Outcomes of Anatomical Transphyseal Double-Bundle Anterior Cruciate Ligament Reconstruction in Skeletally Immature Adolescents with Open Physes

Asahi University Hospital
   Itaru Kawashima, MD.
   Takashi Tsukahara, MD, PhD. Ryosuke Kawai, MD. Yoshiaki Kusaka, MD, PhD.

Toyota Memorial Hospital
   Tadahiro Sakai, MD, PhD

Nagoya University Graduate School of Medicine
   Hideki Hiraiwa, MD, PhD
BACKGROUND

The rate of growth disturbance following Anterior Cruciate Ligament Reconstruction (ACLR) was low with no difference between transphyseal and physeal-sparing techniques.

Transphyseal Double-Bundle (T-DB) ACLR may result in a reduction in the re-rupture rate compared to Single-Bundle (SB) ACLR.


In Asahi University Hospital

We are performing anatomical T-DB ACLR with hamstrings autograft for adolescents aged 13 years or over with open physes.


This study aimed to report the outcomes and complications of our anatomical T-DB ACLR, including growth disturbances.

I have no financial conflicts to disclose.
Patients and Methods

Retrospective analysis of our database from January 2010 to August 2016

22 knees in 22 patients aged 13-16 years at the time of surgery

with open physes as determined by high-signal intensity on T2-weighted MRI and radiography

undergone primary ACLR in one institution during this period

with two or more years of observation until at least closure of the epiphyseal plate

Male: 10 cases  Female: 12 cases

Median Age at surgery  14.2±0.5 yo (13~16 yo)

Median Follow-up  45.2±2.5 months (24~103 months)

All Surgical Procedure:  Anatomical complete T-DB ACLR with semitendinosus and gracilis autograft
Clinical Evaluation and Statistical Analysis

① Changes in patient height

② The anteroposterior (AP) knee laxity assessed by arthrometry
   (KS measure KSM-100 arthrometer, SIGMAX MEDICAL)

③ Graft failures and contralateral ACL tears

④ Tegner Activity Scale (TAS), IKDC and Lysholm score

Statistically analyzed by paired t-tests. P values <0.05 were considered statistically significant.
Clinical Evaluation and Statistical Analysis

Radiographic Evaluation at final follow-up

- Side-to-side differences
  - By full-length standing anteroposterior radiographs
    - Mechanical lateral distal femoral angle (LDFA),
    - Mechanical medial proximal tibial angle (MPTA),
    - Lower limb length
  - By standard lateral knee radiographs.
    - Intercondylar roof angle (IRA)
    - Posterior tibial slope (PTS)

Statistically analyzed by paired t-tests. P values <0.05 were considered statistically significant.
Results: Patient Height and AP Knee Laxity assessed by arthrometry

- Median Changes in Patient Height: 4.86cm (3-8cm)
  - P<0.001

- Arthrometry side-to-side difference
  - Pre-op Median: 4.45mm (3-8mm)
  - Post-op Median: 0.91 (-2 – 3mm)
  - P<0.001
Results: Graft Failures and Contralateral ACL Tears

Graft Failure: 0.0 % (0 case/22 cases)

Contralateral ACL tears: 18.2 % (4 cases/22 cases)

(13, 15, 19, 22 months after primary operation)
Results: TAS, Lysholm and IKDC score

TAS

Pre-op: 8.55 ± 0.80
Post-op: 7.86 ± 1.61

Lysholm

Pre-op: 74.4 ± 12.4
Post-op: 99.8 ± 1.10

P < 0.001

IKDC

Pre-op: 63.4 ± 10.5
Post-op: 96.8 ± 3.70

P < 0.001
Results: Radiographic Evaluation at final follow-up

<table>
<thead>
<tr>
<th></th>
<th>operated knee</th>
<th>contralateral knee</th>
<th>side-to-side difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>LDFA</td>
<td>$87.1 \pm 1.1^\circ$</td>
<td>$87.1 \pm 1.0^\circ$</td>
<td>$0.09 \pm 0.29$ (0 ~ 1) (P=0.16)</td>
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<td></td>
<td></td>
<td></td>
<td>2 cases had 1° differences</td>
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<tr>
<td>MPTA</td>
<td>$87.8 \pm 1.7^\circ$</td>
<td>$87.9 \pm 1.6^\circ$</td>
<td>$0.09 \pm 0.29$ (0 ~ 1) (P=0.16)</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>2 cases had 1° differences</td>
</tr>
<tr>
<td>IRA</td>
<td>$36.2 \pm 3.2^\circ$</td>
<td>$36.3 \pm 3.0^\circ$</td>
<td>$0.09 \pm 0.43$ (0 ~ 1) (P=0.33)</td>
</tr>
<tr>
<td>PTS</td>
<td>$9.5 \pm 3.0^\circ$</td>
<td>$9.6 \pm 3.0^\circ$</td>
<td>$0.05 \pm 0.38$ (0 ~ 1) (P=0.58)</td>
</tr>
<tr>
<td>Lower limb length</td>
<td>$81.5 \pm 4.4$ cm</td>
<td>$81.5 \pm 4.4$ cm</td>
<td>$0.0 \pm 0.0$ cm</td>
</tr>
</tbody>
</table>
Discussion: Risk and Benefit of ACLR in Skeletal Immature

ACLR in skeletalImmature:
- Drilling physes and force of graft to physes cause valgus deformity and leg-length discrepancy

Conservative treatment has poor outcome

Earlier ACLR in children and adolescents is associated with a decreased risk of medial meniscal and articular cartilage damage

We believe: benefit of the earlier ACLR > the risk of delayed ACLR.
Discussion: Transphyseal and Physeal-Sparing ACLR

The rate of growth disturbance following ACLR was low at 2.6% with no difference between transphyseal and physeal-sparing techniques.


Surgical indication of transphyseal autograft ACLR with soft tissue autograft: for males ≥13 years old and females ≥12 years old.


Transphyseal drilling in sheep models with open physes caused remarkable femoral valgus deformity in models with tunnels and left empty, but didn’t cause growth disturbance in models with tunnels filled with Achilles tendon.


Our procedure had no remarkable growth disturbance. This would be influenced by our indication (≥13 years) and by tunnels filled with soft tissue autografts as much as possible.
Discussion: Failure rate of ACLR and T-DB ACLR

19% patients sustained an ACL graft rupture, 13% patients sustained a contralateral ACL tear in patients <18 years of age


DB techniques substantially increase the volume of injury to the physis


Re-rupture rate: Anatomical T-DB ACLR 14.3%
T-SB ACLR 25.7%


Our T-DB ACLR was associated with excellent outcomes without remarkable growth disturbance and graft failures instead of the 18.2% of contralateral tears.
Conclusion

Our anatomical transphyseal double-bundle reconstruction was associated with excellent outcomes without graft failures, leg length discrepancies or remarkable angular deformities.

This procedure is a strong alternative in skeletally immature patients aged thirteen years or over.