“Remnant Preservation in ACL Reconstruction: Is it Worth Doing?”

1. **Presentation** (4 x approx. 5min.)
   i. Mitsuo Ochi
   ii. Freddie Fu,
   iii. Takeshi Muneta
   iv. Rainer Siebold,

2. **Debate** (approx. 10 min.)
ACL Augmentation Procedure with One-incision Technique
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Arthroscopic examination before ACL reconstruction sometimes reveals that there is a relatively thick ACL remnant bridging the femur and the tibia that may contribute to joint stability and proprioceptive function. The purposes of this study were to introduce our ACL augmentation procedure with one-incision technique that preserves the ACL remnant and to examine the clinical outcome of this procedure in terms of joint stability and proprioceptive function.

Since 1996, we performed over 150 ACL augmentations with one-incision technique. Among them, 72 patients who were followed up for more than 2 years were included in this study. The patients’ mean age was 25 years old. When the ACL remnant was attached to the antero-inferior portion of the anatomical femoral origin and the postero-lateral (PL) bundle was well preserved, the antero-medial (AM) bundle was reconstructed. When, in contrast, the ACL remnant was attached to the high noon position with a well preserved AM bundle, the PL bundle was reconstructed. We performed 37 AM bundle reconstructions and 35 PL bundle reconstructions. Anterior laxity of the knee joint measured by KT-2000 and joint position sense of the patients were evaluated preoperatively and at the final follow-up.

There were no significant differences in the background factors between the two groups. The average anterior laxity and joint position sense of ACL augmentation group showed better results than those of ACL reconstruction group, although there were no significance.

The merits of our ACL augmentation procedure are 1) it is performed under arthroscopy with one-incision 2) it avoids resection of the ACL remnant which contributes to prevention of anterior laxity 3) it preserves the ACL remnant’s neural elements and mechanoreceptors 4) it provides a favorable influence on vascularity and reinnervation to the graft. This study clearly demonstrated good anterior laxity and proprioceptive function in the ACL augmentation. Although a longer follow-up period is necessary before a definitive conclusion can be reached, we want to propose this new procedure for the patients whose ACL remnants were well preserved for better joint stability and proprioceptive function.
Remnant Preservation in ACL Reconstruction, is it worth doing?

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I. Remnant Preservation
- Remnant preservation is in line with many of the principles of anatomic ACL reconstruction. There are situations where remnant preservation can be beneficial in anatomic ACL reconstruction.
- Anatomy is the basis of orthopedic surgery and the goals of anatomic ACL reconstruction are to restore 80-90% of the native ACL anatomy, and to maintain a long term knee health.

II. The principle of anatomic ACL reconstruction
- Reproducing the two bundle anatomy of ACL
  - The ACL is composed of two functional bundles, the anteromedial (AM) bundle and the posterolateral (PL) bundle. Cadaveric studies have demonstrated that the AM bundle is approximately twice as long as the PL bundle, and that the two bundles have a similar cross-sectional diameter.
  - Reproducing the insertion sites of ACL
    - The remnants of the insertion sites of the AM and PL bundle should be identified and marked for anatomic tunnel placement. The femoral insertion sites of the AM and PL bundle are oriented vertically with the knee in extension and become horizontal in 90° of knee flexion (surgical position for ACL reconstruction surgery). In extension the two bundles are parallel and in flexion they become crossed.
  - Reproducing the tension pattern of ACL
    - The AM bundle has its highest tension at 45 degrees of knee flexion, and was taut throughout the range of motion. The PL bundle has its highest tension at full extension, and becomes lax as the knee flexes. The AM and PL graft should be fixed at these angles of knee flexion to closely reproduce the native tension pattern.
- Individualized surgery
  - The remnants of the insertion sites of each bundle should be identified and marked, and the size of the insertion sites should be measured to tailor the surgery for each individual. The remnant stumps can be left in place to increase visualization and propriosepsis. The concept of anatomic ACL reconstruction can be applied to all ACL surgeries (single bundle, double bundle, revision, one-bundle augmentation). The decision of whether to perform a single or double bundle ACL reconstruction should be dictated by the unique anatomy of the patient and quantification of the insertion site area. In cases only the AM or the PL bundle was torn, we save the intact bundle completely and “augment” the ACL with a single bundle reconstruction – either the AM or PL, whichever one is torn.
Remnant preserving double-bundle ACL reconstruction

- Significance of preservation of ACL remnant
  - Remnant is good anatomic landmark
  - Enhancement of graft healing
    - Earlier recover/ return to sports
  - Better proprioception
    - Less frequency of reinjury
    - Better subjective function
- Transtibial technique
- Comparative study in our hospital

Greater tendon-bone junction area is achieved in double-bundle technique

- Greater tendon-bone junction area initiates better stabilize function of the graft
- Greater tendon-bone junction area facilitates graft healing

1.4 : 1
6mm x 2 : 9mm x 1

- Anterior notch plasty is less performed.
- More ideal graft initial setting can be performed
Our surgical policy of ACL reconstruction

- Preservation of ACL remnant as much as possible for 20 years
- DB reconstruction using 4-strand ST tendon
- Intra-remnant 2-tunnel creation of tibia
- Anatomic bony landmark oriented tunnel creation of femur
- Trans-tibial approach to the femur

Tibial guide wire placement and tunnel creation

- AM guide wire
- PL guide wire
- AM enlarged drill hole
- PL enlarged drill hole

Roof impingement free tunnel placement
Physiological impingement accepted off-set placement

Tibial tunnel creation

- Bony landmark assessment with a drill guide tip
- Intra-remnant placement
- Off-set placement
- Physiological impingement accepted
- Initial 4.5mm drill-hole creation
- Drill hole enlargement with a bony rasp
**Tibial tunnel creation**
- Bony landmark assessment with a drill guide tip
- Intra-remnant placement
- Off-set placement
- Physiological impingement accepted
- Initial 4.5mm drill-hole creation
- Drill hole enlargement with a bony rasp

**Femoral tunnel creation**
- Bony landmark assessment after stripping femoral attachment with RF
- Aimed at the center of midsubstance for AMB and PLB
- Initial 4.5mm drill-hole creation
- Drill hole enlargement with a 4.5mm drill
- Current femoral tunnel creation in figure-4-position

**How remnant preserving technique is worth doing?**
- Comparative evaluation -

Results of well preserved cases vs. remnant disappeared cases
Patients with ACL remnant well preserved

- 55 cases of unilateral ACL injury
- 26 males, 29 females; Ave. 26 years (13 - 51)
- Preoperative Tegner score: Ave. 7.1 (3 - 9)
- Arthroscopic evaluation of remnant preservation: Ave. 63% (50 - 90)
  Subjective arthroscopic evaluation by two independent observers as femoral attachment 20%, midsubstance 60% and tibial attachment 20%
- Anterior laxity measurements by KT-1000 under anesthesia:
  Ave. 6.4mm (2 - 15)

Outcome of remnant preserving double-bundle reconstruction for patients with ACL remnant well preserved: stability

![Graph showing KT side-to-side measurements]

<table>
<thead>
<tr>
<th>Test</th>
<th>Average</th>
<th>Range</th>
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<tbody>
<tr>
<td>Lachman</td>
<td>0.9 +/- 1.2</td>
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<tr>
<td>ADT</td>
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<tr>
<td>Pivot</td>
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Outcome of remnant preserving double-bundle reconstruction for patients with ACL remnant well preserved: general

<table>
<thead>
<tr>
<th>Test</th>
<th>Average</th>
<th>Range</th>
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</thead>
<tbody>
<tr>
<td>Lysholm knee score (total)</td>
<td>95 (81 - 100)</td>
<td>94 (83 - 100)</td>
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<tr>
<td>Subjective recovery score</td>
<td>87 (40 - 100)</td>
<td>88 (70 - 100)</td>
</tr>
<tr>
<td>Sports performance recovery</td>
<td>87 (40 - 100)</td>
<td>87 (50 - 100)</td>
</tr>
<tr>
<td>Post op Tegner score</td>
<td>6.9 (3 - 9)</td>
<td>6.8 (3 - 10)</td>
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Still, many things have to be done!
Indications and own surgical techniques on ACL remnant preservation

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The anatomical double bundle concept of the anterior cruciate ligament (ACL) changed our understanding of symptomatic anteromedial (AM) and posterolateral (PL) bundle tears and helped us to understand different injury pattern. Depending on the injury of the ACL patients may demonstrate a wide spectrum of clinical symptoms. In the literature and in our clinical experience we observe symptomatic one-bundle tears in about 5% - 23% of ACL cases {1-6}.

Indications
The natural history of partial ACL tears shows that the number of patients resuming sports at the preinjury level is only between 30% to 44% - on the other hand about 60% are good or excellent with conservative treatment {7-8}. On the other hand the results of Partial ACL reconstruction are good {1-6}. Therefore we see the indication for ACL surgery in case of a symptomatic partial ACL tears. Our goal is always to preserve ACL fibres: (1) when there is one intact bundle, (2) when the continuity of the fibres from the tibia to the femur is intact {9,10,11} (3) when the ACL is scared from the tibia to the roof of the notch or to the PCL{9,10}. We also try to always keep a reasonable size stump on the tibia {5}.

Potential advantages
The potential advantages to preserve remnants may be: better stability of the reconstruction {9,10,11}, higher level of proprioception {12, 13,14}, increased anatomical accuracy of bone tunnel placement and faster vascularisation and rehabilitation. However, an ACL augmentation requires a precise diagnostic assessment of the injury pattern with clinical examination and MRI, knowledge of the arthroscopic anatomy and a precise augmentation while preserving intact ACL tissue {5,13}.
**Surgical examination of remnants**

Our technique includes an arthroscopic examination of the tibial and femoral insertion site with a probe in 60° - 90° for the AM-bundle and an examination close to extension and in a figure of four for the PL bundle. Most of the time we see a proximal tear of one of both bundles – the number of AM- and PL bundle tears is similar from our experience. We are aware, that the “intact” remnants may also be partially elongated and damaged. Therefore the decision to perform an augmentation of one bundle of the ACL has to be critically considered. The stability of the whole construct (augmentation + remnants) has to be perfect like for a regular ACL reconstruction. In no case the augmentation should compromise stability.

**Surgical technique**

To establish the femoral bone tunnel we carefully resect the necessary femoral fibres of the torn parts of the AC to visualize the femoral insertion site of the AM or PL. Then we create an adequate low anteromedial portal to establish the femoral bone tunnel using the Endobutton (S&N) technique. After using the 4.5 mm Endobutton drill the final diameter of the femoral bone tunnel is usually established by dilatation for not to damage the intact ACL remnants by the head of a drill. Usually the length of the femoral bone tunnel is between 32-40 mm. Consequently we choose a 15mm or 20 mm long Endobutton-CL for femoral fixation.

On the tibial side the ACL stump is usually intact. For the establishment of the AM bone tunnel we incise the intact AM stump with a knife and insert the aimer into the AM stump. Then the AM bone tunnel is established carefully without damaging the intact fibres. For the PL bone tunnel we position the aimer behind the intact AM bundle stump into the PL insertion. Then the PL bone tunnel is drilled. Before breaking the subchondral bone the final drills are made by hand for not to damage the tibial stump.

For augmentation we usually use the semitendinosus tendon, 3x or 4-fold over the Endobutton-CL. This gives us a size 7-8 mm grafts, length approximately 7-8 cm. Fixation on the tibial side is performed with a resorbable screw and by fixing the distal fibre-wire sutures over a tibial bone bridge. This is needed because the 3-4fold graft is to short for screw fixation alone. The result is a double fixation on the tibia. Fixation is performed in 5°-10° for PL and 45° for AM.

Rehabilitation allows full weight bearing from week 2 and free ROM from day one. Return to sports is depending on the process of rehabilitation and the type of sports after 8 to 12 months.
**Literature:**