Technical Note

Tibial Press-Fit Fixation Technique in Anterior Cruciate Ligament Reconstruction

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Abstract: Implant-free press-fit tibial fixation technique has gained popularity recently due to the problems in bone tunnel expansion, defect, and revision surgery due to the tibial fixation material preferred in anterior cruciate ligament surgery. Patellar tendon-tibial bone autograft offers several advantages in anterior cruciate ligament reconstruction. We describe a tibial tunnel preparation method and the use of patellar tendon-bone graft in the implant-free tibial press-fit technique. We call this the Kocabey press-fit technique.

Introduction

It has been shown that tibial fixation of the graft is more prone to problems in anterior cruciate ligament (ACL) reconstruction surgery. Reasons for this are that the tibial tunnel axis and the forces acting on the graft are colinear, and the bone mineral density of the tibial bone metaphysis is lower compared to the femoral metaphysis.[1,2] Many tibial fixation materials cause biomechanical problems by directing the graft away from the anatomical insertion point. Many implant materials have been reported as tibial fixation in the literature. Some implants are associated with tunnel expansion or bone defects, causing problems in revision cases.[3]

It has been shown that bone tunnel expansion does not affect primary graft stability, but this may complicate revision surgery and possibly delay ligament reconstruction as a second stage after bone grafting and healing.[4,5] Therefore, new tibial fixation surgical techniques are required that reduce the risk of bone tunnel expansion after ACL reconstruction. Implant-free tibial fixation techniques have been developed to solve these problems; in addition, it is cost-effective, as no additional fixation material is used.

Our purpose is to present implant-free press-fit tibial fixation technique for patellar tendon-bone (PT-B) graft. Our hypothesis is that press-fit tibial fixation is technically possible.

Surgical Technique

Patellar tendon thickness and length are measured from a magnetic resonance imaging sagittal section before surgery. Patellar tendon length was measured by determining the inner surface of the tendon from the middle of the patella by counting the sections where the patella was visible from sagittal T1-weighted magnetic resonance images.[6] If the tendon length of the patellar tendon-bone graft is less than 45 mm (patella baja), we recommend against the press-fit tibial fixation technique.

Diagnostic arthroscopy using the anterolateral and anteromedial arthroscopic portals is performed prior to graft harvest to confirm ACL rupture and evaluate the presence of other intra-articular pathologies.

Graft Harvest (Patellar Tendon − Tibial Bone) and Preparation

We prefer patellar tendon-bone (tibial tubercle) graft without bone grafting from the patella. Our experience has shown that with the harvesting technique, anterior

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knee pain and numbness complaints will be reduced compared to the bone-patellar tendon-bone graft.

A longitudinal incision that starts from inferior pole of the patella to the tibial tubercle (TT) is made, and the center one-third of the patellar tendon is harvested. A 9-mm oscillating saw and a curved ¼ inch osteotome are used to get a 20-25-mm bone block from the tibial tubercle. A patellar tendon graft with 2.5-cm bone block and 5-cm free tendon is obtained. The diameter of the bone part of the graft is 12 mm, while the diameter of the tendon part is 8 mm. The bone block of the graft is transformed into a trapezoidal shape using a rounger. The bone block was shaped with a base (width) of 12 mm and a tendinous part of 11 mm. Afterward, two 1.5 mm holes are drilled in the bone part of the graft 1 cm apart. Then no. 2 FiberWire (Arthrex, Naples, FL) are passed through these holes. The sutures allow control of the bone plug if the bone graft doesn't advance in the tibial tunnel, or if a possible fracture on the tibial joint surface develops during the impaction of the graft, the bone graft can be withdrawn from the tibial cortex. The cancellous bone remaining from the bone block is placed in the defect in the tibial tubercle, and then, the donor site is closed anatomically.

For the tendon part of the graft, we plan for 3-4 mm in the tibial tunnel, 25 mm intra-articular and 15-20 mm in the femoral tunnel. The tendon end of the graft is attached to the adjustable loop device (Arthrex TightRope® Reverse Tensioning [RT]) via baseball whipstitch suture and represents the femoral end, while the bone block represents the tibial part (Fig 1). To measure the tunnel size, the prepared graft is passed through the sizing block. A line is then marked 15-20 mm distal from the tendinous end of the graft. This will be the arthroscopically observable limit for the graft placed in the femoral socket. Once the adjustable-loop cortical suspensory device steps are complete, the graft is now ready to be inserted.

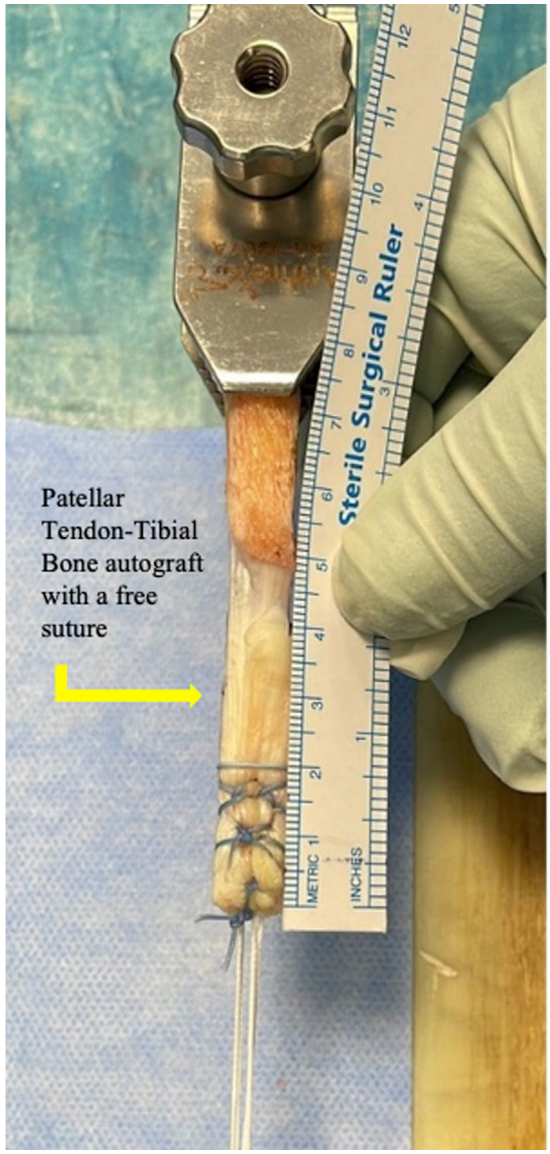

Fig 1. Graft preparation is completed by placing the adjustable-loop cortical suspensory device) on the tendinous part of the patellar tendon-tibial bone autograft with a free suture, two 1.5-mm holes are then drilled into the bone block, and suture is passed through these 2 holes.

Preparation of the Femoral Tunnel

The ACL femoral footprint is located, and the remaining soft tissues are excised (Fig 2A). Using Flip-Cutter, a 25-mm femoral socket is created using the same diameter as the tendinous part of the graft (Fig 2B). The shuttle suture FiberStic (Arthrex), which is then advanced through the femoral socket, is taken through the joint into the anterolateral portal and clamped for later use (Fig 2C).

Preparation of the Tibial Tunnel

The tibial footprint of the ACL is revealed, and the remaining fibers are resected. The tibial guide is placed and fixed at a 50° angle over the center of the tibial insertion of the ACL. This angle ensures that the tibial tunnel is long enough to allow the bone block to fill most of the tunnel after the soft tendon graft has passed through the tunnels. A guide pin is passed through the tibial guide targeting the attachment site of the ACL (Fig 2D and Video 1). The 8-mm reamer is advanced over the guide pin until the tip of the reamer is within 3-4 mm of the tibial articular surface under flouroscopic control (Fig 3A) and the tibial plateau cortex is palpated. After that, the tibial cortex is reamed for approximately a 5-mm length from the tunnel tibial cortex with a 12-mm diameter reamer, so that the broad edge of the bony end of the graft can pass through the tibial cortex. The tunnel is expanded with a 10-mm dilator over the guide pin within 3-4 mm of the tibial articular surface (Fig 3B). Finally, the opening

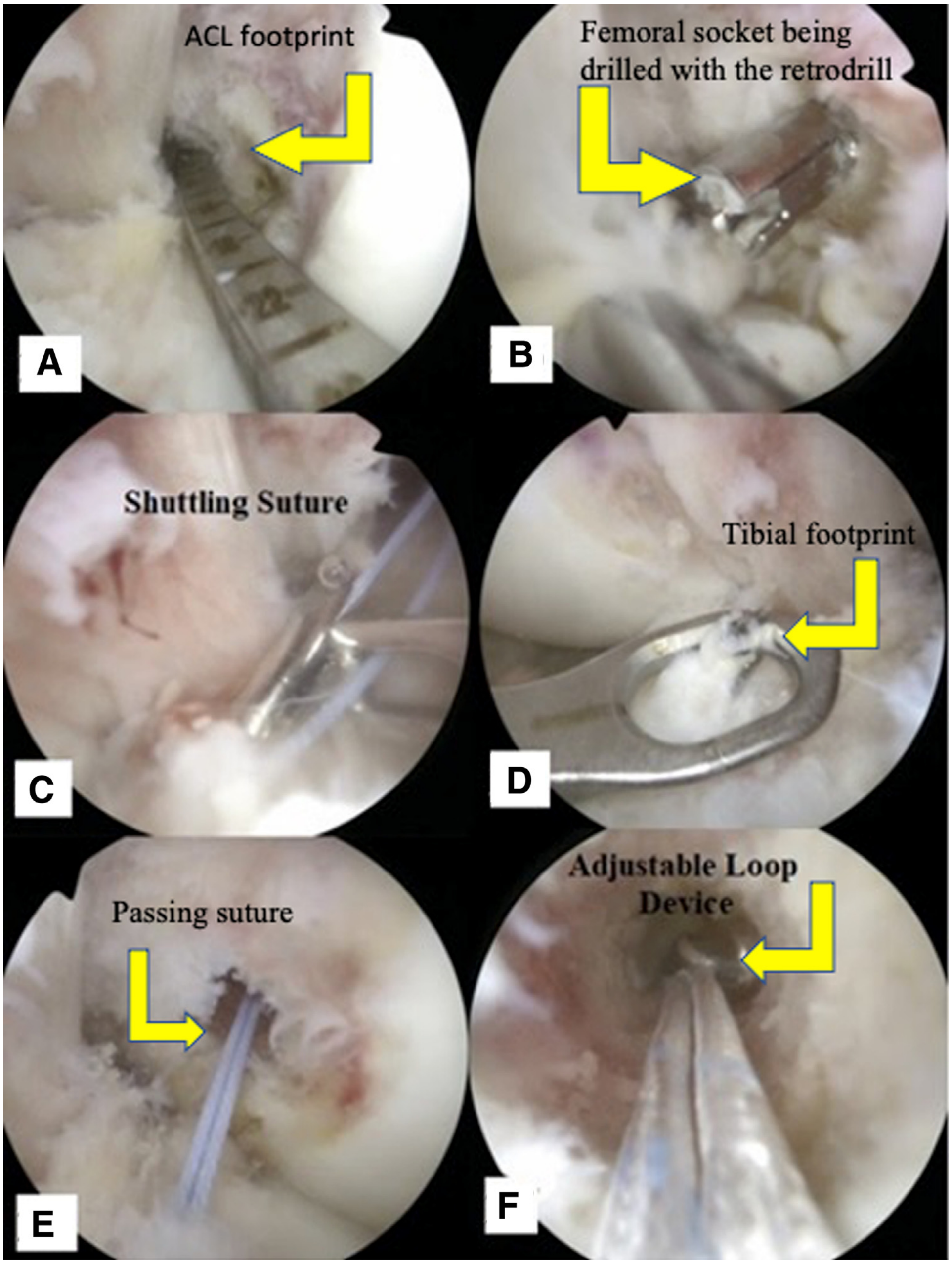

Fig 2. (A) The anterior cruciate ligament (ACL) femoral footprint of the left knee is identified under arthroscopic observation from the anteromedial portal. (B) Anteromedial portal view of the femoral socket being drilled with the retrodrill. (C) Anteromedial portal view of the shuttle suture taken from the femoral socket to the anterolateral portal. (D) A standard anatomical tibial tunnel is determined using the tibial guide under arthroscopic observation from the anterolateral portal. (E) The end of the passing suture in the anterolateral portal is taken into the tibial tunnel to transport the adjustable loop cortical suspension device sutures. (F) Antermedial portal view of the femoral adjustable loop device being brought into the femoral socket.

into and through the tibial plateau is enlarged with an 8-mm reamer over a guide pin.

Graft Passage, Fixation, and Tensioning

The end of the passing suture at the anterolateral portal is brought out from the joint through the tibial tunnel in a distal direction by advancing a loop grasper through the tibial tunnel (Fig 2E). Adjustable-loop cortical suspensory device sutures are first carried into the joint by means of the shuttling suture and then passed out through the femoral tunnel (Fig 2F). The tendinous part of the graft is first passed through the tibial tunnel using an adjustable-loop cortical device, then inserted into the femoral socket (Fig 4, A and B). In order to compress the graft into the tibial tunnel, the graft is hammered with an impactor until the bone plug

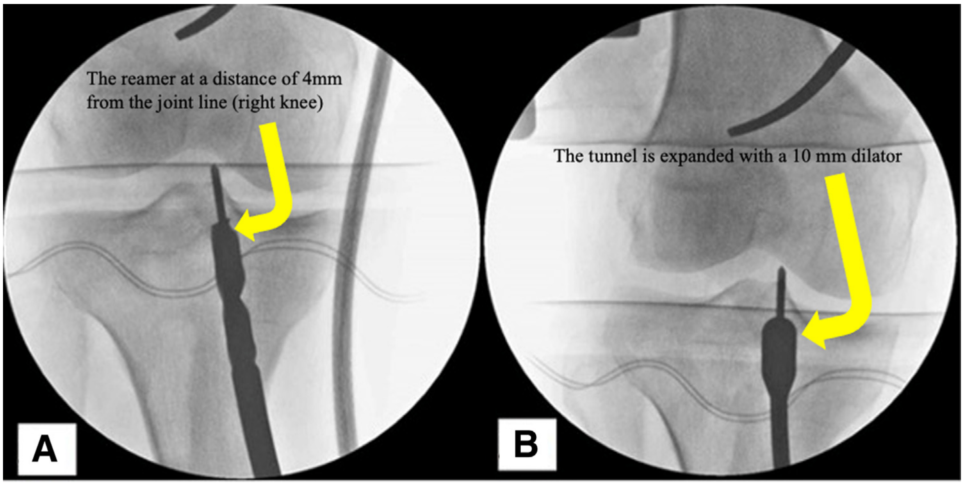

Fig 3. (A) Fluoroscopic view of the reamer at a distance of 4 mm from the joint line (right knee). (B) The tunnel is expanded with a 10-mm dilator over the guide pin until 4 mm is left of the tibial articular surface.

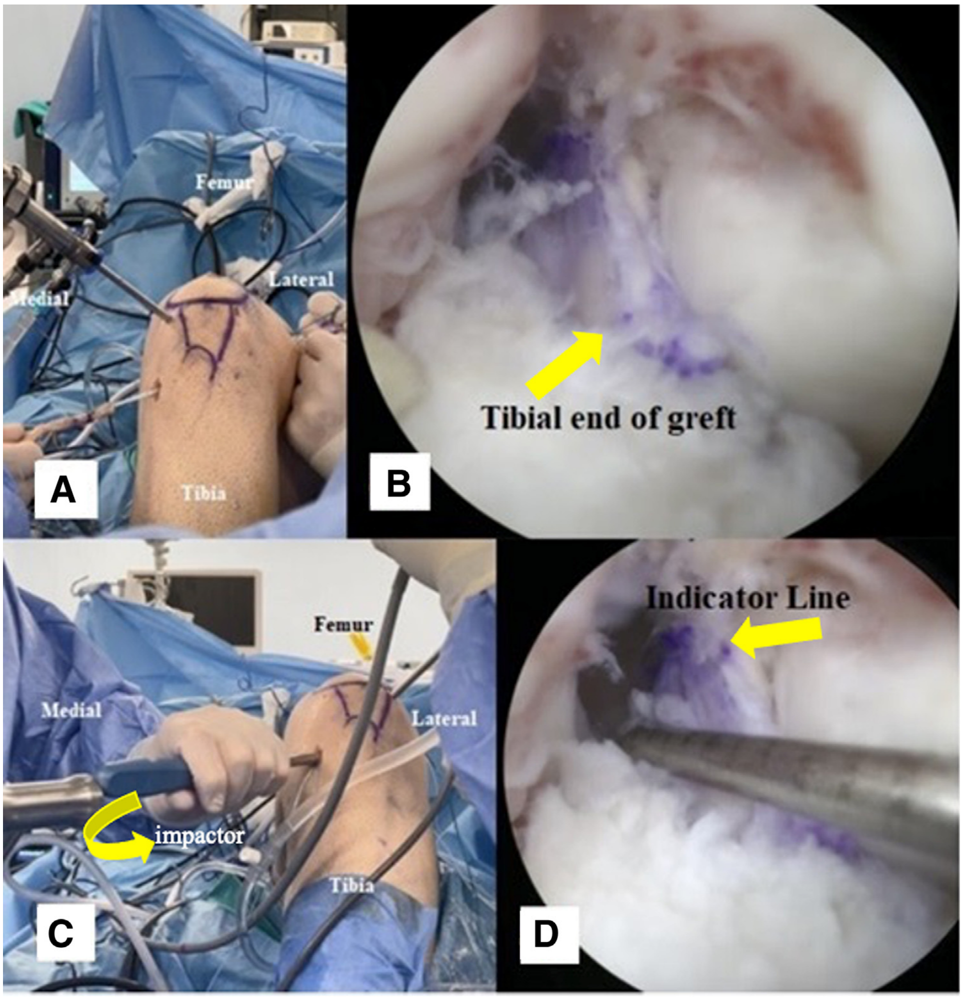

Fig 4. (A) The tendinous part of the graft is first passed through the tibial tunnel using an adjustable-loop cortical suspension device, and then inserted into the femoral socket. (B) Anterolateral view of the tendinosus graft after initial tightening. (C) The bone graft is hammered into the tibial tunnel with an impactor and placed in a press-fit manner. (D) Anterolateral view of the tendinosus graft examination after 150 cycles of flexion and extension.

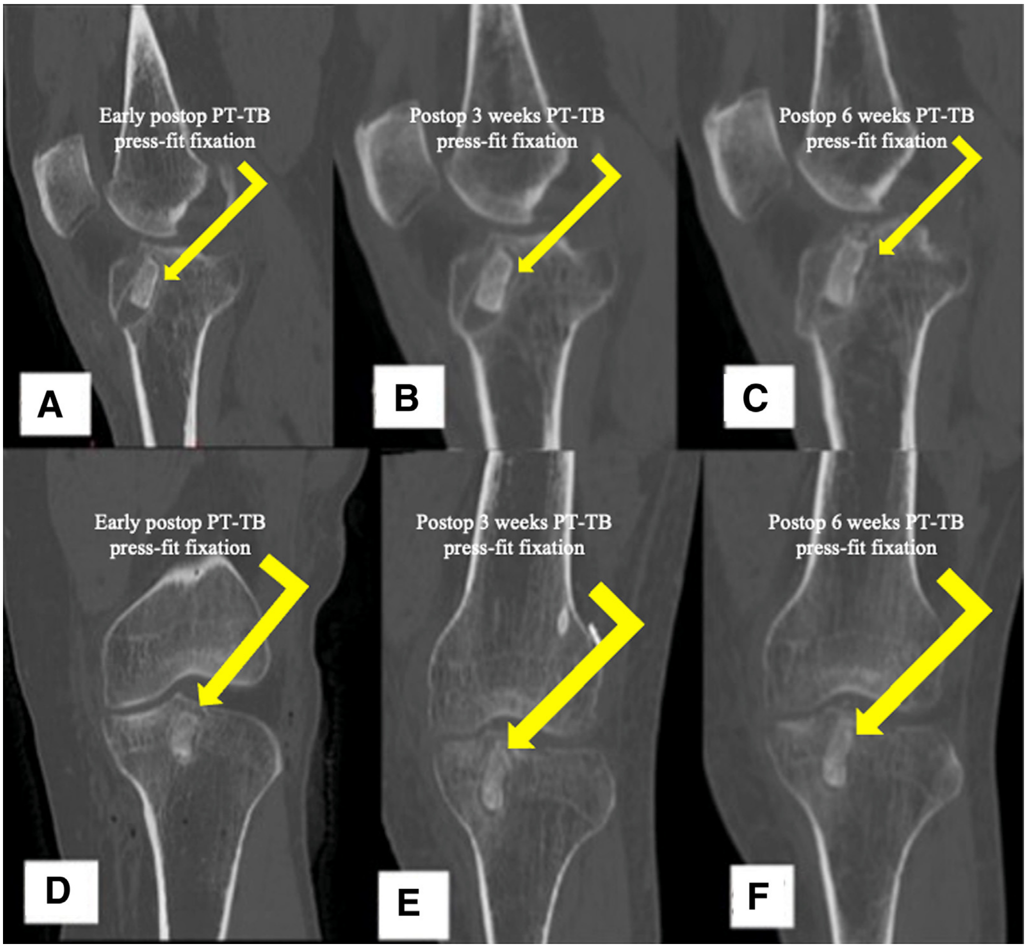

Fig 5. (A) Early postoperative sagittal computed tomography (CT) scan image of a patellar tendon-bone (PT-B) press-fit fixation (left knee). (B) Sagittal CT scan image of 3 weeks tibial pressfit. (C) Sagittal CT scan image of 6 weeks tibial pressfit. (D) Early postoperative coronal CT scan image of a PT-B press-fit fixation. (E) Coronal CT scan image of 3 weeks tibial pressfit. (F) Coronal CT scan image of 6 weeks tibial pressfit. The bone block is stable and in the correct anatomical position; no sclerosis is observed in the images.

is 3-4 mm from the tibial articular surface and has reached the end of the undilated part of the tunnel (Fig 4C and Video 1). Once the graft is securely in place, a fluoroscopy image is taken to confirm the button is fixed on the lateral femoral cortex and to evaluate the location of the bone graft in the tibial tunnel. The knee is flexed to 20°, and the graft tensioning is performed using the tensioning sutures passed through the adjustable-loop cortical suspensory device. After tensioning, the tightness of the graft is examined with a probe (Fig 4D). The knee is flexed and extended 30-50 times, and then the graft is checked for tightness once again.

Postoperative weight-bearing radiographs, Computed tomography (CT) scans, and magnetic resonance imaging (MRI) may be taken to reveal if the bone blocks are press-fit in the right place (Fig 5 and Fig 6).

Rehabilitation

Our rehabilitation program allows for early postoperative movement. Patients can bear as much weight as they can tolerate. Full weight bearing is usually achieved within 1 week. At the end of the first week, 90° of knee flexion is aimed and gradually increased according to the tolerance of the patients. The incorporation of the graft with the bone, the ligamentization of the graft, and the physical examination findings determine the patients' return to activity.

Discussion

The press-fit tibial bone plug fixation for patellar tendon-tibial bone plug graft offers implant free fixation in the tibial tunnel.

It is accepted that the weakest fixation in ACL reconstruction is on the tibial side, especially when soft tissue grafts are used.[2,7] There are several variables that effect the strength of fixation of the ACL graft, such as material of the screw or suspensory system, the density of the bone, the length of the tunnel, the insertion torque, and the geometry of the screws.[8] Putnis et al. compared the adjustable suspensory fixation system

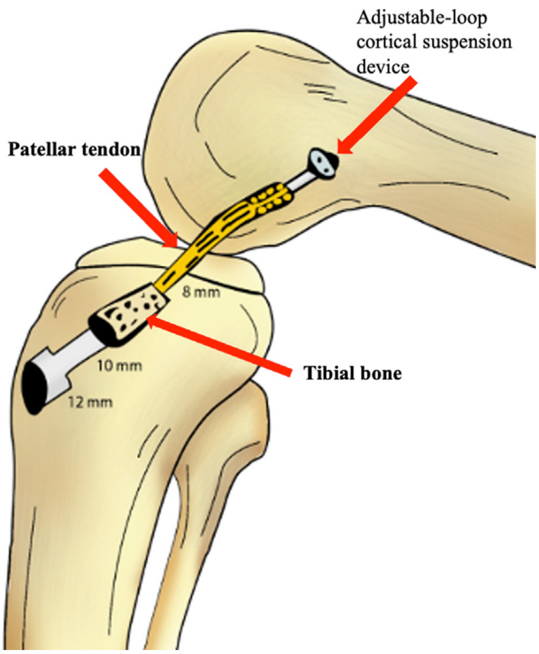

Fig 6. As a modification for distal fixation, a 8-mm tibial drill hole is created until 4 mm is left of the tibial articular surface, and then the tibial cortex is widened 12 mm, so that the bone fragment of the graft can pass through the tunnel. The tibial tunnel is expanded with a 10-mm dilator and advanced to the articular surface with an 8-mm reamer over the guide pin. After the tibial tunnel is prepared as described above, the bone graft is taken into the tibial tunnel with an adjustable loop device, and a press-fit is placed by hammering with the impactor inserted into the tunnel.

with hybrid (screw and sheath) tibial fixation, and hybrid fixation resulted in significantly more tibial tunnel cysts and twice as much tunnel widening at the tibial aperture.[9] Other complications reported in the literature are screw breakage, soft tissue inflammation, infection, local bony lysis, and release of implant fragments into the joint space. And also it is reported that volumetric bone mineral density decreased after ACL reconstruction.[10]

An implant-free ACL reconstruction technique has been developed to reduce the disadvantages of internal and extracortical fixation devices and maintain the bone mineral density. It has been shown in animal models that press-fit fixation has similar pullout strength and stiffness compared to fixation with interference screws.[11,12] Papageorgiou et al. showed complete incorporation of bone blocks 6 weeks after surgery in an animal model.[13] Felmet reported good to excellent results after 10 years for their press-fit ACL reconstruction tecnique.[14]

Press-fit fixation includes fast bone to bone healing and minimize the risk of tunnel widening and hardware-related complications, such as graft laceration, local cysts, infection, bioincompatibility,

Table 1. Advantages and Disadvantages of the Press-Fit Technique

• No need for an interference screw at the tibial tunnel • Avoids the known complications of implant fixation such as graft laceration, local cysts, infection, bioincompatibility, biodegradability or allergic reactions • Fast bone to bone healing • Maintain the bone density • Ensures ease of revision	• Fluoroscopy • Tibia plateau fracture • Anterior knee pain

biodegradability or allergic reactions (Table 1).[14,15] Fluoroscopy imaging in the preparation of the tibial tunnel is our main limitation. The graft should be placed carefully under the fluoroscopy. It should be kept in mind that excessive hammering of the graft on the tibial side can cause a plateau fracture. Additionally, there is a need for clinical and biomechanical comparison of this technique with other fixation techniques and graft types, ideally in randomized controlled trials.

In conclusion, the implant free tibial fixation is technically feasible and offers advantages over implant-based fixation, avoids the known complications of implant fixation, maintains the bone density, and ensures ease of revision. We call this the Kocabey press-fit technique.

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