Anterior tibial translation as a potential indicator of the long-term anterior cruciate ligament reconstruction outcome

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Aims and objectives

Anterior cruciate ligament (ACL) is the primary restraint of anterior tibial translation (ATT) relative to femur [1]. Following ACL injury, most patients have detectable excess knee laxity and may experience instability problems. The aim of anterior cruciate ligament reconstruction (ACLR) is to reduce excess joint laxity [2]. Measurement of knee laxity is clinically important from the point of view of making a diagnosis and also to compare laxity before and after ACLR [1]. In clinical practice excess knee laxity can be determined subjectively with clinical examination or may be objectively measured with arthrometric devices. MRI has become a valuable complementary method to clinical examination in the evaluation of the degree of anterior subluxation [3]. On MRI anterior subluxation can be measured directly as ATT and is analogous to anterior drawer test elicited during physical examination [4]. Furthermore, it has been shown on MRI that ATT of 5 mm or more has a sensitivity of 86% and a specificity of 99% for ACL tear [4]. Most studies have investigated the importance of ATT in predicting ACL injury, however few studies have focused on post-reconstruction ATT values [2,5,6,7,8,9].

The aim of this study was to evaluate ATT as a potential predictor of the long-term outcome after ACLR. We hypothesized that the long-term outcome can be predicted by the degree of passive knee joint laxity.
Methods and materials

Subjects

The National Medical Ethics Committee approved the study and informed consent was obtained from the subjects after the nature of the study had been fully explained. Forty patients (26 males) after ACLR were recruited for the study. The inclusion criteria for the ACLR group were (1) 16-45 years at ACLR, (2) body mass index (BMI) of 18.5 to 30, (3) preoperative sports activity of at least 4 on Tegner scale. Exclusion criteria were (1) known chondropathy, (2) concomitant collateral ligament injury, (3) concomitant posterior cruciate ligament injury, (4) MRI contraindication and (5) total meniscectomy.

Surgically treated subjects were invited from the period (years 2008-2010) when our institution routinely performed transtibial and anteromedial portal technique. Twenty-three subjects underwent transtibial and seventeen underwent anteromedial portal ACLR. ACLR procedures were performed by two senior orthopedic surgeons with the same perioperative procedure and same graft type (semitendinosus-gracilis tendon graft), all patients underwent same rehabilitation program.

Subjective clinical evaluation

Standardized questionnaires were used for patient-reported measures of knee function and general health. Knee injury and Osteoarthritis Outcome Score (KOOS), International Knee Documentation Committee Subjective Knee Form (IKDC), and Lysholm score are knee-specific instruments widely used for evaluation of the patients’ perception of knee related problems [10,11,12,13]. Tegner scale is used to assess patient’s sport activity [14]. To evaluate health related quality of life RAND-36 Health Survey instrument was presented to the subjects [15]. The questionnaires were presented to study subjects at the MR examination.

Imaging Protocol

MRI examinations were performed by using a 3.0 T imager (Magnetom® Trio, Siemens, Erlangen, Germany) with an 8-channel transmit-receive knee coil (Invivo, Gainesville, Florida, USA). Protocol included proton density (PD) turbo spin echo (TSE) fat saturation (FS) images in the sagittal plane (2230/29 [TR msec/TE msec], 16 cm field of view [FOV], 3mm/1mm [slice thickness/interslice gap], 512 x 512 matrix, 120° flip angle, 2 signals acquired) and in the coronal plane (2540/35, 15 cm, 3mm/1mm, 384 x 384 matrix, 150°, 2) [14]. PD TSE images were obtained in the sagittal plane (2000/29, 16 cm, 3mm/1mm,
512 x 512 matrix, 120°, 2) and in the axial plane (2230/29, 15 cm, 3mm/1mm, 512 x 512 matrix, 140°, 2).

Evaluation of the ATT

To evaluate ATT tangential lines perpendicular to the lateral tibial plateau were drawn along the midsagittal plane of the lateral compartment at the posterior of the lateral femoral condyle and tibial plateau [16]. A maximal distance between the tangential lines was measured (Figure 1).

Semi-quantitative MRI assessment

Semi-quantitative MRI assessment was performed by a musculoskeletal radiologist with 15-years experience. For the assessment of morphologic degeneration Whole Organ Magnetic Resonance Imaging Score (WORMS) system was used [17]. The final WORMS scores were tabulated as (1) cumulative surface feature (cartilage, marrow abnormality, subarticular cysts, bone attrition, osteophytes) scores for each compartment, (2) cumulative scores for each feature throughout the knee, and (3) a total combined score for the entire knee [17]. Specific WORMS features were graded in accordance with the paper published by Peterfy et al [17].

Statistical Analysis

Pearson correlation coefficient was calculated to evaluate correlation. Significance was set at P<0.05. Statistical analysis was performed with SPSS v.17.0 (SPSS Inc., Chicago, Illinois, USA).
Images for this section:

Fig. 1: Sagittal proton density MR images in a (A) 48-year old man after ACL reconstruction with anterior tibial translation measurement of 1.45 cm and (B) 37-year old women after ACLR reconstruction with anterior tibial translation measurement of 0.45 cm.

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Results

Significant correlation was observed between the LFTJ (lateral femorotibial joint) score and the ATT ($R=0.452; P=0.003$) as well as between the total WORMS score and the ATT ($R=0.332; P=0.036$), (Figure 2). No correlation was observed in PFJ (patelofemoral joint) and MFTJ (medial femorotibial joint) score (both $P>0.05$). Significant correlation was found between subjective clinical evaluation and the ATT (Figure 3).
**Fig. 2:** (A) correlation between the total WORMS score and the anterior tibial translation (ATT), (B) Correlation between the lateral femorotibial joint (LFTJ) score and anterior tibial translation (ATT),

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<table>
<thead>
<tr>
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<th>ATT</th>
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<tr>
<td>Lysholm</td>
<td>-0.282; P=0.078</td>
<td>-0.135; P=0.405</td>
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<tr>
<td>KOOS A</td>
<td>-0.270; P=0.092</td>
<td>-0.122; P=0.492</td>
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<tr>
<td>KOOS P</td>
<td>-0.294; P=0.066</td>
<td>-0.375; P=0.017</td>
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<tr>
<td>KOOS Q</td>
<td>-0.326; P=0.040</td>
<td>-0.415; P=0.008</td>
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<tr>
<td>KOOS S</td>
<td>-0.353; P=0.025</td>
<td>-0.399; P=0.011</td>
</tr>
<tr>
<td>KOOS Sp</td>
<td>-0.343; P=0.030</td>
<td>-0.379; P=0.016</td>
</tr>
<tr>
<td>IKDC</td>
<td>-0.328; P=0.039</td>
<td>-0.347; P=0.028</td>
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**Fig. 3:** KOOS, Knee injury and Osteoarthritis Outcome Score; IKDC, International Knee Documentation Committee Subjective Knee Form; #, significant at P<0.10; *, significant at P<0.05.

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In this study, we correlated subjective clinical evaluation and semi-quantitative MRI assessment with ATT. ATT showed significant correlation with subjective clinical evaluation and semi-quantitative MRI assessment.

Current methods of ACLR have been successful at restoring joint stability by reducing excess sagittal anteroposterior laxity and perhaps by restoring more normal proprioception, however ACLR does not restore normal tibiofemoral kinematics [2]. Furthermore, various reports show that ACLR is not capable of fully restoring ATT, leaving the tibia with persistent subluxation [2,5,6,7,8,9]. It has been proposed that tightening of the posterior-restraining structures may cause the fixed subluxation and that such a process can be initiated by the ACLR itself [7]. Fixed subluxation will likely prevent improved tibiofemoral kinematics even in the face of reduced ATT [7]. This may explain, at least in part, why ACLR may not reduce the incidence of osteoarthritis [2,7]. Our results support this, since we have showed statistically significant correlation between semi-quantitative MR assessment and ATT. Interestingly, significant correlation was found in total WORMS score and the lateral compartment, however none was found in the medial compartment nor patella. This may be explained by the fact that ACLR patients have abnormal tibiofemoral kinematics especially in the lateral compartment [2]. It should be noted that ATT was measured only in the lateral compartment and the results for the medial compartment may have differed, if we had taken into analysis the medial compartment as well. This said Haughom et al showed that abnormal patterns of ATT have increased cartilage breakdown in the medial compartment as well as patella [6].

To our knowledge this is the first study correlating subjective clinical evaluation in ACLR patients with passive laxity on MRI. Previous studies suggest that symptoms and laxity are unrelated [9,18,19]. Contrary to these results, our study showed significant correlation between subjective clinical evaluation and ATT. Previous studies evaluated laxity manually or with arthrometer, hence studied laxity with passive knee manipulation. This is an important difference with our study, since passive laxity assessed in our study, may demonstrate different underlying pathological mechanisms. We propose, that in knee manipulation some degree of reflex muscle tone may persist due to muscle stretching and activation of proprioceptors, thus masking the actual passive laxity. On MRI patient`s muscles are fully relaxed, revealing the true femorotibial relationship. An important factor that needs to be considered as well is the difference in the follow-up time between the studies, since it is known that a decrease of knee laxity over time is observed in ACLR patients [20]. This suggests that laxity is a dynamic process, stabilizing after a longer observational time. A long-term follow up in our study may be an important factor in the significance of our results.

The results of our study suggest that ATT may be a good indicator of patient`s symptoms and osteoarthritic changes after ACLR at a long-term follow up.
Personal information

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