Anterior cruciate ligament (ACL) injuries in children appear to be occurring with increasing frequency. On analyzing insurance data for 6 million pediatric and adolescent athletes, Shea et al. found that knee injuries accounted for 22% of all claims. Among these, 37% of female and 24% of male knee injury claims were for ACL tears, with injuries as early as 5 years of age. Furthermore, among 14- to 18-year-old athletes, girls’ soccer had an ACL injury rate of 14.08 per 100,000 athletic exposures and football had an ACL injury rate of 13.87 per 100,000 athletic exposures. Skeletally immature patients with complete ACL ruptures treated nonsurgically have a higher risk of secondary meniscus tears, episodes of instability, inability to return to a prior level of athletic performance, and even radiographic degenerative changes. This is especially notable in patients who continue to participate in nonlinear athletics such as soccer or football.

In addition to recommending operative treatment for patients with complete ruptures, Kocher et al. also recommended reconstruction for adolescent athletes with partial tears greater than 50%, tears that primarily involve the posterolateral aspect of the ACL, or partial tears in patients with skeletal age greater than 14 years.

Given the number of pediatric and adolescent patients undergoing ACL reconstruction, it is important to optimize surgical techniques. Although soft tissue grafts such as hamstring autografts have demonstrated excellent load to failure characteristics surpassing the native ACL, the graft fixation interface has been described as the weakest link in the postoperative period.

To address this potential for fixation failure, biomechanical studies have demonstrated the benefit of hybrid fixation techniques for tibial fixation of soft tissue grafts. However, one of the drawbacks with early hybrid fixation techniques was the prominence of the additional cortically based supplemental fixation devices. Especially when considering the limited soft tissue envelope surrounding the anteromedial tibia, prominent hardware can be a source of significant discomfort and require additional surgery for removal.

To capture the biomechanical benefit of hybrid fixation while eliminating prominent hardware and the potential for subsequent surgical removal, Coleman et al. developed a low-profile hybrid fixation technique using knotless anchors. The biomechanical analysis performed by Coleman et al. demonstrated that hybrid fixation using anchors and an interference screw had a significantly higher resistance to failure following cyclic loading and subsequent load to failure testing than an interference screw alone.

The current authors have modified this hybrid fixation technique to apply its biomechanical advantage and low profile benefit to pediatric and...
adolescent ACL reconstruction, taking physeal considerations into account.

**TECHNIQUE Indications**

The senior author (T.J.G.) uses this technique for adolescent patients who are approaching skeletal maturity but still have an open proximal tibial physes. Typically, these adolescents will have a bone age of 14 if male and 13 if female. Larger than skeletally immature preadolescents, this population is unique in that they have bones approaching adult dimensions but still require caution regarding an open physes.

**Graft Choice and Preparation**

The graft is harvested and its tibial side is prepared with a whipstitch technique using FiberLoop suture (Arthrex, Naples, Florida). The authors prefer to use hamstring tendon autograft, but their technique may also be applied to other forms of soft tissue grafts, including allograft.

The femoral side of the graft is prepared with the preferred femoral fixation construct. The authors use the ACL TightRope RT (Arthrex), although any button-based femoral cortical suspension device or other preferred method could be used.

The femoral and tibial tunnels are prepared in the preferred standard fashion.

**Determine Optimum Dimensions of the Tibial Interference Screw**

Once the tibial tunnel has been prepared, the arthroscope is introduced into the tunnel from the distal end (Figure 1A). A calibrated probe is used to measure the distance available for distal fixation prior to crossing the physes (Figure 1B).
This measurement is used to determine the length of the tibial interference screw such that it does not cross the open physsis. A typical screw length is 23 mm, shorter than adult fixation length. Screw width is based on the width of the tunnel.

If the measured screw length is shorter than 23 mm, it is still possible to use a 23-mm screw. The desired depth is measured and marked on the 23-mm screw. The screw is inserted to the desired depth. A small round burr is then used to make the 23-mm screw flush with the tibia.

**Pass the Graft, Cycle, Tension, and Secure**

The graft is passed. The femoral limbs are secured using the preferred femoral fixation.

The graft is cycled. A tensioner is used to apply approximately 25 lb of load to the graft. This is accomplished by tying 2 loops, 1 for each limb of the graft, into the whipstitches on the tibial side of the graft.

While a constant tension is being applied, a bioabsorbable interference screw with bone ingrowth properties is placed into the tibial tunnel for fixation (Figure 2).

**Hybrid Fixation**

Two anchor drill holes are made, using the standard technique for an arthroscopic anchor, distal to both the physis and the tibial interference screw insertion site (Figure 3). The authors use 3.5-mm PushLock anchors (Arthrex).

The sutures attached to each limb of the graft are separated.

The sutures attached to an individual graft limb are passed through the eyelet of 1 anchor (Figure 4).

Tension is pulled on the sutures and the anchor is placed into a tibial drill hole.

Using the same technique, the sutures for the second graft limb are passed through the second anchor. With tension on the sutures, the anchor is placed into the second tibial anchor site (Figure 5).

The final construct provides low-profile supplemental fixation for the tibial interference screw while respecting the physis (Figure 6).

**DISCUSSION**

The graft fixation interface is a weak point in the final soft tissue-based ACL construct.\(^5\)\(^7\) Hybrid techniques have demonstrated biomechanical superiority to a single interference screw for fixation of soft tissue ACL grafts in the skeletally mature population.\(^8\)\(^-\)\(^10\) A potential negative result of the original cortically based hybrid fixation methods is prominent hardware, which may require additional surgery for removal. The development of the low-profile technique in adult patients allowed for biomechanical superiority to traditional fixation and less likelihood of irritating, prominent hardware. Application of this technique to the pediatric or adolescent patient necessitating ACL reconstruction has not previously been reported. The authors have modified the technique, keeping the physis free from bone interposition and crossing interference screw graft fixation.

This novel method of pediatric ACL reconstruction using low-profile tibial fixation provides biomechanical superiority to traditional fixation while keeping the physis free from any potential disturbances from a crossing interference screw.

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**Figure 5:** Intraoperative photograph showing the final construct of 2 anchors (inferior) providing fixation in addition to the tibial interference screw (superior). Abbreviation: MCL, medial collateral ligament. (© The Children’s Hospital of Philadelphia. Used with permission.)

**Figure 6:** Drawing of the final tibial fixation construct. (© The Children’s Hospital of Philadelphia. Used with permission.)


