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Arthroscopic transphyseal anterior cruciate ligament reconstruction in adolescent athletes

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ABSTRACT

Purpose. To evaluate the 5-year outcome of arthroscopic transphyseal anterior cruciate ligament (ACL) reconstruction in 19 adolescent athletes.
Methods. 14 male and 5 female adolescent athletes aged 12 to 16 (mean, 13.9) years with Tanner stage 2 or 3 open physes underwent arthroscopic transphyseal ACL reconstruction by a single surgeon and were followed up for 5 years. Patients were evaluated using the numerical rating score (NRS) for pain, knee osteoarthritis outcome score (KOOS), International Knee Documentation Committee (IKDC) score, Tegner Activity Scale, and Lysholm Score, as well as the leg length discrepancy, femorotibial alignment, varus or valgus deformities, active and passive knee range of motion.
Results. At 5-year follow-up, physes were closed in all patients. The mean NRS for pain improved from 7.2 to 1.6; the KOOS improved from 55.3 to 88; the mean IKDC score improved from 34.5 to 84; the mean Tegner Activity Scale improved from 2.7 to 8.2 and was comparable with that before injury (8.4); and the mean Lysholm score improved from 36.3 to 84.6. All except 2 patients returned to their pre-injury level of sports activity after a mean of 25 weeks. The 2 exceptions had a 2+ Jerk test and a 3+ Lachman test; one of them also had positive signs for a lateral meniscal lesion. Both had sustained a second trauma not long before the 5-year follow-up. Two patients had reduced sensitivity in the anteromedial aspect of the proximal third of the tibia. One patient had leg length discrepancy of +1.5 cm owing to overgrowth response of the physis.
Conclusion. Transphyseal ACL reconstruction is a viable option for skeletally immature patients, with high reproducibility, a high rate of return to sport, and a low incidence of growth disturbance. Early surgery can prevent the onset of meniscal lesions and early osteoarthritis.

Key words: *adolescent; anterior cruciate ligament reconstruction*

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INTRODUCTION

An increase in the incidence of anterior cruciate ligament (ACL) injury in younger patients is due to the increase in sports participation, activity level, awareness of the injury, and diagnosis with arthroscopy and magnetic resonance imaging (MRI), as well as a decrease in conditioning levels.[1,2] ACL injuries account for 31% of all knee injuries in the young population.[3] Higher risk is associated with closure of the physes and increased skeletal rigidity.[4] Partial lesions and tibial spine avulsions are far more common.[5] Males are more likely to have an ACL injury before skeletal maturation, but are 2 to 8 times less at risk once the physes are closed.[6] Female adults are at higher risk (up to 10 times) than male adults.[7,8] ACL injury is present in 47% of patients aged 7 to 12 years and 65% of patients aged 13 to 18 years who present with acute effusion. Nonetheless, the ACL appears injured in 58% of female and 12% of male young patients who present with a patellofemoral injury.[9]

The choice of treatment remains controversial in younger patients. Preserving the open physes is important owing to their growth potential and inability to repair once damaged. Knee stability prevents future damage. Patients with conservative treatment have a 7-fold higher risk of osteoarthritic changes than normal subjects. Similar findings were also noted in patients with operative treatment although at a lower magnitude.[10]

This study evaluated the 5-year outcome of arthroscopic transphyseal ACL reconstruction in 19 adolescent athletes.

MATERIALS AND METHODS

Between January and December 2009, 14 male and 5 female adolescent athletes aged 12 to 16 (mean, 13.9; standard deviation [SD], 3.25) years with Tanner stage 2 or 3 open physes (Fig.) underwent arthroscopic transphyseal ACL reconstruction of the right (n=12) or left (n=7) knee by a single surgeon and were followed up for 5 years. Patients with closed physes, age >18 years, leg length discrepancy, previous surgery, concomitant fractures, or infection in the affected limb were excluded.

Patients were asked to complete questionnaires for the numerical rating score (NRS) for pain,[11] knee osteoarthritis outcome score (KOOS),[12,13] International Knee Documentation Committee (IKDC) score,[14,15] Tegner Activity Scale,[16] and Lysholm Score.

Clinical and radiological examination included measurement of leg length discrepancy, femorotibial alignment, varus or valgus deformities, active and passive knee range of motion (ROM), swelling, patellar tilt, patellar glide, Lachman test, jerk test, anterior drawer test in the 3 positions, posterior drawer, varus stress, valgus stress, Bragard test, external rotation test, Whipple test, Apley test, Ege test, and arthrocentesis of serum haematic fluid (for 4 patients only).

Symptoms reported included articular block (n=8), recurrent effusion (n=14), and 'giving way' (n=10). Three patients had limb shortening (mean, 0.3 cm), and 5 patients had limb lengthening (mean, 0.2 cm); no patient had varus or valgus alignment exceeding 3° to 7°.

Figure Preoperative radiographs showing Tanner stage 2 open physes in a 13-year-old girl with anterior cruciate ligament rupture in the left knee.

The treatment protocol was standardised.[17] The mean time from injury to surgery was 4 (range, 2–32) weeks. The patient was placed supine under peripheral anaesthesia. A pneumatic tourniquet was used. Tear of the medial (n=6) or lateral (n=1) meniscus was treated with meniscectomy (n=2) or meniscal suture (n=5). A double hamstring tendon graft and a femoral suspension fixation device was used.[18] A Howell alignment guide was used to drill a pin guide from the tendon harvest incision to the attachment site of the ACL tibial footprint, medially, and avoiding tibial spines. The graft was mounted on the appropriate-size femoral fixation device. Tibial fixation was achieved at 20° of flexion using a 25-to-30-mm-long bioresorbable screw of the same diameter as the tibial tunnel and a metallic staple.

Postoperatively, no weight bearing was allowed for 4 weeks, and then partial and full weight bearing was allowed at week 4 to 6 and week 7, respectively. Passive ROM of 10º to 60º was allowed at week 1 and then increased to 80º at week 2, 100º at week 3, and 120º at week 4. Active ROM of 10º to 90º was allowed at week 2 and then increased to full flexion and extension at week 4. Isometric exercises pro-quadriceps electrostimulations were started at month 1, and then cycling, proprioception, flexors-extensors strengthening, isotonic and isokinetic exercises were allowed at month 2, and then proprioception and running was allowed at month 3 but no jumps or torsions.

Patients were evaluated by an assessor independent of the surgery. Preoperative and 5-year outcome was compared using the Wilcoxon-sign rank test. A p value of <0.05 was considered statistically significant.

RESULTS

At 5-year follow-up, physes were closed in all patients. The mean NRS for pain improved from 7.2 (SD, 1.9; range, 5–9) to 1.6 (range, 0–8) [p<0.001]; the KOOS improved from 55.3 (SD, 13.8; range, 46.4–64.9) to 88 (range, 54.2–98.8) [p<0.001]; the mean IKDC score improved from 34.5 (SD, 13.4; range, 19.5–57.5) to 84 (range, 29.9–100) [p<0.0001]; the mean Tegner Activity Scale improved from 2.7 to 8.2 and was comparable with that before injury: 8.4 (SD, 2.1; range, 7–10), and the mean Lysholm score improved from 36.3 (SD, 16.7; range, 14–64) to 84.6 (range, 40–100) [p<0,0001].

All except 2 patients returned to their pre-injury level of sports activity after a mean of 25 weeks. The 2 exceptions had a 2+ Jerk test and a 3+ Lachman test; one of them also had positive signs for a lateral meniscal lesion. They had sustained a second trauma not long before the 5-year follow-up. Two patients had reduced sensitivity in the anteromedial aspect of the proximal third of the tibia. One patient had leg length discrepancy of +1.5 cm (but no complaint of any limitation in his professional lifestyle) owing to overgrowth response of the physis; a discrepancy of 2 cm is considered clinically relevant.[2,19]

DISCUSSION

In our study, the outcome of transphyseal ACL reconstruction in adolescents with higher growth potential was good. The physes provide about 70% of the total length of the lower limbs, with 40% from the distal femoral physis and 27% from the proximal tibial physis.[18,20,21] When a physis is damaged, complete or partial growth plate arrest may occur depending on the magnitude, size, and location, and result in shortening of the affected limb, asymmetrical rotation, angular deformation, and/or overgrowth, as well as new lesions and/or degeneration in the long term.[22]

In the past, conservative treatment was suggested until physes closure. Nonetheless, it affects a patient's ability to return to the pre-injury level of activity,[23,24] and results in a high proportion of symptomatic unstable knees, with early and severe meniscal degeneration and osteochondral defects.[21,25] Therefore, conservative treatment is indicated only for partial (<50%) tears in patients with no comorbidity, high compliance, and low outcome expectation.[25–27]

When the time from injury to surgery exceeds12 weeks, there is a 4-fold increase in meniscal injury (mostly irreparable), an 11-fold increase in lateral chondral lesions, and a 5-fold increase in patellofemoral injuries.[28,29]

The all-epiphyseal, over-the-top, and transphyseal techniques are physeal sparing and achieve a good long-term outcome.[26] Nonetheless, there is no consensus on the optimal technique.[30] The over-the-top technique can restore the condition to almost the same as an intact ACL, although it is not an anatomic or isometric reconstruction and may change the contact pattern in the joint, or increase the risk of a new rupture, and it results in more rigidity than other techniques, especially for flexion and internal rotation.[30] Excessive tensioning of the graft increases the risk of growth disturbance even if not directly damaging the physes.[31] Physeal-sparing techniques achieve good outcome, but they have low reproducibility and a steep learning curve. The transphyseal technique has a high success rate and a

growth disturbance rate of 1.8% only.[32]

In a rabbit model, the central distal femoral physis can be drilled up to 8% and filled with inert material without resulting in growth disturbances.[33] Even if a bony bridge is created in the physis, the growth plate still retains a minimum of potential that does not allow development of any dysmetria.[34] Growth plates also possess intrinsic force to destroy the bony bridge but the force diminishes with increasing age, and thus most cases of growth discrepancy develop in adolescents approaching skeletal maturity.[31]

Surgeons should avoid (1) leaving any fixation device or bone block in the physes, (2) over-tensioning the graft, and (3) iatrogenic damage to the physes >9%. Surgeons should (1) use the smallest possible diameter of drill (an 8-mm tunnel size is equal to 3 to 4% of physis damage), (2) create a more vertical femoral tunnel to avoid damage to the perichondral ring, (3) fill in as much soft tissue as feasible in the drilled tunnel, and (4) perform early surgery.[24,26,35–38]

There were limitations to our study. The number of patients was small and there were no controls. Outcome was assessed at first presentation and 5-year follow-up only; there was no intermediate follow-up.

CONCLUSION

Transphyseal ACL reconstruction is a viable option for skeletally immature patients, with high reproducibility, a high rate of return to sport, and a low incidence of growth disturbance. Early surgery can prevent the onset of meniscal lesions and early osteoarthritis.

DISCLOSURE

No conflicts of interest were declared by the authors.

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