Technical Note

The Original Technique for Tibial Deflexion Osteotomy During Revision Anterior Cruciate Ligament Reconstruction: Surgical Technique

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Abstract: The original technique for tibial deflexion osteotomy (TDO) was first described by Henri Dejour during the Lyon knee meeting in 1991 to reduce excessive posterior tibial slope during second revision anterior cruciate ligament reconstruction (ACLR). The technique is nowadays increasingly performed during first-revision ACLR in patients at risk for graft retear. This Technical Note describes and updates the original TDO technique.

Revision anterior cruciate ligament reconstruction (ACLR) has considerably inferior outcomes compared to primary ACLR, with graft rupture reported in up to 25% and objective clinical failure reported in up to 82%.[1-3] Failure of revision ACLR is associated with a number of extrinsic and intrinsic factors that should be considered when planning surgery. Extrinsic factors include graft incorporation, type of sport, and physical preparation, which could be optimized by adjusting tunnel positioning, postoperative rehabilitation, and return to sports.[4-6] Intrinsic factors include genetic, hormonal, and anatomic aspects, notably the patient age, concomitant ligament injuries, width of the intercondylar notch, and posterior tibial slope (PTS).[1,7-9]

An excessive PTS has been associated with a higher number of ACL ruptures and reruptures and could lead to high-grade anterior and rotational knee laxity. Biomechanical studies reported that excessive PTS increases anterior tibial translation (ATT)[10,11] and alters knee kinematics, as well as tibiofemoral pressure distributions (Fig 1). Excessive PTS therefore exacerbates tension within the native or grafted ACL.[12,13]

Tibial deflexion osteotomy (TDO) can be performed to correct excessive PTS during revision ACLR and has proved to reduce the risks of recurrent failure in patients with intrinsic predisposing risk factors by reducing the load on the reconstructed ligament.[14-18] The purpose of this Technical Note is therefore to present an update of the original TDO technique, which was described by Henri Dejour during the Lyon knee meeting in 1991.[19]

Surgical Technique

Indications and Contraindications

Tibial deflexion osteotomy is indicated in knees with PTS $\geq 12°$[14,17,18] and static anterior tibial translation (sATT) >5 mm, although it is important to consider other factors such as the number of ACL ruptures, rotational instability, and concomitant meniscal tears (Table 1). The procedure is contraindicated in skeletally immature patients, as well as knees with severe coronal malalignment or osteoarthritis of Kellgren and Lawrence grade III or IV.[20]

Preoperative Assessment and Planning

Radiographic assessment requires weightbearing frontal views, true sagittal views at 30° of flexion ensuring that the condyles are superposed, and axial

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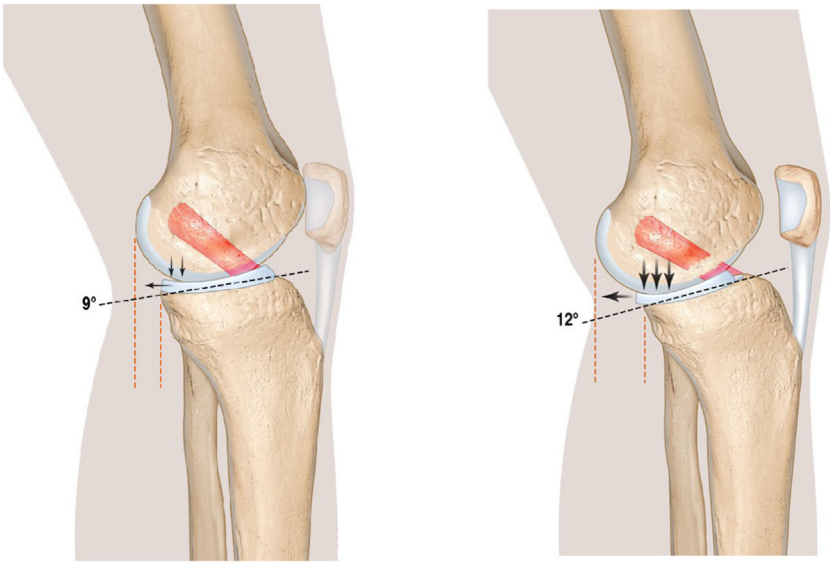

Fig 1. Lateral view: excessive posterior tibial slope increases anterior tibial translation and alters knee kinematics, as well as tibiofemoral pressure distributions.

views at 30° of flexion. The PTS is calculated as described by Dejour and Bonnin,[19] using the true sagittal view to measure the angle between the line perpendicular to the tibial diaphyseal axis and the tangent to the most superior points at the anterior and posterior edges of the medial tibial plateau (Fig 2). The height of the wedge that must be removed to obtain a target PTS between 2° and 5° is calculated assuming that 1 mm equates to 1°.[21] The sATT is defined as the distance between the posterior part of the femoral condyles and the posterior tibial plateau using the posterior tibial cortical as a reference. Magnetic resonance imaging (MRI) is required to evaluate the cartilage, the width and position of the previous tunnels, and the status of the meniscus to plan adjuvant procedures.

Patient Positioning and Anesthesia

The operation is performed with the patient in the supine position, with the knee flexed at 80° and a tourniquet under either general or regional anesthesia (Fig 3).

Graft Harvest

An anterior longitudinal incision is performed along the medial border of the tibial tuberosity, 4 cm below the joint line (Video 1). This incision allows harvesting of bone–patellar tendon–bone (BPTB) graft or hamstrings tendon graft, depending on preoperative planning; if the primary ACLR was performed using a hamstrings tendon autograft, the revision ACLR is performed using a BPTB autograft and vice versa. If both BPTB and hamstrings tendon graft are already taken, the quadriceps tendon will be harvested.

Table 1. Indications and Contraindications

Indications	Contraindications
ACLR graft tear	Osteoarthritis grade III or IV
PTS ≥12°	Hyperextension
sTTA >5 mm	Coronal malalignment
	Skeletal immaturity

ACLR, anterior cruciate ligament reconstruction; PTS, posterior tibial slope; sTTA, static anterior tibial translation.

Arthroscopy

Arthroscopic exploration is performed to evaluate the positioning and characteristics of the previous tunnels and concomitant lesions. During this exploration, any meniscal and/or chondral lesions are treated. Following this, the new femoral and tibial tunnels are drilled, but the graft is not yet inserted. The femoral tunnel is prepared using an outside-in guide for anatomic femoral tunnel placement, and the tibial tunnel is prepared using a standard 55° angulation guide.

Tibial Deflexion Osteotomy

The patellar tendon insertion is exposed using the existing incision, and the deep medial collateral ligament (MCL) and the tensor fascia lata on Gerdy's tubercle are released up to the posterior part of the tibia and protected with retractors (Table 2). Using the patellar tendon insertion as a landmark, 2 superior k-wires are inserted under fluoroscopic guidance on both sides of the patellar tendon, and 2 inferior k-wires are inserted below the tibial tuberosity using a sterile ruler to indicate the height of the wedge that must be removed. The 2 k-wires should converge posteriorly and proximally 1 cm below the joint line (Fig 4). The upper and lower cuts are made by placing the oscillating saw under the k-wires, keeping the posterior

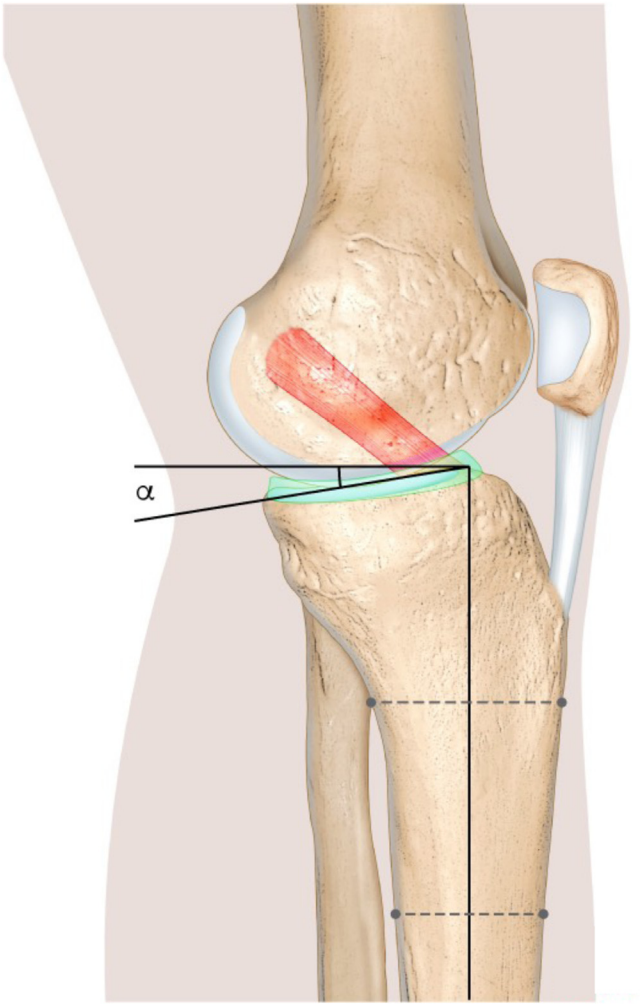

Fig 2. The posterior tibial slope is calculated as described by Dejour and Bonnin, using the true sagittal view to measure the angle between the line perpendicular to the tibial diaphyseal axis and the tangent to the most superior points at the anterior and posterior edges of the medial tibial plateau.

Fig 3. The patient is positioned with the knee flexed at 80°.

cortex intact, and another short biplanar cut is performed just behind the patellar tendon. The bone wedges are then removed, and the posterior hinge is drilled to facilitate closing the osteotomy by pushing down the upper part of the tibia and extending the knee (Fig 5). A temporary fixation is made using a single staple 2 cm lateral to the patellar tendon, and the tibial slope is measured intraoperatively by fluoroscopy (Fig 6). If the slope correction is satisfactory, a second staple is inserted 2 cm medial to the patellar tendon.

ACL Fixation

The tibial tunnel is redrilled either manually or motor-assisted to keep the cylindricity of the tibial tunnel, and then the graft is passed through the femur to the tibia and fixed with interference screws (SBM) at 70° of flexion to overtension the graft and prevent hyperextension. A second tibial fixation is added by knotting the absorbable threads, used to pull the graft to the staple. No further extra-articular procedures are required following TDO. The tunnel is then grafted with the bone removed from the osteotomy, and the MCL and the tensor fascia lata are sutured to the patellar tendon.

Rehabilitation

The leg is immobilized in an extension brace for 6 weeks following surgery, to prevent hyperextension, but the brace is removed for rehabilitation sessions and daily care. Weightbearing is not allowed for the first 3 weeks. Rehabilitation is started immediately after surgery, by progressive passive and active range-of-motion exercises, aiming to achieve full extension and avoiding hyperextension, which could harm the graft. At weeks 3 to 4 following surgery, partial weightbearing is allowed with an extension brace, aiming for full weightbearing. At week 6, the patient will follow a standard anterior cruciate ligament (ACL) rehabilitation protocol. Return to sports is allowed at 6 months following surgery, while for pivoting sports, it is allowed at 9 months.

Discussion

In 1991, TDO was described for the first time by H. Dejour at the Lyon knee conference, and its first results were published in 1998 by Dejour et al.[15] in patients with ACL tears and that had increased tibial slope. The benefit of this technique is that it maintains the coronal alignment of the knee, as the proximal cut is parallel to the joint line and provides a safe and reproducible method for tibial slope correction with satisfactory results, in terms of recurrent failure, minimal progression of osteoarthritis, and/or risks of meniscal tears.[11] Performing ACLR with TDO without detaching the ATT means that the extensor mechanism is maintained, as described by H. Dejour, and it may decrease the risks of

Table 2. Pearls, Advantages, and Pitfalls

Pearls	Advantages	Pitfalls
Accurate soft tissue dissection	Rapid and reproducible technique	Bad exposure
"Biplanar" osteotomy with a vertical cut on TT	Vertical cut preserves the extensor mechanism	TT fracture during osteotomy
Drilling the hinge posteriorly to weaken it	No plates or screw = no obstacles in the ACL tunnel	Wires not converging posteriorly
Use a sterile ruler to calculate the cut		Under- or overcorrection
"Test" the hinge by pushing down the upper part of the tibia		Fluoroscopy malposition (disprojection)
Just 1 staple before fluoroscopy		Forced extension (hinge damage)
Tibial manual redrill of the tunnels		

ACL, anterior cruciate ligament; TT, tibial tubercle.

complications such as malunion and tibial tubercle fracture as well as facilitate postoperative rehabilitation. Furthermore, as the ATT is not detached, the patellar height remains unchanged.

More recently, additional studies on the TDO technique have been published.[14,17,18] In 2014, Sonnery-Cottet et al.[18] also published the outcomes of this technique with detaching the ATT in 5 patients with good results. In 2020, Akoto et al.[14] investigated a 2-stage procedure, by first performing TDO and filling the bone tunnels and, in a second stage, performing an ACLR and lateral extra-articular tenodesis. We believe that a lateral extra-articular tenodesis is unnecessary in most cases, as the pivot-shift phenomenon is associated with an increased tibial slope. Furthermore, in the senior author's experience, 2-stage revision surgery is unnecessary in these cases because the outside-in technique ensures precise tunnel placement with less comorbidities than a 2-stage procedure. Finally, Rozinthe et al.[17] reported the outcomes of second revision ACLR with TDO and found that at 7 to 15 years following surgery, patients did not experience any retears or reoperations. Although 8 of the 9 knees had meniscectomies or meniscal sutures, osteoarthritis progressed in only 1 of the 6 knees that had signs of arthritis at the previous follow-up. These results could confirm that TDO can protect the ACL graft from retear, with minimal progression of osteoarthritis and/or risks of meniscal tears, suggesting that correction of excessive tibial slope should be considered when performing ACLR, whether a revision or primary procedure.

Both Sonnery-Cottet et al.[18] and Akoto et al.[14] aimed to achieve a PTS of 8° to 10°, but they used a different method to measure the slope. Nevertheless, we prefer a

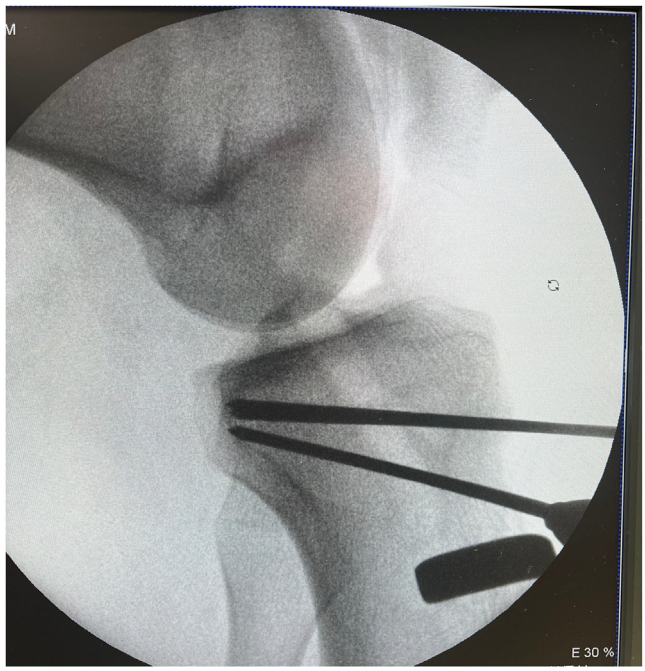

Fig 4. The 2 k-wires converge posteriorly and proximally 1 cm below the joint line.

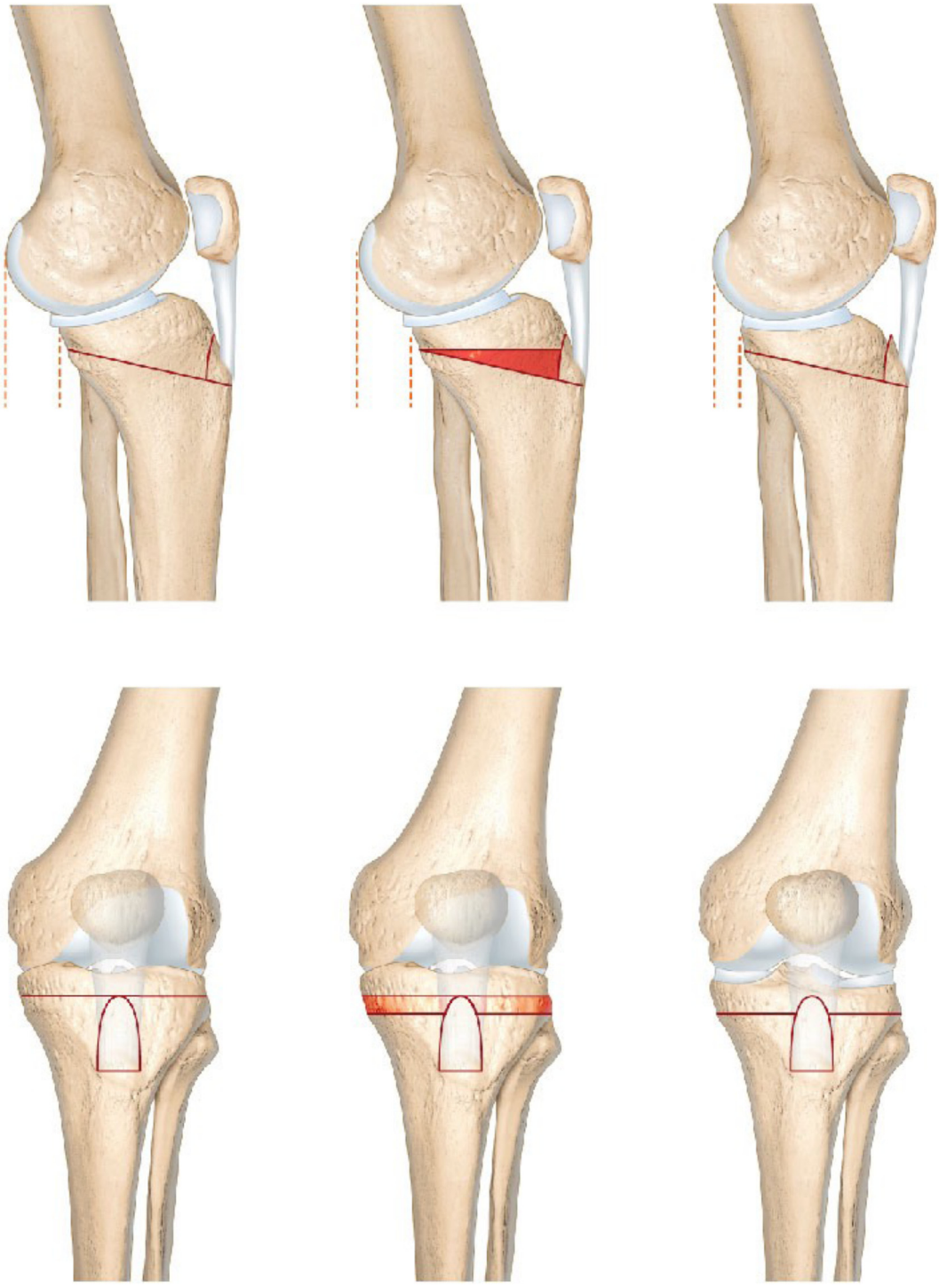

Fig 5. The tibial deflexion osteotomy is performed by performing a biplanar cut behind the patellar tendon. The bone wedges are then removed, and the posterior hinge is drilled to facilitate closing the osteotomy by pushing down the upper part of the tibia.

slight hypercorrection with a target between 2° and 5° of PTS based on available biomechanical data that suggest the significant positive linear effect that tibial slope has on ACL graft under load and to avoid unnecessary additional procedures.[14,17,18,22]

Tibial deflexion osteotomy is a technically demanding procedure associated with significant risks and potential complications that can be avoided with careful and adequate guidewire placement, as well as the use of fluoroscopy to control bone cuts to avoid posterior

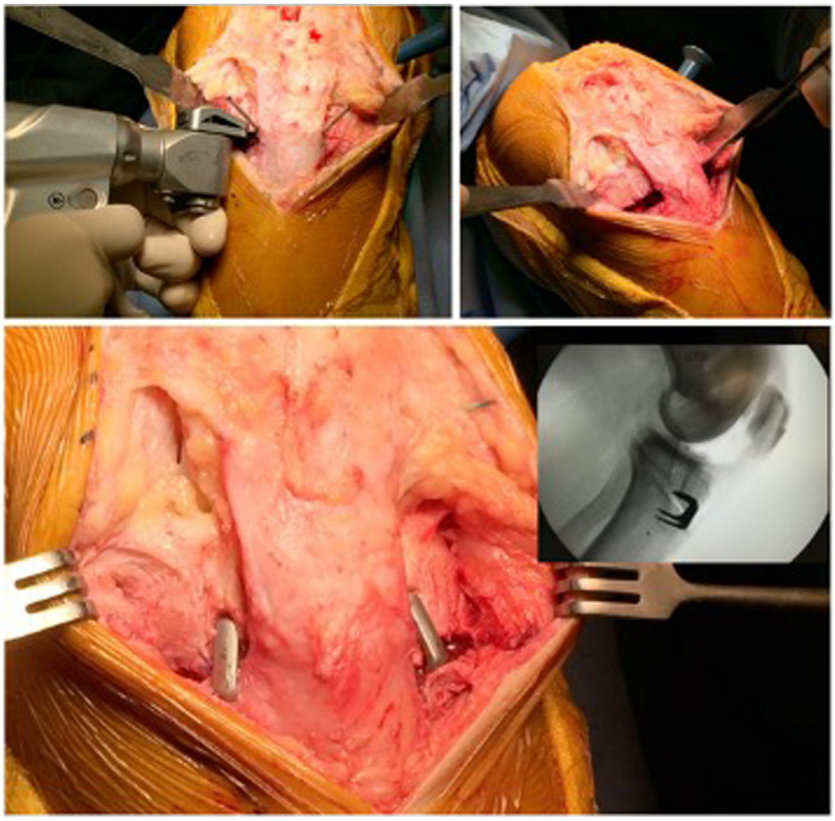

Fig 6. Intraoperative view of the temporary fixation using a single staple 2 cm lateral to the patellar tendon.

cortical damage. It is a safe and very protective surgery in case of first and second ACL revisions that fulfill the criteria.

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