofast scaffold depending on the location of the defect within the knee. A, A flat cut for femoral condylar lesions. B, A 30° cut for femoral condylar edge lesions. C, A 45° cut for femoral trochlear lesions. Different cuts are advised to improve the conformity of the cannula to the femoral surface, thereby facilitating a smooth and efficient application of the scaffold.

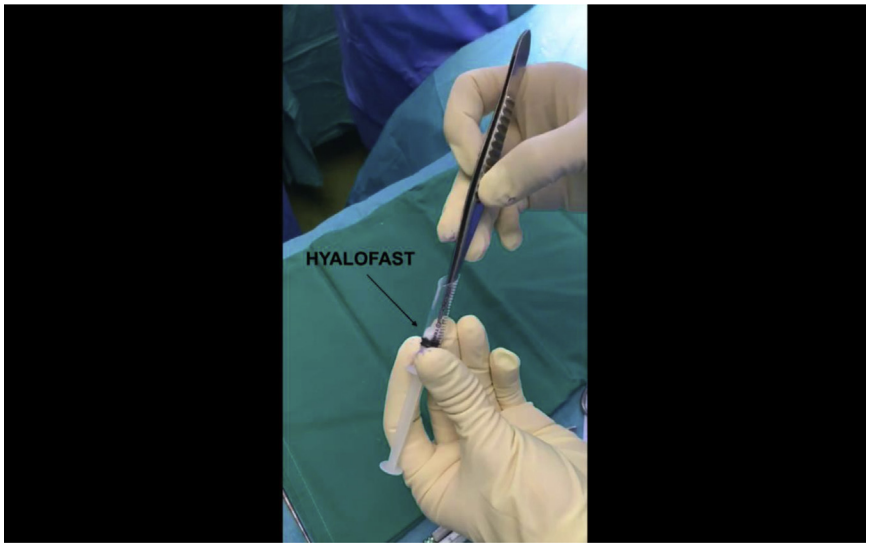

Fig 7. Loading the scaffold onto the cannula. With a pair of forceps, the trimmed Hyalofast scaffold can be loaded into the cannula, taking care to avoid bunching or folding of the scaffold during the process.

removed and additional Hyalofast scaffolds can be passed through the syringe to better fill in the shape of the defect. Once all the scaffolds have been placed, the cannula can be removed, and arthroscopic tools can be used to adjust the scaffolds as necessary. After all adjustments have been made and the scaffold has been allowed to set for $\geq$5 minutes, the instrumentation is removed, the arthroscopic portals are closed with a nonabsorbable suture, and dressing with gauze and crepe is applied to the knee.

Postoperative Rehabilitation

In the postoperative phase, the goal of rehabilitation is to allow for early range of motion and graduated return to weightbearing without subjecting the Hyalofast scaffold to excessive mechanical stress. Although some authors advocate for immobilizing and non-weightbearing after all AMIC procedures, our rehabilitation protocol depends on the specific location of the cartilage defects.[13] If AMIC was performed for a defect localized over a weightbearing surface (e.g. the femoral condyles), patients are advised by their physiotherapist to immobilize the knee and avoid weightbearing for 4 weeks, followed by 4 weeks of increasing range of motion exercises and partial weightbearing, before being allowed to return to full weightbearing with full range of motion. For repairs done in weightbearing regions, restricting range of motion and avoiding weightbearing is done to avoid subjecting the scaffold to excessive compressive forces that might destabilize the scaffold prematurely. If AMIC was performed for a defect located over non-weightbearing surfaces (e.g.

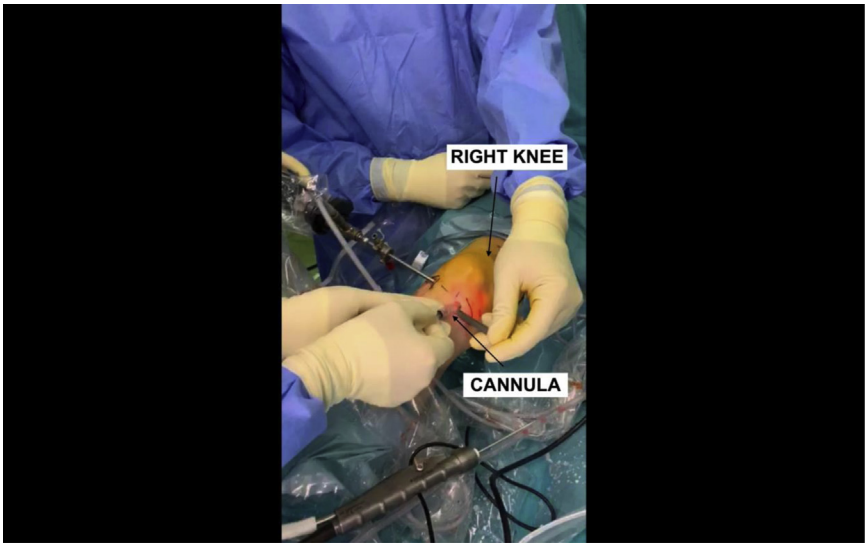

Fig 8. Inserting the cannula into the knee. With the knee flexed to 90° and the patient supine, the cannula with the Hyalofast loaded can be directly inserted into the medial portal, entirely avoiding the need for an arthrotomy.

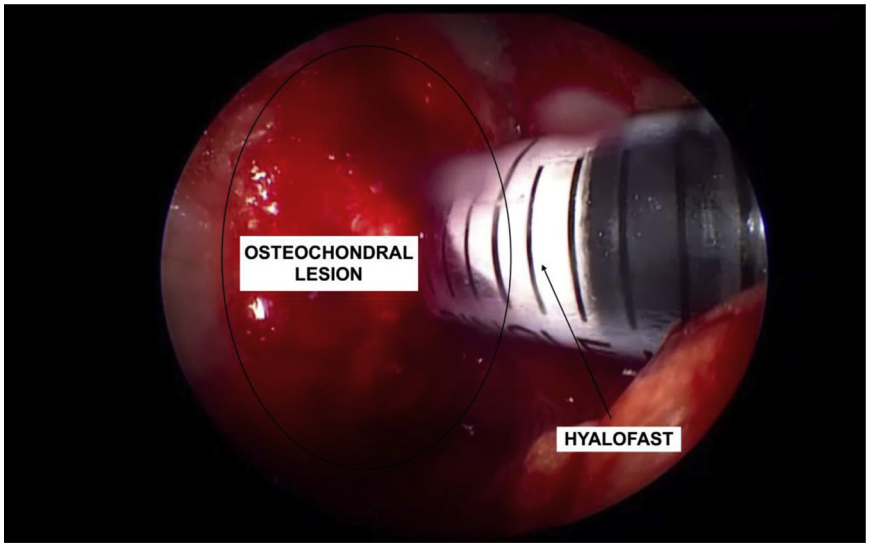

Fig 9. Placing the Hyalofast scaffold onto the defect. With the knee maintained at 90° flexion and the patient supine, the Hyalofast scaffold can be applied directly to the osteochondral lesion overlying the medial femoral condyle under direct visualization from the arthroscope placed in the lateral portal.

the femoral trochlea), patients are advised by their physiotherapist to proceed with partial weightbearing using a brace with the knee locked in extension for 4 weeks, followed by full weightbearing with full knee range of motion afterward. For repairs done in non-weightbearing regions, patients are allowed to begin weightbearing, but still advised to immobilize the knee, as ranging the knee may place excessive shear forces on the scaffold, which may also destabilize the scaffold prematurely. As per standard rehabilitation protocols for cartilage repair surgeries, patients are advised to return to high-impact activities $\geq$6 months postoperatively and to sports $\geq$1 year postoperatively.[13]

Details of the technique are shown in the Video, and the Table contains a step-by-step technique summary.

Discussion

Although AMIC provides patients with an attractive, cost-effective, single-stage option for the treatment of focal articular defects of the knee, insertion of the scaffold can be technically challenging depending on the location of the lesion. We describe here a low-cost, accessible, and easy-to-fashion solution to facilitate insertion of the scaffold via a fabricated cannula, which enables surgeons to efficiently and effectively place the matrix arthroscopically while avoiding the need to extend the arthroscopic incisions or convert to an arthrotomy. Keeping AMIC as a minimally invasive, single-stage procedure with a relatively short procedure duration may help to reduce risk of fibrosis, postoperative hematoma formation, and infection, as well as facilitate earlier rehabilitation and recovery.

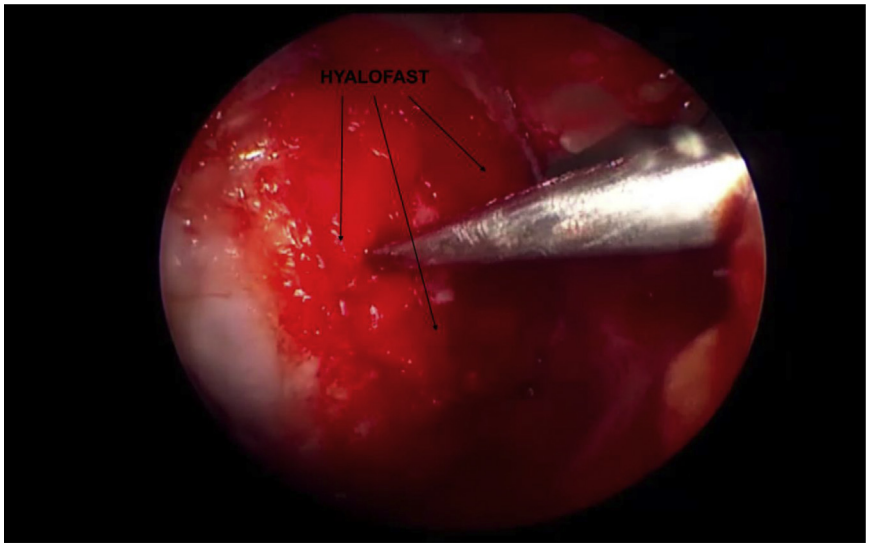

Fig 10. Adjusting the Hyalofast scaffold. While keeping the patient supine and the knee flexed to 90°, the Hyalofast scaffold can be seen becoming soft and adherent to the defect site, as visualized through the arthroscope placed in the lateral portal. The scaffold can be adjusted using the plunger as a trocar or using arthroscopic tools inserted through the medial portal.

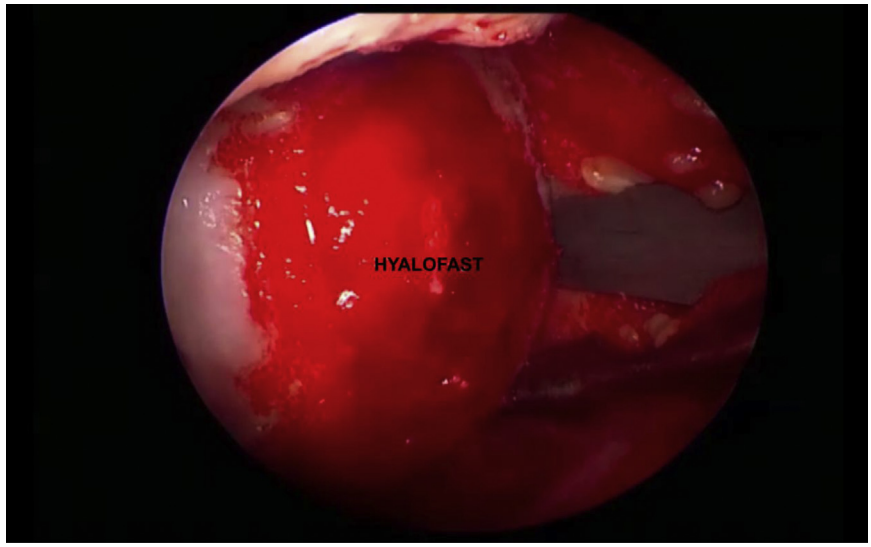

Fig 11. Final appearance of the scaffold. The final scaffold can be seen here visualized through an arthroscope placed in the lateral portal with the patient supine and the knee flexed at 90°.

Furthermore, our cannula can be easily created from readily available surgical equipment at minimal cost and provides ease and speed for graft passage in a variety of locations within the knee. Particularly for trainees and young surgeons, this technique may enable them to effectively perform AMIC independently and efficiently.

Limitations

There are a few disadvantages to this technique. First, if there are multiple lesions in different locations to be addressed in the same setting, creating multiple cannulas can add up to 2 or 3 minutes per syringe. However, we feel that this is a short amount of time compared with the convenience and speed at which the cannula allows for scaffold placement into the knee, which is often one of the most challenging steps of the procedure. Furthermore, unlike prefabricated cannulas available commercially, the syringe used in our technique is smooth and lacks threads to screw onto the portal site. Although this means the surgeon must hold the cannula in place while inserting the scaffold, generally this has not been a major inconvenience as reported by our surgeons using this technique. Lastly, as the 5-mL syringe was chosen for its small diameter to fit through the arthroscopic incisions, scaffolds cut for larger osteochondral defects may become bunched up within the cannula during insertion. However, this is an inherent limitation of the minimally invasive approach, and we have found that inserting multiple scaffold patches and repositioning the cannula intraoperatively is an effective and convenient workaround for this issue.

Conclusion

We describe here a technique of fashioning a low-cost arthroscopic cannula made from readily available medical equipment to facilitate the passage of scaffolds into the knee. The advantage of the cannula is that it enables rapid, effective placement of the scaffold into various locations of the knee while avoiding excessive wetting, incurring minimal cost, and maintaining a minimally invasive approach.

Table. Surgical Technique

1. Standard diagnostic knee arthroscopy is performed to document the size and shape of the lesion (Figure 1).
2. The lesion of interest is debrided until a stable shoulder surrounds the defect (Figure 2).
3. Based on the diagnostic arthroscopy, the Hyalofast matrix is cut into an appropriate shape (Figure 3).
4. Microfracture is performed using a handheld awl or K-wires (Figure 4).
5. The cannula is prepared using a standard sterile 5-mL syringe depending on the location of the defect. In the example, a 30° cut is used for a femoral condyle lesion (Figure 5).
6. The matrix is loaded onto the cannula directly using forceps (Figure 7).
7. The matrix-loaded cannula is placed into the knee through one of the standard anterolateral or anteromedial portals under dry arthroscopy (Figure 8).
8. Under direct visualization, the Hyalofast is applied directly to the lesion (Figure 9).
9. As the matrix becomes soft and adsorbent, it can be adjusted with a tool or the plunger (Figure 10).
10. In the example, the final product can be visualized conforming neatly to the edges of the defect (Figure 11).

References

1. Benthien JP, Behrens P. Autologous matrix-induced chondrogenesis (AMIC). A one-step procedure for retropatellar articular resurfacing. *Acta Orthop Belg* 2010;76:260.
2. Gobbi A, Whyte GP. One-stage cartilage repair using a hyaluronic acid—based scaffold with activated bone marrow—derived mesenchymal stem cells compared with microfracture: Five-year follow-up. *Am J Sports Med* 2016;44:2846-2854.
3. Sofu H, Camurcu Y, Ucpunar H, Ozcan S, Yurten H, Sahin V. Clinical and radiographic outcomes of chitosan-glycerol phosphate/blood implant are similar with hyaluronic acid-based cell-free scaffold in the treatment of focal osteochondral lesions of the knee joint. *Knee Surg Sports Traumatol Arthrosc* 2019;27:773-781.
4. Riff AJ, Davey A, Cole BJ. Emerging technologies in cartilage restoration, *Joint Preservation of the knee*. New York: Springer, 2019;295-319.
5. Kalamegam G, Memic A, Budd E, Abbas M, Mobasheri A. *A comprehensive review of stem cells for cartilage regeneration in osteoarthritis*. In: *Cell Biology and Translational Medicine*, ume 2. New York: Springer, 2018;23-36.
6. Hinzpeter J, Zamorano A, Barahona M, Campos P. Treatment of osteochondritis dissecans of the knee with autologous iliac bone graft and hyaluronic acid scaffold. *Knee Surg Relat Res* 2019;31:143.
7. Bistolfi A, Ferracini R, Galletta C, et al. Regeneration of articular cartilage: Scaffold used in orthopedic surgery. A short handbook of available products for regenerative joints surgery. *Clin Sci Res Rep* 2017;1:1-7.
8. da Cunha CB, Andrade R, Veloso TR, Learmonth DA, Espregueira-Mendes J, Sousa RA. Enhanced microfracture using acellular scaffolds improves results after treatment of symptomatic focal grade III/IV knee cartilage lesions but current clinical evidence does not allow unequivocal recommendation. *Knee Surg Sports Traumatol Arthrosc* 2020:1-13.
9. Sofu H, Kockara N, Oner A, Camurcu Y, Issın A, Sahin V. Results of hyaluronic acid—based cell-free scaffold application in combination with microfracture for the treatment of osteochondral lesions of the knee: 2-year comparative study. *Arthroscopy* 2017;33:209-216.
10. Zanasi S, Ventura C. One step tissue engineering for cartilage reconstruction in severe osteoarthritis of the knee and ankle: A comprehensive review of the technique resorting to isolated BMAC or ADSCS and their last combination. *NanoWorld J* 2017;3:S9-S15 (suppl 3).
11. Verdonk P, Dhollander A, Almqvist K, Verdonk R, Victor J. Treatment of osteochondral lesions in the knee using a cell-free scaffold. *Bone Joint J* 2015;97:318-323.
12. Gobbi A, Scotti C, Karnatzikos G, Mudhigere A, Castro M, Peretti GM. One-step surgery with multipotent stem cells and hyaluronan-based scaffold for the treatment of full-thickness chondral defects of the knee in patients older than 45 years. *Knee Surg Sports Traumatol Arthrosc* 2017;25:2494-2501.
13. Lee YHD, Suzer F, Thermann H. Autologous matrix-induced chondrogenesis in the knee: A review. *Cartilage* 2014;5:145-153.
14. Abbas M, Alkaff M, Jilani A, et al. Combination of mesenchymal stem cells, cartilage pellet and bioscaffold supported cartilage regeneration of a full thickness articular surface defect in rabbits. *Tiss Eng Regen Med* 2018;15:661-671.
15. Tomaszewski R, Ł Wiktor, Gap A. Enhancement of cartilage repair through the addition of growth plate chondrocytes in an immature skeleton animal model. *J Orthop Surg Res* 2019;14:260.
16. Steadman J. Microfracture technique for full-thickness chondral defects: Technique and clinical results. *Operative Tech Orthop* 1997;7:294-299.
17. Pridie K. A Method of resurfacing osteoarthric knee joints. *J Bone Joint Surg Br* 1959;3:618-619.