Technical Note

Single-Stage Revision Anterior Cruciate Ligament Reconstruction Using the Stacked Screws Technique

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Abstract: Single-stage revision anterior cruciate ligament (ACL) reconstruction is preferable to 2-stage revision, when possible, as it avoids an additional surgery and recovery period. Malpositioned and/or widened bone tunnels are a common cause of ACL reconstruction failure and are challenging to manage in revision reconstructions. The "stacked screws construct" fills the previous malpositioned tunnels and bone voids with an oversized biocomposite screw as graft material. The revised tunnel can then be drilled in an anatomic "primary" location, even partially overlapping the filler screw. This technique simplifies tunnel management in revision ACL reconstruction.

As anterior cruciate ligament (ACL) tears and reconstructions become more frequent in the United States, graft failures and subsequent revision ACL reconstruction have become more common as well.[1] Revision ACL reconstruction presents multiple challenges that increase the complexity compared to a primary reconstruction. A key issue in planning revision ACL reconstruction is bone loss and previous tunnel management.[2] Previous femoral or tibial tunnels may be malpositioned and/or widened.[3] Single-stage revision ACL reconstruction is preferred to 2-stage reconstruction to avoid the risks and recovery time associated with a second procedure.[4] Techniques to facilitate one-stage revision ACL reconstruction, even in the setting of tunnel malpositioning or widening, are therefore valuable.

The stacked screws technique is a construct that fills bony defects from previous malpositioned or widened tunnels in the femur or tibia with biocomposite or bioabsorbable screws, in essence turning a revision procedure into a primary procedure. Subsequently, the new anatomic tunnel may be drilled such that it overlaps the filler screw. The graft is then passed and fixed in place with a second biocomposite screw (Fig 1).

Surgical Technique (With Video Illustration)

Preoperative Planning

Preoperatively, the surgeon evaluates knee radiographs and magnetic resonance imaging to assess femoral and tibial tunnel placement, width, and widening. If either tunnel position or width is abnormal, a computed tomography scan should be obtained to define these characteristics more precisely. Using this information, the surgeon can plan for single-stage versus 2-stage revision, being aware that intraoperative findings could change the plan, particularly from single-stage to 2-stage. One-stage is feasible with nearly any tunnel malpositioning and with tunnel widening of less than 16 to 17 mm.[3]

Each intra-articular tunnel aperture should be preoperatively classified and intraoperatively verified as accurate/anatomic, overlapping, nearly overlapping, or completely inaccurate.[3] Overlapping means that the tunnel site is not entirely anatomic but overlaps an anatomic tunnel aperture. Nearly overlapping means

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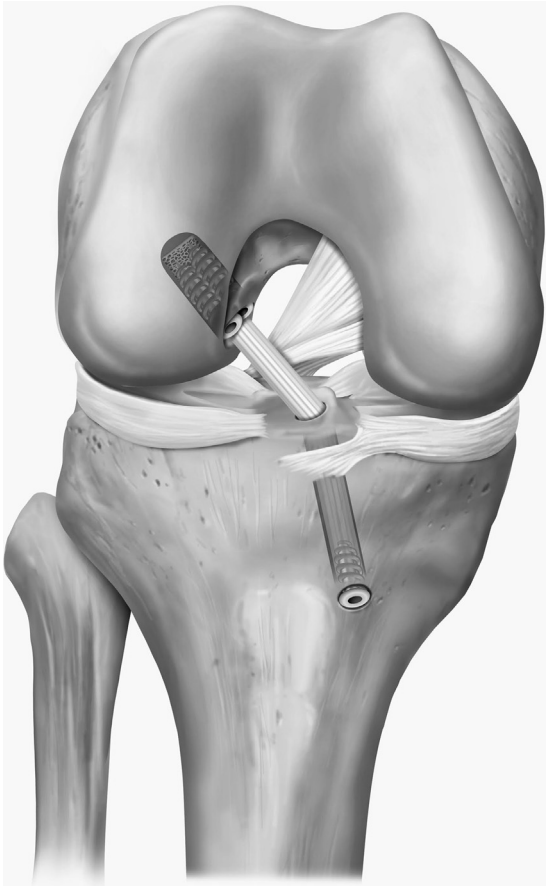

Fig 1. Stacked screws construct in the femur for revision anterior cruciate ligament reconstruction. The femur contains 2 biocomposite screws—a filler screw that bone grafts the previous tunnel, and an interference screw that fixes the graft in place—as well as the bone block from the bone–patellar tendon–bone autograft.

that an anatomic tunnel would be entirely separate from the previous tunnel, but there would be a narrow bone bridge of 5 mm or less between the tunnels. Completely inaccurate means that the previous tunnel is far from an anatomic tunnel without leaving a narrow bone bridge, in which case the revision tunnel would not be compromised by the previous tunnel.

Stacked screws are primarily used for overlapping tunnels in the femur or tibia, when drilling a new tunnel would create a large void in which the graft cannot be adequately fixed. The technique is best used with 25% or less overlap between tunnels, although more could be accepted pending surgeon preference. Biomechanical studies show adequate fixation strength when removing 25% of the filler screw, but removal of 50% has been shown to compromise fixation.[5,6]

With a stacked screws construct, a graft with a bone block, such as bone–patellar tendon–bone, is preferred. This allows fixation with an interference screw as well as bone-to-bone healing. Quadriceps or Achilles allograft tendon with bone block may be used similarly. The surgeon may select an all-soft tissue graft secured with an interference screw, although this may be a biomechanically weaker fixation technique, and backup fixation may need to be considered, especially on the tibia.

In a modification of stacked screws, in the setting of nearly overlapping tunnels, the old tunnel can still be grafted with a biocomposite screw. This buttresses the narrow bone bridge that would otherwise risk fracture with graft fixation in the new tunnel.

Intraoperative Evaluation

The surgeon ensures that the appropriate equipment is available for the procedure. Milagro biocomposite screws made of beta-tricalcium phosphate and PLGA (poly (L-lactide, co-glycolide)) or similar bioabsorbable screws are used (DePuy Mitek, Raynham, MA). These come in diameters from 7 to 12 mm and lengths of 23, 30, and 35 mm. The size of the biocomposite filler screw selected depends on the size of the void to be filled, oversizing by 1 to 2 mm.

The patient is positioned in accordance with surgeon preference for ACL reconstruction. A diagnostic arthroscopy is performed. The previous ACL tunnels are visualized, hardware is removed, graft is debrided, and tunnels are assessed. Each tunnel aperture should be verified as accurate, overlapping, nearly overlapping, or completely inaccurate, as described previously. In the case of overlapping tunnels, a stacked screws construct may be employed.

Stacked Screws Construct

The following steps hold true for stacked screws on the femur or the tibia (Video 1). Previous screws should be removed to allow maximum flexibility for the placement of an anatomic revision tunnel. Previous bioabsorbable screws should be removed because they may not have adequate fixation following resorption. The previous tunnel is debrided of graft and fibrous tissue. A nitinol wire is inserted into the tunnel. The tunnel is sized with a dilator or tap. The tunnel may be minimally reamed to facilitate bleeding bone and thus healing, although this should be avoided if the tunnel is already wider than 11 mm, given the 12-mm maximal screw diameter (Fig 2A). A biocomposite screw, ideally oversized in the tunnel by 2 mm, is placed into the tunnel and advanced until flush with the surrounding bone (Fig 2B).

Attention is turned to the tunnel starting point. When using stacked screws on the femur, a guide pin is placed at the tunnel starting point, which balances the anatomic ACL attachment site and not excessively overlapping the filler screw (Fig 3A and B). The new tunnel is reamed in the desired anatomic location, allowing the reaming to proceed through part of the filler screw (Fig 3C). If desired, tunnel divergence may

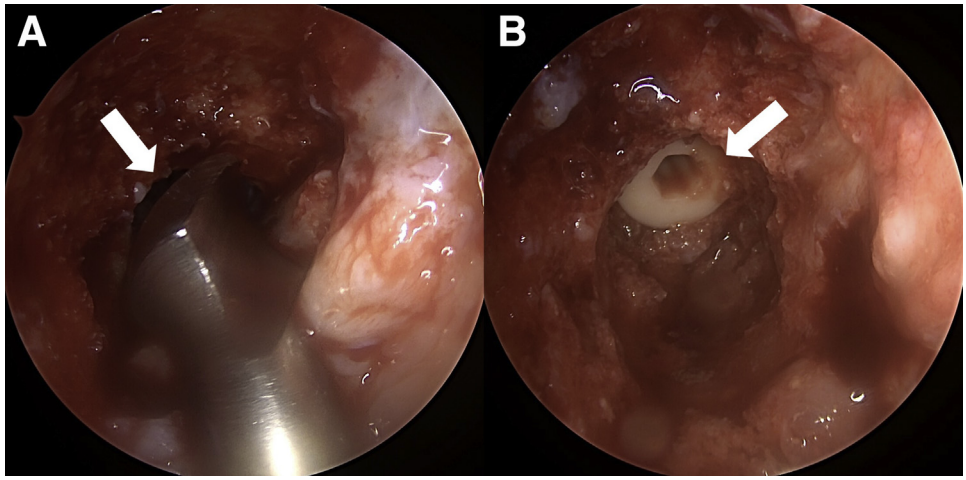

Fig 2. Arthroscopic view of a right knee from the anteromedial portal. (A) The previous tunnel (arrow) is over-reamed by 1 mm to facilitate healing. (B) After the tunnel is sized, a biocomposite filler screw (arrow), oversized by 2 mm, is placed into the previous tunnel.

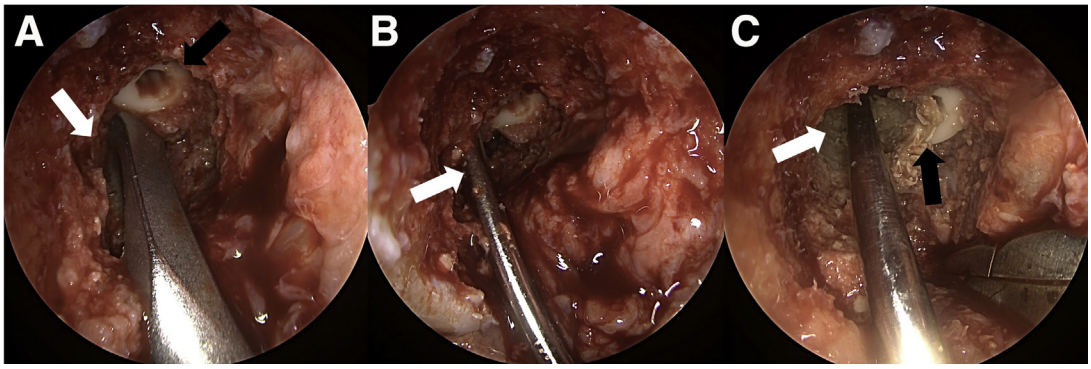

Fig 3. Arthroscopic view of a right knee from the anteromedial portal. (A) The anatomic anterior cruciate ligament attachment site is identified (white arrow), here just off the margin of the biocomposite filler screw (black arrow). (B) A guide pin for the new femoral tunnel (arrow) is inserted at this site. (C) The new femoral tunnel (white arrow) is reamed over the guide pin, removing about 25% of the filler screw (black arrow).

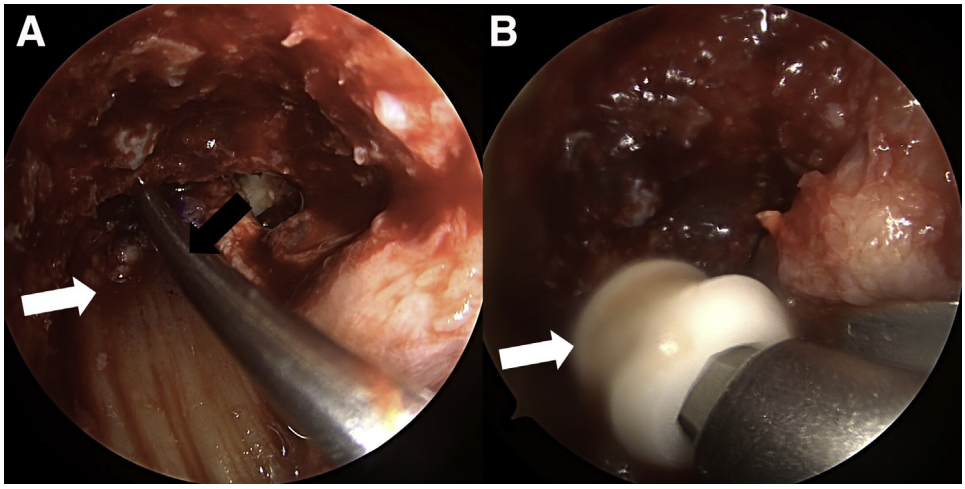

Fig 4. Arthroscopic view of a right knee from the anteromedial portal. (A) A bone–patellar tendon–bone autograft (white arrow) is passed up the new tunnel, and a nitinol wire (black arrow) is placed adjacent to the graft. (B) A biocomposite interference screw (arrow) is placed to fix the graft.

be achieved by using a different drilling technique on the femur (e.g., outside-in, anteromedial, transtibial).[7]

When using stacked screws on the tibia, a tibial ACL drill guide is placed at the anatomic tunnel starting point. Divergence from the previously drilled tunnel is more easily achieved in the tibia than the femur by using a different drill guide angle and starting point on the tibia. The tunnel is then drilled in standard fashion.

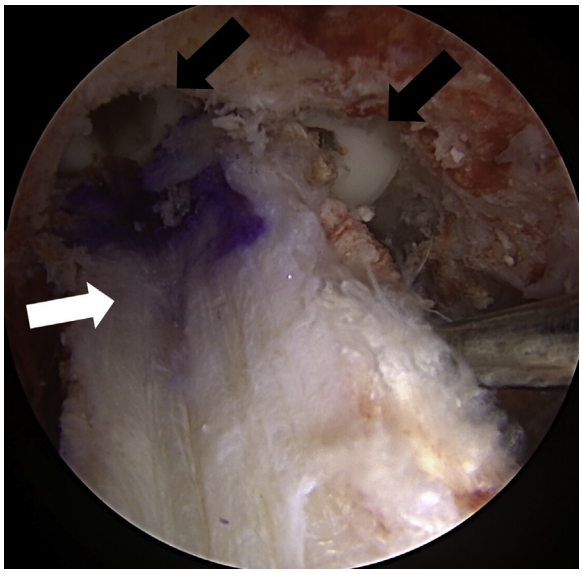

Fig 5. Arthroscopic view of a right knee from the anteromedial portal. The final stacked screws construct, with the bone-patellar tendon-bone autograft (white arrow) securely fixed to the femur between 2 biocomposite screws (black arrows).

A bone–patellar tendon–bone graft, or other graft as indicated, is prepared and then passed (Fig 4A). Of note, the bone block may be oversized to fill particularly large bony voids. Fixation is achieved with a biocomposite interference screw placed between the filler screw and the graft, ensuring at least 50% contact between graft and native bone (Fig 4B). Similar fixation strength is seen with the interference screw placed between the filler screw and graft or with the graft placed between the 2 screws, although the former maximizes graft–native bone contact and may facilitate graft healing.[6] The remainder of the reconstruction proceeds in standard fashion (Fig 5).

Of note, optimal healing is likely if the filler screw is posterior to the graft on the femur or anterior to the graft on the tibia. The line of pull of the ACL will compress the graft along the anterior aspect of the femoral tunnel and the posterior aspect of the tibial tunnel. Therefore, that aspect of the tunnel should be bone, instead of screw, to take advantage of that compression in facilitating bone-to-graft healing (Table 1).

Postoperative Course

Rehabilitation may proceed according to surgeon preference. This technique shows equivalent time zero fixation as a primary reconstruction, so rehabilitation does not need to be slowed due to use of this construct alone.[2,6,8]

Discussion

A stacked screws construct is a useful, biomechanically sound technique to obtain secure fixation during single-stage revision ACL reconstruction in the presence of malpositioned or widened bone tunnels (Table 2). The ease and simplicity of instrumentation involved in the technique allow it to be performed on short notice or when unexpectedly large bone voids are encountered, with only appropriately sized biocomposite screws needed. This is helpful given the complexity of revision ACL reconstruction, particularly when previous tunnels appear differently intraoperatively than they appeared on preoperative imaging, and thus a late adjustment in technique is needed.

Single-stage revision ACL reconstruction is much preferable to 2-stage revision if the clinical context allows, with ramifications for the patient, their team, and the healthcare system. Significant downsides to 2-stage revision are added recovery time, often with 3 to 4 months between stages due to graft healing;

Table 1. Pearls and Pitfalls of a Stacked Screws Construct

Pearls
- Using preoperative planning and intraoperative assessment, assess whether the previous tunnel is overlapping the new anatomic tunnel site
  - Ideal overlap of tunnels is 25% or less
- Remove previous hardware/screws
- Size the previous tunnel with sequential tunnel dilators until a snug fit is obtained
- Consider slightly over-reaming the previous tunnel to stimulate bony healing
- Oversize the biocomposite filler screw by 2 mm to ensure bony compression
- Center the new anatomic tunnel at or peripheral to the margin of the filler screw if possible to avoid removing too much of the filler screw
- Diverge the new tunnel from the previous tunnel if possible
- Interference screw may be placed on the filler screw side or native bone side of the new tunnel, though the former is preferred to maximize graft–native bone contact for healing
- Consider oversizing the bone–patellar tendon–bone bone block in the setting of large bone voids

Pitfalls
- Attempting stacked screws with too large of a bony defect could lead to inadequate graft fixation
- Leaving previous hardware/screws in place could compromise tunnel placement (with metal screws) or fixation (with bioabsorbable screws)
- When reaming, removing >25% of the filler screw may destabilize the screw
- Undersizing the filler screw leads to inadequate screw fixation

Table 2. Advantages and Disadvantages of the Stacked Screws Technique

Advantages
• Allows for single-stage revision anterior cruciate ligament reconstruction in the setting of tunnel malpositioning or tunnel widening
• Simple technique, with little advanced notice needed in the case of an intraoperative deviation from the preoperative plan
• Provides biomechanically proven fixation strength
Disadvantages
• Unable to be used in especially large bone voids
• Graft–native bone contact is not circumferential
• Clinical studies are needed to establish long-term outcomes

intra-articular damage to the knee during these months of instability; added costs to the patient, healthcare system, and potentially athletic team; and added risks of another anesthetic and operating room event.[9]

Biomechanical studies of the stacked screws technique demonstrate adequate fixation strength at time zero.[2,6,8] Most recently, an evaluation of 2 different stacked screws constructs showed no difference in fixation strength and no less stiffness when compared with a primary ACL reconstruction construct in a porcine femur.[6] Both constructs, with the graft between the screws or on the periphery of the screws, were shown to be biomechanically similar to a primary reconstruction, although the latter maximizes graft–native bone contact and is clinically preferred.

There are limitations to this technique. Excessive tunnel widening, varying in the literature from 14 to 17 mm, may make 2-stage revision a better option.[3,7] In the case of the stacked screws technique, bone voids that may be filled are limited by the size of the biocomposite screws available and the size of the graft. Although biomechanical studies of the stacked screws construct demonstrate adequate time zero fixation comparable to a primary reconstruction, clinical studies are needed to demonstrate its effectiveness in vivo.[10]

In conclusion, a stacked screws construct is a straightforward technique to facilitate single-stage revision ACL reconstruction in the setting of overlapping or widened tunnels. It is an important technique for surgeons to be familiar with given that it can be used on short notice, with only an array of biocomposite screws needed beyond standard instrumentation.

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