Technical Note

# C-Arm Guidance During Thin Flap Arthroscopic Trochleoplasty for Chronic Patellar Instability

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**Abstract:** The purpose of this paper is to provide a complete Technical Note for our treatment of choice for recurrent patellar dislocation in cases of trochlear dysplasia, especially in patients with types B and D trochlear dysplasia according to the Dejour classification. Different surgical procedures have been reported for the treatment of recurrent patellar instability. One of the most important anatomic factors to address when treating a recurrent patella dislocation is trochlear dysplasia. Few types of open trochleoplasty have been classically described to treat a dysplastic trochlea. However, in recent years, arthroscopic techniques have been reported to reduce invasiveness and complications as well as to improve accuracy and clinical outcomes. In this technique is described an arthroscopic thin-flap tracheoplasty with the use of C-arm guidance in order to precisely control the bone resection and to verify intraoperatively the disappearance of the radiologic landmarks used for diagnosis and classification of the dysplasia. The advantage of this technique is the precision in removal of the supratrochlear spur and bump, the accurate and delicate reshaping of the sulcus with preservation of cartilage vitality, combined with increased reproducibility and safety.

Patellar dislocation has a peak incidence in adolescent and young adult patients. Female patients are typically more affected than male patients. A first episode of patellar dislocation can open the way to subsequent instability and recurrent dislocations. An incidence of up to 5 cases per 100,000 has been registered. Recurrence after a first episode can range from 15% to 80%. Recurrence after a second dislocation is roughly 50%.[1,2] Many associated anatomic risk factors have been described and are well known, and therefore the underlying cause of dislocation must be identified and treated accordingly.[3]

The most important is probably trochlear dysplasia, as it is described in approximately 85% of patellar instability.[4] The Dejour classification is still used to divide dysplastic trochleas into 4 subtypes. This classification is based on the presence on standard lateral radiographs of a crossing sign, believed to be pathognomonic.[4] This sign corresponds to the deepest point of the trochlear sulcus crossing the anterior border of the femoral condyles. In the presence of trochlear dysplasia, open trochleoplasty, which consist of the restoration of the trochlear sulcus, is considered the best choice of surgical treatment.[5] Nevertheless, this procedure is associated with many issues, including the technical challenge, invasiveness, and the risk of complication such as the arthrofibrosis. In recent years, some authors have proposed an arthroscopic variation of the technique that may overcome these troubles.[6,7]

In this Technical Note, we describe our technique for thin-flap arthroscopic trochleoplasty with the implementation of the intraoperative C-arm visualization to control and optimize the amount of bony resection combined with medial patellofemoral ligament (MPFL) reconstruction with autologous semitendinosus tendon for recurrent patellar instability in cases of trochlear dysplasia. The main advantages of this procedure, achieved through arthroscopic and intraoperative radiographic control, are the reduced invasiveness

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combined with a highly accurate bone resection. This results in a reduced risk of postoperative arthrofibrosis while preserving cartilage and capsule integrity.

## Surgical Technique (With Video Illustration)

### Preoperative Assessment

Before surgery, it is very important to acquire complete history, clinical findings, and imaging of the patient to determine the type of surgery to perform, as not all patients are eligible for an arthroscopic procedure. The typical patient has a history of recurrent patellar dislocation. Physical examination has some common findings, such as the J sign and apprehension sign. First-level examinations include standard radiographs in anteroposterior, a true lateral view with superimposition of the femoral condyles at 20° of flexion, in order to identify the landmarks of trochlear dysplasia and the sunshine view of the patella (Fig 1). Our standard protocol, moreover, includes a computed tomography (CT) scan of both limbs acquired in a single sequence both at 0° and 30° of flexion associated with a CT of the lower limb for rotational study. CT scan is helpful to assess the trochlear shape, the presence of lateral bump, and to measure the sulcus and tilt angles (Fig 2). Magnetic resonance imaging (MRI) is useful to evaluate associated lesions, chondral defects, and loose bodies and is also routinely performed. MRI is also an effective tool to assess the trochlear morphology and define the landmarks of the dysplasia as recently shown by Sales-Fernández and Shah.[8] Measurement of patellar height, tibial tubercle–trochlear groove distance, and patellar tilt angle are acquired. Patellar height is evaluated on the lateral view radiographs using the Caton–Deschamps index (CDI) ratio. As reported an index ratio greater than 1.2 suggests a tibial tubercle distal transfer.[3] However, this measurement should be always related to the sagittal patellofemoral engagement (SPE) measured on MRI, which represents the functional engagement between patella and trochlea.[9] A SPE $<0.45$ is a sign of insufficient engagement of the patella on the trochlear groove and it suggests a patellar distalization even if the CDI results are normal.[3] On the contrary, in our experience, many patients with trochlear dysplasia show a CDI at the upper limit of normality (1-1.2) with SPE $>0.45$, not requiring patellar distalization.

Many instability factors have been described. Among these, trochlear dysplasia is probably the most important; other factors include patellar height and increased tibial tubercle–trochlear groove distance, patellar tilt angle, femoral and tibial deformities, and minor association with genu valgum.

The Dejour classification for trochlea dysplasia is still universally recognized, and it is useful to classify the type of dysplasia. It can be obtained with a simple radiograph in a true lateral view (with the femoral condyles superimposition) (Fig 3).[10]

Our indication to perform the thin-flap arthroscopic trochleoplasty is Dejour type B and D trochlea

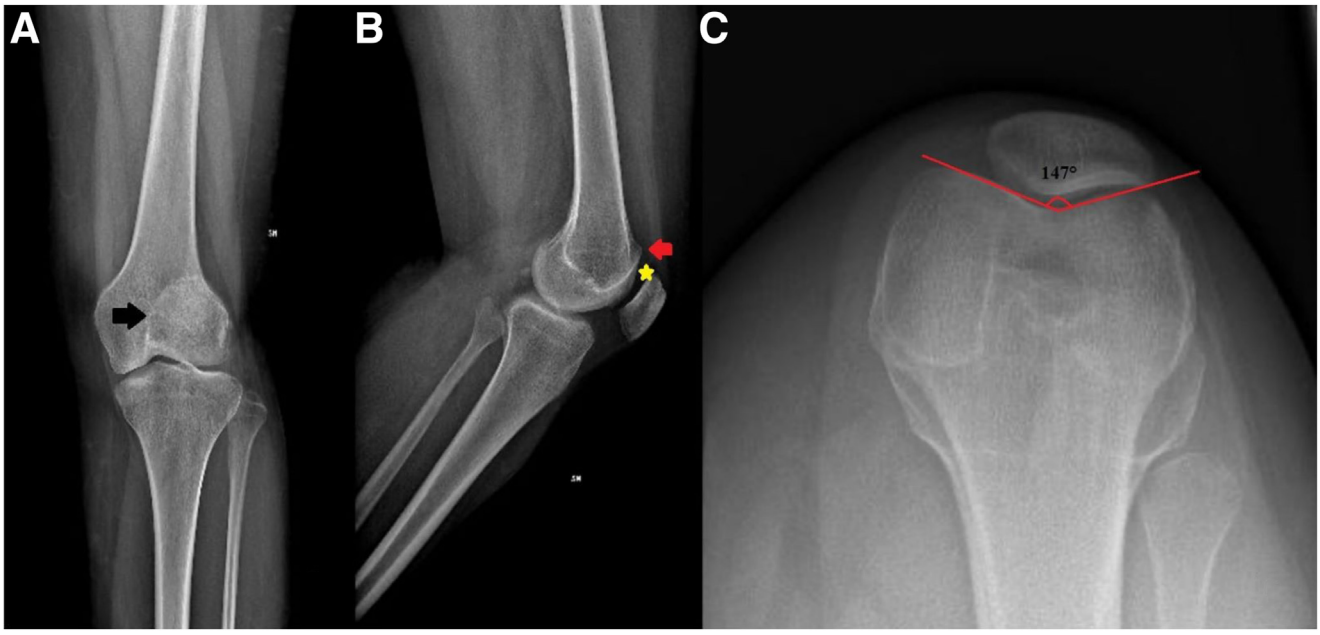


**Fig 1.** Left knee. (A) Anteroposterior preoperative left knee radiograph showing patellar lateralization (black arrow). (B) True lateral preoperative radiograph demonstrating a dysplastic femoral trochlea characterized by crossing sign (yellow star) and a supratrochlear spur (red arrow). (C) Preoperative patellar sunshine-view radiograph showing patellar lateralization and a slightly increased sulcus angle of 147° (red angle).

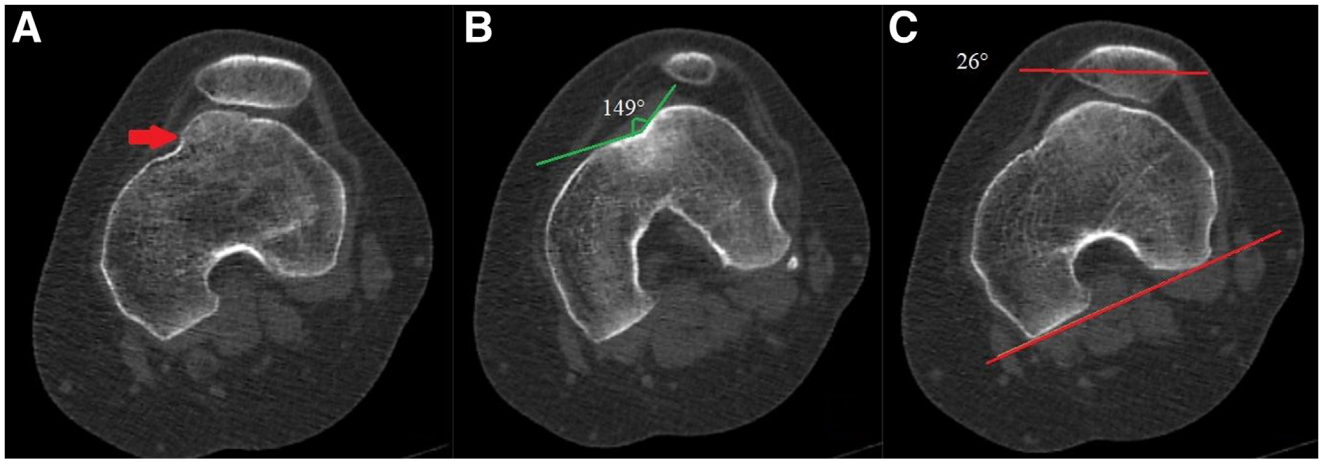


**Fig 2.** Left knee. A preoperative computed tomography, axial view, is shown. (A) Abnormal trochlear shape with supratrochlear spur and lateral bump (red arrow). (B) Sulcus angle of 149° (green angle). (C) Patellar tilt of 26° (red lines) and a lateralized patella.

associated with recurrent episodes of patellar dislocation. We always associate MPFL reconstruction to grant a passive restraint to the patella because in this type of injury the MPFL is either chronically deficient or broken.[11] Contraindications include type A trochlea, patellofemoral osteoarthritis, major chondral defects and the skeletal immaturity due to the risk of physeal damage. Arthroscopic trochleoplasty is not indicated when other open procedures are needed, such as lateral retinacular lengthening in fixed lateral patellar dislocation or in case of severe patellar dysplasia requiring patellar osteotomy as observed in some cases of trochlear dysplasia, particularly among type C.

**Fig 3.** Preoperative true lateral view of the left knee a dysplastic trochlea with a crossing sign (red line) and a supratrochlear spur (green line).

## Step-Guided Surgical Technique

A demonstration of the procedure is presented in Video 1.

### Patient Positioning and Examination Under Anesthesia

The patient is positioned supine on the operating table. A lateral support for the thigh and a foot support are positioned to allow flexion at 90°. It is important to assess that the lateral support does not interfere with the arthroscopic instrumentation during the procedure while the knee is fully extended. A tourniquet is placed around the thigh, and it is inflated throughout all the phases to ease arthroscopic visualization. The leg is prepared and draped in a sterile fashion. Full range of motion of the knee is explored, including lateral tilt and patellar tracking. Patellar mobility and the presence of J sign it is also evaluated (Fig 4).

### Diagnostic Arthroscopy

Standard anterolateral and anteromedial arthroscopic portals are made. Diagnostic arthroscopy is performed with a standard 30° arthroscope. At first, the shape of the femoral trochlea, the position of the patella, and its tilt is evaluated (Fig 5). The other compartments of the knee are explored for evaluation of associated lesions. Loose intra-articular bodies and cartilage flaps are removed. Any concomitant injuries are addressed and treated accordingly.

High superomedial (HSM) and superolateral (SL) portals are obtained. Excess of synovia and tissue are removed through those portals to improve trochlear visualization. An 8.25-mm cannula (Twist-in Cannula;

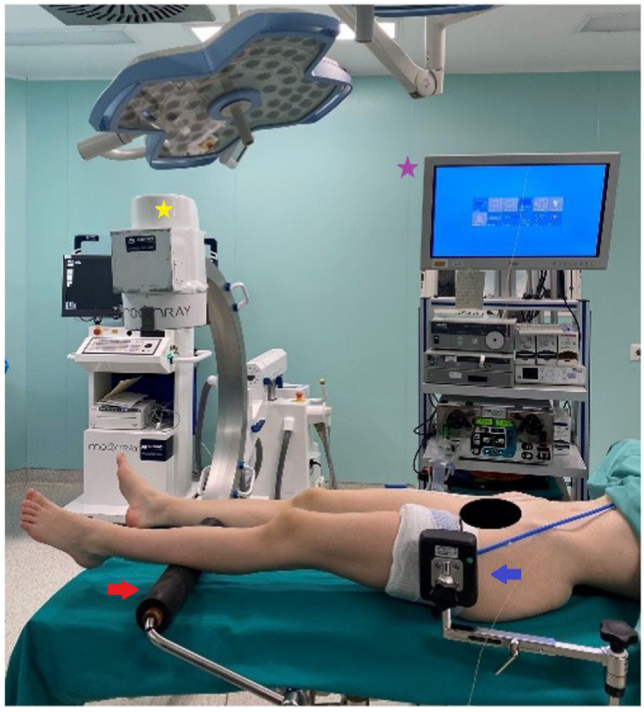

**Fig 4.** Operating room setup and patient positioning: the patient is positioned supine on the operating table with a lateral support for the thigh (blue arrow) and a foot support to allow flexion at 90° during the procedure (red arrow). A tourniquet is placed around the thigh. C- arm (yellow star) and arthroscopic tower (purple star) are placed on the opposite side of the affected limb.

Arthrex, Naples, FL) is used to facilitate the instrumentation passage through the HSM portal, while a 10 mm flexible low-profile cannula (PassPort Cannula; Arthrex) allows adequate maneuverability into the SL portal. These portals allow direct access to the trochlea with good visualization of the patellar relationship and tracking.

### Identification and Marking of the New Trochlear Groove

Ideally, the new trochlear groove should be located on a virtual line passing from the anterior tibial tubercle (ATT) to the anterior superior iliac spine (ASIS). As described by Xu et al.,[7] a guide spine needle is inserted into the joint in a proximo-distal position superior to the lateral border of the patella along the line that joins the ASIS and ATT. Visualization through the HSM portal allows marking of the lateral edge and midline of the new trochlear groove with a radiofrequency device proximally to the cartilage as proposed by Xu et al.[7]

### Osteochondral Flap Elevation and Molding

A small osteotome (4-6 mm) is inserted through the SL portal and the borders of the osteochondral flap are marked and gently elevated to allow the insertion of a 4.5 mm high-speed spherical burr (Sterling bur; Conmed Linvatec, Largo, FL). Using the high-speed burr, an initial trench is made along the superolateral border of the trochlea. In order to deepen under the osteochondral flap, it is helpful to alternate the use of the small chisel and the high-speed burr (Fig 6). These steps allow the removal of the supratrochlear spur and the trochlear bump and the creation of a new trochlear groove. During the trimming, it is useful to switch frequently the visualization between the SL and HSM portals to verify from different points of view the shape of the new trochlea. The osteochondral flap is extended distally according to preoperative planning and until the flap itself is made malleable enough to be reduced into the new position. Hereafter, a double curved blunt elevator, intended for posterior cruciate ligament reconstruction, is used to put the flap into position so that it sits upon the new groove. During the reaming process, it is mandatory to leave at least 1 to 2 mm of subchondral bone to avoid chondronecrosis of the cartilage or chondrolysis. This step is essential for a

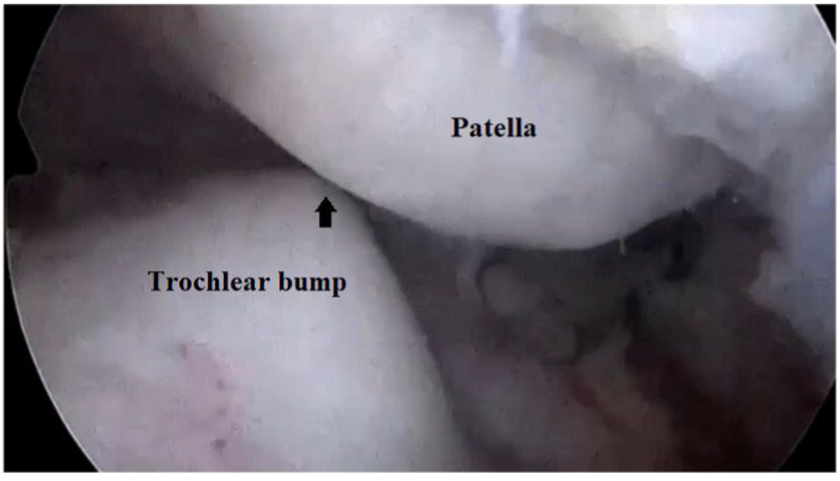


**Fig 5.** Left knee. Arthroscopic view from superolateral portal of the trochlearpatellar rapports revealing patellar lateralization and an abnormal trochlear shape characterized by a pronounced bump and an altered patellar tracking (black arrow).

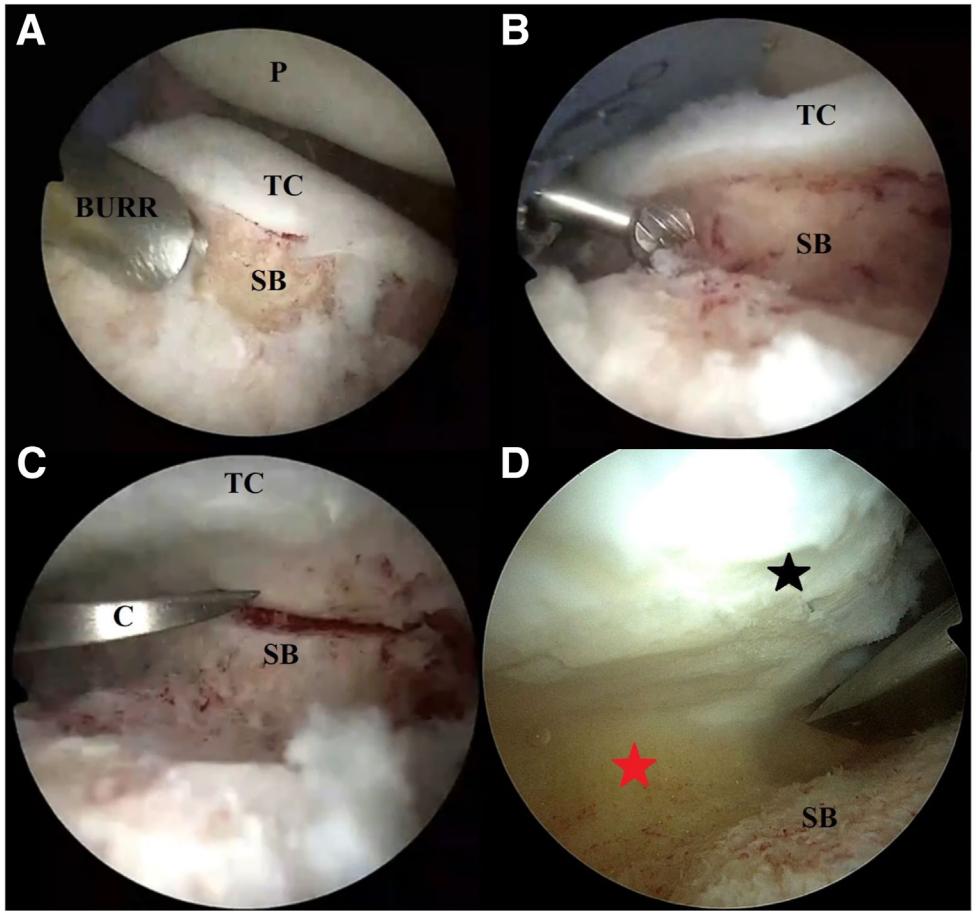


**Fig 6.** Left knee. Arthroscopic view from the high superomedial portal. (A) A 4.5-mm high speed burr is introduced from the superolateral portal and used to develop a thin osteochondral flap by trimming subchondral bone. (B) The burr is deepened under the trochlear cartilage during the thin osteochondral flap development. (C) A 4- to 6-mm chisel is alternately inserted under the osteochondral flap to remove the trochlear bump and supratrochlear spur, thus creating a new trochlear groove. (D) Left knee viewed from superolateral portal after switch of the visualization. The chisel is introduced from the high superomedial portal to visualize the extension of the trimming (red star). The thin osteochondral flap (black star) is definitely developed preserving 1-2 mm of subchondral bone to avoid chondronecrosis or chondrolysis. (C, chisel; P, patella; SB, subchondral bone; TC, trochlear cartilage).

successful procedure. The total width of the flap should not be less than 3 mm and no more than 5 mm, including the subchondral bone. Extreme care must be taken while handling the flap, as its breakage can be a devastating complication.

### Fluoroscopic Evaluation of the New Trochlear Groove

Once the new trochlear groove has been trimmed and the osteochondral flap became flexible enough, the amount of resection should be checked using the C-arm. We developed some tricks to facilitate the intraoperative radiographs evaluation: (1) Distal extension of the trimming: to verify the adequate distal extension along the femur, a small chisel is inserted through the HSM portal under the osteochondral flake and the depth of the trimming is checked with the C-arm in a true lateral view. This control is important to prevent a flattening due to excessive trimming at the point of transition between anterior femoral cortex and condyle (Fig 7A). (2) Depth of the new sulcus and bone resection verification: 2 spinal needles are inserted along the new medial and lateral facet of the trochlea crossing at the deepest point of the new sulcus. These are used as a reference to verify the adequate depth of the groove: if in a true lateral view, the tips of the needles result posterior to the prolongation of the anterior femoral cortex (elimination of crossing-sign) the resection is to be considered adequate (Fig 7 B and C). (3) Verification of the flap reduction: a blunt elevator conceived for posterior cruciate ligament reconstruction is used to maintain reduced the flap on the new sulcus during the radiographic acquisition. A true lateral view with the superimposition of the femoral condyles should be obtained to verify the absence of the crossing sign and supratrochlear spur confirming the adequate reshaping of the subchordal bone (Fig 7D).

### Osteochondral Flap Fixation

A point approximately 1 cm proximal to the apex of the intercondylar notch is identified on the distal femoral cartilage for the first suture anchor implant. A 3.5-mm PushLock anchor (Arthrex) is loaded with 4 adsorbable suture wires (VICRYL 2; Ethicon, Somerville, NJ) each with 2 free ends (8 free ends) and inserted on the previously identified point on the intercondylar notch. Once the anchor is securely deployed, 3 free ends of the suture wires are made to sit

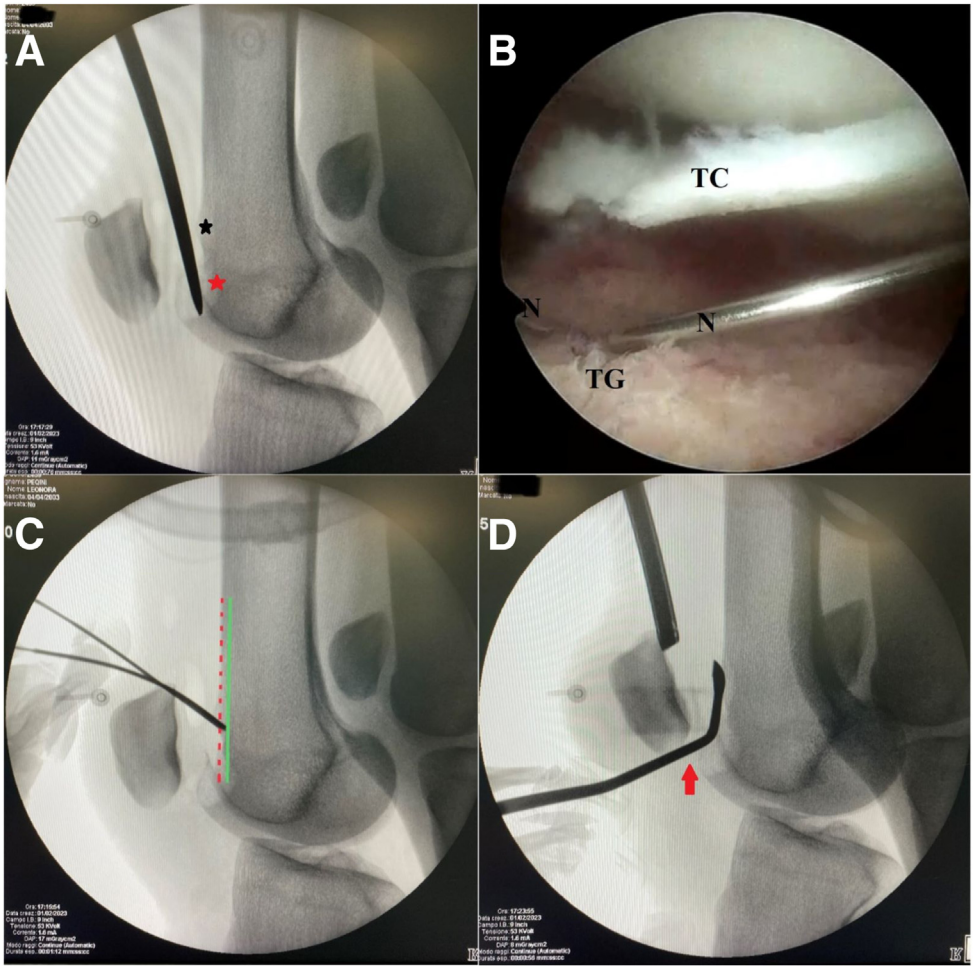


**Fig 7.** After trimming the new sulcus, combined arthroscopic and C-arm guidance checks are performed. (A) After the introduction of the chisel from the high superomedial portal, a true lateral view of the knee is obtained to verify the distal extension of the trimming along the femur. The supratrochlear spur (black star) and crossing sign (red star) elimination can be seen. (B) Left knee. Arthroscopic view of the knee from the high superomedial portal. Two spine needles are percutaneously inserted at the medial and lateral border of the new trochlea crossing at the deepest point of the new sulcus to verify the depth of the new trochlear groove. (C) After the arthroscopic check of needles' position, the needles tips are studied with a true lateral view with a C-arm acquisition. The depth of the resection is considered adequate when the tips of the needles (green line) result posterior to the prolongation of the anterior femoral cortex (dashed red line), indicating the disappearance of the crossing sign. (D) A double-curved arthroscopic elevator for posterior cruciate ligament reconstruction (red arrow) is finally introduced through the superolateral portal and used to temporarily reduce the osteochondral flap above the new trochlear groove. A final C-arm check is performed confirming the correct reshaping and reducibility of the osteochondral flap on the new trochlear groove. (N, spine needle; TC, trochlear cartilage; TG, new trochlear groove.).

upon the most medial point of the new trochlea and retrieved through the superior portal. A second PushLock loaded with those 3 wires is then placed at the medial facet of the trochlea while the flap is maintained reduced with the blunt elevator. Then, retrieving other 3 free ends of the suture, a third PushLock is seated on the lateral facet of the groove. A fourth anchor loaded with the 2 remaining sutures could be placed in correspondence of the midline of at the lateral border of the new trochlea to stably lay down the osteochondral flap upon the femoral cancellous bone. Tension is applied to the sutures until the osteochondral flap sits stably upon the femoral cancellous bone (Fig 8). Patellar tracking and patellofemoral relationship throughout the whole range of motion are then confirmed. Once the arthroscopic trochleoplasty has been completed, MPFL reconstruction using an autologous semitendinosus graft is routinely performed (Table 1).

## Postoperative Protocol and Rehabilitation

After surgery, the knee is placed in a hinged knee brace with quick extension locking device for 6 weeks. Range of motion is encouraged immediately in a 0 to 100° range of movement for the first 2 weeks. After

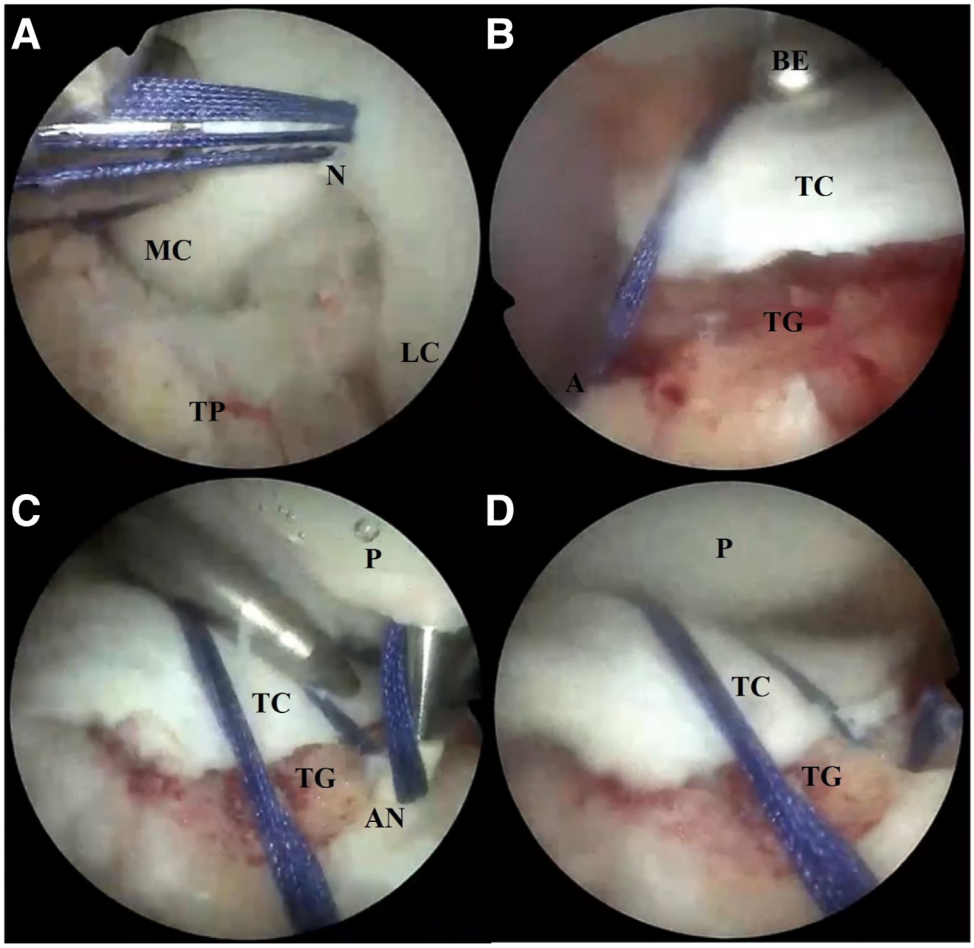


**Fig 8.** After the combined arthroscopic and C-arm guidance checks, the osteochondral flap is fixed on the new femoral trochlea using 3.5-mm PushLock anchors and no. 2 absorbable suture wires. (A) Arthroscopic view from the anterolateral portal. The first PushLock anchor loaded with four no. 2 absorbable suture wires (purple VICRYL 2 suture wires) is introduced through a transpatellar tendon portal and positioned approximately 1 cm proximal to the apex of the intercondylar notch. (B) Arthroscopic view from the high superomedial portal. Three tails of the no. 2 absorbable suture wires are retrieved from the superolateral portal and loaded into a 3.5-mm PushLock anchor. The anchor (A) is then positioned at the lateral border of the new trochlear groove (TG), gently approaching the trochlear cartilage (TC) with the aid of the blunt elevator (BE). The same procedure is repeated after retrieving and loading other three no. 2 absorbable suture wires onto a third PushLock anchor. The third anchor is then introduced through the high superomedial portal and positioned at the medial border of the new trochlear groove. (C) A fourth optional anchor can be loaded with the 2 remaining no. 2 absorbable suture wires and positioned at the midline or at the lateral border of the new trochlear groove, keeping gentle pressure on the osteochondral flap. (D) Arthroscopic view from the superolateral portal. At the end of the procedure, a final arthroscopic check is performed, patellar tracking and flap stability on the new trochlear groove are verified during flexion and extension of the knee. (LC, lateral femoral condyle; MC, medial femoral condyle; N, intercondylar notch; P, patella; TC, trochlear cartilage; TG, trochlear groove; TP, tibial plateau).

2 weeks, full range of movement is allowed and encouraged. Weight-bearing is allowed keeping the brace in extension for the first 40 days. Return to normal activities and sport can be achieved after 6 months from surgery.

## Discussion

The key role of trochlear dysplasia in the pathologic mechanism of patellar instability is well known. The shape alteration of the trochlear groove is considered the main risk factor for patellar instability being present in up to 96% of patients who experience recurrent patellar dislocations.[4] Despite this, trochlear remodeling is quite uncommon compared with other patellofemoral surgeries such as MPFL reconstruction or ATT transfer. These procedures in some cases are performed to get around the problem, solving the patellar instability but causing an overload on the patellofemoral compartment, resulting in increased pain, range of motion restriction, and osteoarthritis progression.[12] The

**Table 1.** Surgical Steps for C-arm Guidance During Thin-Flap Arthroscopic Trochleoplasty

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| Operative room set-up and patient positioning |
| Place the arthroscopy tower and C-arm on the contralateral side of the affected knee |
| Position the patient supine on a radiolucent table with a foot and lateral support allowing the knee flexion at 90°, in neutral rotation of the hip |
| Mark the skin with a straight line going from the anterior superior iliac spine (ASIS) to the anterior tibial tuberosity (ATT) |
| Perform standard diagnostic arthroscopy, address any concomitant disease, and verify the shape of the trochlea patellar position, tilt, and tracking |
| Trochleoplasty |
| Obtain a high superomedial and a superolateral arthroscopic portal, place cannulas |
| Identify and mark the position of the new sulcus using a needle along the line connecting the ASIS to the ATT |
| Debride the synovia that cover the border of the trochlea and with a small chisel trough the SL portal gently elevate the borders of the osteochondral flake |
| After initial flap elevation, insert a 4-mm burr and start the reshaping of the new trochlea |
| Alternate the use of chisel and burr to deepen under the osteochondral flap, switching the portals |
| Extend the burring distally until the flap is malleable enough to be reduced on the groove |
| Leave at least 1-2 mm of subchondral bone under the flap to avoid chondronecrosis |
| C-arm assessment |
| 1. Verify the adequate distal extension of the trimming inserting a chisel under the flake and acquiring a true lateral view using the C-arm |
| 2. Check the depth of the new sulcus inserting two spinal needles along the new lateral and medial facets of the trochlea, crossing at the deepest point of the new sulcus. Then verify the disappearance of the supratrochlear bump and the crossing sign (the tips of the needles must lie posterior to the prolongation of anterior femoral cortex visualized on a true lateral view) |
| 3. Flap reducibility: insert a blunt curved elevator to maintain reduced the flap. A wide contact between flap and the sulcus must be obtained |
| Osteochondral flap fixation |
| Position the first 3.5-mm PushLock anchor, loaded with four no 2 adsorbable sutures, 1 cm above the intercondylar notch |
| Transport the wires proximally and fix the flap with two or three more anchors on medial, central and lateral side of the trochlea |
| Tension the suture wires until good contact is achieved |
| Perform the medial patellofemoral ligament (MPFL) reconstruction |

SL, superolateral.

reason for the unpopularity of trochleoplasty is probably due to the technical complexity with its variable rate of complications.[13] Many surgical techniques have been described to address a dysplastic trochlea, but they can be grouped into 3 main subtypes: lateral facet elevation trochleoplasty, deepening trochleoplasty, and recession wedge trochleoplasty.[14] The results of those procedures in terms of recurrence of instability are satisfactory. In a systematic review that included 392 knees treated with deepening and recession wedge trochoplasties the overall rate of dislocation was only 2%.[13] Despite the significant success rate, trochleoplasty is considered a highly demanding procedure for both patient and surgeon with a considerable percentage of complications.[13,15] As reported by Longo et al.[13] in their review, the overall complication of the procedures rate was 40%, including increased pain, decreased range of motion, osteoarthritis, and arthrofibrosis. In recent years, arthroscopic versions of deepening trochleoplasty have been described with the aim

**Table 2.** Pearls and Pitfalls

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| Pearls |
| It is essential to collect all the clinical and radiologic findings (plain radiograph, magnetic resonance imaging, and computed tomography) to provide the right indication and to plan properly the procedure |
| The position of the patient on the operative table must ensure the freedom of movement of the arthroscopic instrumentation through the superolateral and high superomedial portals |
| It is important to mark the orientation of the new trochlear during the initial arthroscopic evaluation |
| Proceed with trimming alternating the use of the high-speed burr and the small chisel |
| Leave at least 1-2 mm of subchondral bone under the flake to preserve the cartilage vitality |
| Advancing distally trough the subchondral bone, care must be taken to not violate the cartilage of the intercondylar notch: using a chisel as a landmark, check with the C-arm in lateral view to assess the progression of the burring |
| Once the flap is malleable it must be handled with care to avoid its breakage |
| Verify the depth of the new sulcus, the absence of the supratrochlear spur and the crossing sign and reducibility of the flap using the C-arm before the fixation |
| Fix the osteochondral flap using at least 3 (preferably 4) anchors to distribute the tension over cartilage surface |
| Pitfalls |
| Performing the procedure without an accurate preoperative workup or in a case that is contraindicated |
| Starting the reshaping without the identification of the new sulcus may led to loss of orientation |
| Aggressive maneuvers during the trimming could penetrate or break the cartilage flake |
| If the osteochondral flap is made too thick it cannot gain the necessary mobility to be bent over the trochlea with the risk of breakage during the attempt |
| Leave the flap too thin can cause the necrosis of the overlying cartilage |
| Using arthroscopic visualization without the use of intraoperative radiographs could led to an excess or even to an inadequate burring |

**Table 3.** Advantages and Limitations

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| Advantages |
| All the related advantages of an arthroscopic technique compared with an open procedure: reduced exposition, preservation of the capsule integrity, treatment of concomitant meniscal or chondral lesions, reduced pain, cosmesis |
| Combining arthroscopic and intraoperative radiographic information enhance the tridimensionality and the orientation during the trochlear reshaping |
| Using both arthroscopic and radiographic guidance allow to optimize the amount of subchondral bone resection minimize the risk of flap breakage of insufficient correction |
| C-arm guidance helps to verify intraoperatively the disappearance of the radiologic landmarks used for the diagnosis and classification of the dysplasia |
| Reducing the pain and the local invasiveness, patient can start immediately the range of motion recovery with minor risk to develop arthrofibrosis |
| Disadvantages |
| Technically demanding procedure reserved for surgeons skilled in knee arthroscopy |
| During the learning curve, the operative time may be longer than the open technique |
| Not indicated when other open procedures on the patella–femoral compartment are needed (e.g., lateral retinacular lengthening or patellar osteotomy) |

to improve the clinical outcome and reduce the complication rate. Blønd and Schöttle[16] in 2010 were the first to report an arthroscopic technique similar to the Bereiter–Gautier, U-shape trochleoplasty.[17] Then, Xu et al.[7] reported a modification of the technique, the precise arthroscopic mini-trochleoplasty, with minor involvement of the lateral and medial ridges of the trochlear subchondral bone. Our technique is similar to others arthroscopic techniques with the implementation of the intraoperative fluoroscopic evaluation of the burring in order to better verify the reshaping of the subchondral bone and optimize the amount of resection. In fact, during the arthroscopic procedure alone, it can be difficult to assess the tridimensionality of the new groove. The surgeon could easily remove an unnecessary amount of subchondral bone, causing the breakage of the flake or even not burr enough to remove completely the supratrochlear spur. Otherwise, using the fluoroscopy with respect to radiographic landmarks proposed by Dejour[4] (double contour, crossing sign, supratrochlear spur) the adequate amount of resection can be easily confirmed (Table 2). Although arthroscopic trochleoplasty has been introduced more than 10 years ago, it has not gained the expected popularity for several reason. First, the indication to perform a trochleoplasty are quite rare and can be difficult to treat a sufficient number of patients to overcome the learning curve in a reasonable period of time. Second, the arthroscopic version of trochleoplasty brings specific technical issues, such as the optical distortion, that could complicate the orientation during the trochlear reshaping. A first method to reduce the distortion effect is to frequently switch the arthroscopic portals and perform the trimming from different points of view. A second trick is the implementation of the C-arm guidance to verify intraoperatively the disappearance of the same radiologic landmarks used for diagnosis and classification of the trochlear dysplasia. Using these 2 suggestions, we found an improvement in terms of reliability, reproducibility and safety of the procedure. Compared with other arthroscopic trochleoplasty previously reported, our technique has the advantage of a new protocol for intra-operative C-arm guidance that helps (1) to verify the distal extension of the trimming avoiding the excessive burring and flattening of the anterior femur; (2) to check intraoperatively the elimination of the pathognomonic landmarks of dysplasia (crossing sign and supratrochlear spur) combining arthroscopic and C-arm visualization; and (3) confirm before the fixation the adequate reducibility of the osteochondral flap (Table 3). As with other arthroscopic techniques, the main limitation is the need to perform other open procedures such as lateral retinacular lengthening or patellar osteotomy. Based on our experience, C-arm guidance may improve the reproducibility and safety of arthroscopic trochleoplasty and may help to facilitate the adoption and diffusion of this procedure in the treatment of recurrent patellar instability.

## References


1. Fithian DC, Paxton EW, Stone ML, et al. Epidemiology and natural history of acute patellar dislocation. *Am J Sport Med* 2004;32:1114-1121.
2. Weber AE, Nathani A, Dines JS, et al. An algorithmic approach to the management of recurrent lateral patellar dislocation. *J Bone Joint Surg Am* 2016;98:417-427.
3. Dejour DH, Mesnard G, Giovannetti de Sanctis E. Updated treatment guidelines for patellar instability: "Un menu à la carte". *J Exp Orthop* 2021;8:1-11.
4. Dejour H, Walch G, Nove-Josserand L, Guier C. Factors of patellar instability: An anatomic radiographic study. *Knee Surg Sports Traumatol Arthrosc* 1994;2:19-26.
5. Dejour DH, Deroche É. Trochleoplasty: Indications in patellar dislocation with high-grade dysplasia. Surgical technique. *Orthop Traumatol Surg Res* 2022;108:103-160.
6. Blønd L. Arthroscopic deepening trochleoplasty: The technique. *Oper Tech Sports Med* 2015;23:136-142.
7. Xu H, Ding M, Wang Y, Liao B, Shangguan L. Precise arthroscopic mini-trochleoplasty and medial patellofemoral ligament reconstruction for recurrent patellar

instability with severe trochlear dysplasia. *Arthrosc Tech* 2020;9:e1475-e1484.
8. Sales-Fernández R, Shah N. The pathologic double contour sign and the trochlea shape patterns can diagnose trochlea dysplasia. *J ISAKOS* 2023;8:74-80.
9. Dejour D, Ferrua P, Ntagiopoulos PG, et al. The introduction of a new MRI index to evaluate sagittal patellofemoral engagement. *Orthop Traumatol Surg Res* 2013;99:391-398.
10. Dejour H, Walch G, Neyret P, Adeleine P. Dysplasia of the femoral trochlea. *Rev Chir Orthop Reparatrice Appar Mot* 1990;76:45-54.
11. Amis AA, Firer P, Mountney J, Senavongse W, Thomas NP. Anatomy and biomechanics of the medial patellofemoral ligament. *Knee* 2003;10:215-220.
12. Lundeen A, Macalena J, Agel J, Arendt E. High incidence of complication following tibial tubercle surgery. *J ISAKOS* 2023;8:81-85.
13. Longo UG, Vincenzo C, Mannering N, et al. Trochleoplasty techniques provide good clinical results in patients with trochlear dysplasia. *Knee Surg Sports Traumatol Arthrosc* 2018;26:2640-2658.
14. Nolan JE, Schottel PC, Endres NK. Trochleoplasty: Indications and technique. *Curr Rev Musculoskelet Med* 2018;11:231-240.
15. Leclerc JT, Dartus J, Labreuche J, et al. Complications and outcomes of trochleoplasty for patellofemoral instability: A systematic review and meta-analysis of 1000 trochleoplasties. *Orthop Traumatol Surg Res* 2021;107,103035.
16. Blønd L, Schöttle PB. The arthroscopic deepening trochleoplasty. *Knee Surg Sports Traumatol Arthrosc* 2010;18:480-485.
17. Hampton M, Pigott T, Sutton PM. A modification of the Bereiter trochleoplasty: Indications, technique and outcomes. *Eur J Orthop Surg Traumatol* 2021;31:571-578.