Reconstruction of Anterior Cruciate Ligament in Children: Hamstring versus Bone Patella Tendon Bone Graft

James H.P. Hui, MBBS, FRCS, MD[a,*],
Ashwin Chowdhary, MBBS, D Orth, MS Orth, MRCS[b]

KEYWORDS

- Anterior cruciate ligament • Children • Hamstring
- BTB graft

Tears of the anterior cruciate ligament (ACL) are uncommon[1,2] injuries in the skeletally immature population. They were once thought to occur only after closure of the growth plate.[3] However, recent studies have reported mid-substance tears of the ACL with increasing frequency[4,5] in children. This may be due to increased awareness, improved imaging techniques,[6] and increased participation in sports at an earlier age.

Nonoperative treatment of such injuries has shown poor results in the long term, with problems of poor long-term function,[7] instability,[5,8] meniscus tears,[9] osteochondral fractures,[7] osteoarthritic changes,[7,8] and inability to return to pre-injury level of sports.[9] This may be reserved as a temporary procedure to avoid risks of possible growth disturbances or in partial ruptures of ACL without instability.[10] Direct primary repair[11] and extra-articular procedures have not been very successful in providing stability after mid-substance tears of ACL.

The goal of ACL reconstruction is restoration of functional knee stability by replacing the injured ligament with graft material. Commonly used graft materials include the hamstrings and the bone patella tendon autografts. Rarely, Achilles tendon may be used. Allografts, synthetic grafts, and ligament augmentation devices are not commonly used for the pediatric population.

No support or funds have been received for this work.
The authors have nothing to disclose.

[a] Division of Paediatric Orthopaedics, National University Hospital, University Orthopaedics and HRM Cluster, 5, Lower Kent Ridge Road, Kent Ridge Wing 2, Level 3, 119074, Singapore
[b] Division of Paediatric Orthopaedics, National University Hospital, University Orthopaedics and HRM Cluster, 5, Lower Kent Ridge Road, Kent Ridge Wing 2, Level 3, 119074, Singapore
* Corresponding author.
E-mail address: James_hui@nuhs.edu.sg

Clin Sports Med 30 (2011) 751–758
doi:10.1016/j.csm.2011.06.003 **sportsmed.theclinics.com**

In skeletally mature adolescents, standard arthroscopically assisted techniques using hamstrings or bone-patellar tendon-bone (BTB) grafts can be used to reconstruct the ACL. In the skeletally immature, various techniques such as physeal sparing and partial transphyseal techniques have been described to limit the potential of physeal injury. Complete transphyseal reconstructions have the potential of causing physeal damage.[12,13] However, recent studies[7,14,15] have suggested that these might be safe. Growth disturbances are likely to occur if the damage to the physis is more than 9% of its cross-sectional area.[13,16] Janarv and colleagues[16] have shown that the transphyseal tunnels in ACL reconstructions occupy only 3% to 4% of the cross-sectional area of the physes. According to Beasley and Chudik,[17] small tunnels that are centrally placed and filled with soft tissue are less likely to cause growth disturbances unlike eccentrically placed tunnels or those filled with cancellous bone. Soft tissue across an open physis usually prevents its closure as shown classically by Langenskiold[18] for treatment of physeal bars. Hamstrings serve well as a soft tissue graft and allow their placement across the physes. In a study of transphyseal ACL reconstruction in canine models, Edwards and colleagues[12] have shown that significant growth disturbances occurred only when tendons were placed across the physes in excessive tension. Kocher and colleagues[19] have reported that growth disturbances may be associated with bone plugs (of BTB graft) or fixation hardware across the physis.

GRAFT HEALING/STRENGTH AND STIFFNESS

The strength of the graft fixation complex must be considered when choosing between the type of graft, be it the hamstrings or the BTB. The main factor affecting the structural strength of this complex in the initial weeks is not the strength of the graft but the fixation points, especially so on the tibial[20] side. Pinczewski and colleagues[21] found that after bone-to-bone or tendon-to-bone healing has taken place, usually at 6 to 15 weeks postoperatively, the fixation points are not the weakest link. In a study of graft-to-bone healing for ACL reconstructions in a canine model, Rodeo and colleagues[22] have shown that failure occurred by pull out of the tendon from bone tunnels in the first 8 weeks, whereas after 12 weeks, grafts usually failed because of mid-substance rupture of the grafts itself.

Bone-to-bone healing of BTB grafts has been shown to be faster than the healing of hamstrings grafts.[23] In animal models, Rodeo and colleagues[22] found that bone healing with a BTB graft usually occurred by 6 weeks, whereas tendon graft took up to approximately 12 weeks to heal. In a comparative study of intra-osseous healing of tendon grafts and BTB grafts for ACL reconstruction in dogs, Tomita and colleagues[24] have shown that tendon graft anchored to bone at 12 weeks, whereas BTB graft was anchored to bone as early as 3 weeks. They found the pull-out strength of BTB grafts to be superior to tendon grafts at 3 weeks after ACL reconstruction. They have also shown that healing of tendon grafts occurs by newly formed collagen fibers, whereas healing of BTB grafts occurs by new bone formation.

All grafted tendon tissue loses some of its initial strength during the healing period. In a study of ACL reconstruction in dogs, Butler[25] has shown that significant loss in structural mechanical and material properties of grafts occurred early after implantation. In another study, McFarland and colleagues[26] have shown grafts to become weaker by 4 weeks after implantation. According to Prodromos and Joyce,[27] they may retain only about half their initial strength in long-term follow-up. Therefore, an initial graft needs to be significantly stronger than the native ACL in order to produce an ultimate strength at least as strong as the original ACL. Noyes and colleagues[28] have shown that a 14- to 15-mm-wide BTB graft has a mean initial strength of 159%