Isolated Posterior Cruciate Ligament Deficient Knee

- In vivo kinematic evaluation using dynamic biplane radiography and model based tracking-

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INTRODUCTION:
Even though PCL is strongest ligament of knee joint, it is considered that isolated PCL injury is often well tolerated.1 The importance of the conservative treatment for the PCL injury is being emphasized due to good healing potential with plenty blood supply and synovium.2 However nonoperative treatment could maintain excellent muscle strength for the isolated PCL injury, degenerative change was increased with the increase of the duration.3 Osteoarthritis is related increased tangential shearing forces developed by instability after ligament injury. Evaluation of the instability might be the most important prognostic factor. The quantitative methods to evaluate the instability of the PCL injury are stress X-ray using Telos device and KT-2000 arthrometer. But we couldn’t predict the dynamic instability with those static methods during the daily activity which could anticipate osteoarthritic change after posterior cruciate ligament (PCL) injury.4

The purpose of this study is to evaluate the functional instability of the PCL deficient knee compared to the contralateral normal knee during the daily activity such running and stair ascending activity. We hypothesized that the PCL deficient knee could be more functionally unstable than the contralateral normal knee.

METHODS:
Seven patients (range 18-28 years old) with isolated grade II PCL deficient knee underwent high-speed, biaxial cine-radiography during level running (150 frames/s) and stair ascending (100 frames/s) activity. The running activities were performed at 2.5m/s on instrumented dual-belt treadmill (Bertec, Inc.). The stair ascending activities were performed on the custom made three-steps based on the international residential code 2006 (tread: 11.5 inches, riser: 7.75 inches). The mean interval between the injury time and the test time is 9.9 months. Patients underwent CT scan with 3D reconstruction using Mimics software (Materialise, Leuven, Belgium). Digitally reconstructed radiographs (DRRs) were generated with 3D reconstructed CT data via ray-traced projection. By optimizing the similarity between the two DRRs and the x-ray image pairs from bialplane radiography, 3-D cine images of femoral and tibial bones during the activities was reproduced (Fig. 1). During the activity (level running and the stair ascending), the data about two translation parameters (anterior-posterior, medial-lateral) were collected using the relative value of tibial anatomic coordinate over the femoral anatomic coordinate, the data about two rotational parameters (internal/external rotation, abduction/adduction) were collected using the anatomic axis of the femur and tibia. Paired t-test was used for the comparison of the parameter. p-value was set < .05.

RESULTS:
During the level running, the mean lateral-medial position of the tibia was 2.0±2.12 mm for the PCL deficient knees, 0.9± 1.9 mm for the contralateral knees. The tibias of the PCL deficient knees statistically more translated laterally than the contralateral knees (p=0.017). But the ranges of LM translations of two groups were not statistically different (p=0.818). The AP translation, internal/external rotation, abduction/adduction, (mean/minimal/maximal/range) of the PCL deficient knees were not statistically different from those of the contralateral knees.

During the stair ascending, the mean lateral-medial position of the tibia was 1.0±1.2 mm for the PCL deficient knees, 0.1±1.8 mm for the contralateral knees. The tibias of the PCL deficient knees statistically significantly more translated laterally than the contralateral knees (p=0.007). But the ranges of LM translations of two groups were not statistically different (p=0.522). The mean anterior-posterior position of the tibia was 7.0±2.5 mm for the PCL deficient knees, 8.9±1.8 mm for the contralateral knees. The tibias of the PCL deficient knees statistically significantly more translated posteriorly than the contralateral knees (p=0.001). Maximal and minimal anterior-posterior position of the tibia for the PCL deficient knees more posteriorly translated than the contralateral knees with statistical significance (p=0.014 & p<0.001), and The average range of the AP translation of the PCL deficient knees (7.0 ± 2.3 mm) was longer than the contralateral knees (3.3 ± 1.4 mm) with statistical significance (p<0.001)

DISCUSSION:
Functional instability during the daily activity such as stair ascending, level running is considered as the most important factor to predict the prognosis of the posterior cruciate ligament instability and the indication of the ligament reconstruction surgery, especially for the isolated PCL injury patients. But there is no objective method to evaluate the functional instability until now. So, surgeons generally determined the functional instability based on the history taking including giving-way symptom, weakness during the daily living activities such as running or stair ascending.

The isolated PCL deficient knees showed increased anterior-posterior instability during the stair ascending activity. This is first description about the dynamic instability during the daily living activity. We found the tibia was subluxated before the heel strike of the stair ascending activity and reduced by the weight bearing and the contraction of the quadriceps muscle. We thought that this phenomenon was related the increased range of the anterior-posterior translation of the tibia. But we could not find the difference during the level running. We presumed that the functional instability of the PCL deficient knees during the level running was reduced by the continuous activation of the quadriceps muscle and extended position of knee at the time of heel strike. We could find that the tibias of the PCL deficient knees were laterally translated during the level running and stair ascending. PCL is originated from the lateral side of the femoral notch and inserts to the center of the backside of the tibia. Mainly, the PCL is the primary strain for the posterior translation of the tibia. But we can presume that the PCL also has the role to prevent the lateral translation of the tibia based on the results of this study showing the lateral translation of the tibia in PCL deficient knees and the anatomic alignment of the PCL fibers.

In conclusion, the functional instability such as the anterior-posterior translation and the lateral translation of the tibia was increased in the isolated grade II PCL deficient patients during the running and the stair ascending.

REFERENCES:

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