

学位論文の要旨

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学位論文名 Measurement Characteristics of a Force-Displacement Curve for Chronic Patellar Instability.

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論文内容の要旨

INTRODUCTION

Chronic patellar instability is a multifaceted problem involving soft tissue and osseous abnormalities. However, unstable joints often show no abnormality at rest. Thus, the most reliable clinical diagnosis is dependent on the patient's response to displacement on application of passive force. If the lateral apprehension is positive, the patient may be a candidate for surgical reconstruction of the medial soft tissue. However, no objective criterion has been established for assessing such apprehension.

As an objective index, the mechanical limits of patellar displacement have been measured with the application of specific forces: 11, 22, 45, and 80 N. However, in our clinical experience in applying passive forces to the patella during stress radiography examinations, we have found that many patients expressed apprehension before a load application of 11 N was achieved, limiting our ability to measure the mechanical limit of patellar displacement. We therefore hypothesized that a subjective diagnosis and activity-related symptoms could be supported by a numerical evaluation of the slope, or compliance, of the early phase of a force-displacement curve.

In this study, we measured patellar stability in patients with previous traumatic dislocation and chronic instability but without major osseous abnormalities. The clinical feasibility is discussed with regard to the correlation with subjective diagnosis, considering patient discomfort.

MATERIALS AND METHODS

Healthy volunteers (n = 21; 16-33 years old) and patients (n = 21; 15-34 years old) who had a clearly definable diagnosis of unilateral dislocation, followed by chronic anterior knee pain, and positive apprehension signs for more than 6 months, without patella alta or abnormal limb alignment. The Ethics Committee at the Shimane Medical School approved this study (No.558).

Separately from a routine physical examination, lateral displacement and reactive forces were measured with a Patella Stability Tester (Kishi Engineering, Izumo, Japan), an instrument with an accuracy of 0.05 mm in translation and 0.01 N in force. The examiner (N.E.) was blinded to any information about the subjects. The device was placed on the middle of the medial ridge of the patella for a force sensor and on the posterolateral corner of the lateral femoral condyle for a fixation tip. Manual shifting of the patella was performed at approximately 5 mm per second with the knee extended on a flat surface. Data were recorded every 0.01 seconds with a computer system (PSTKT; Miya Denki, Izumo, Japan) and displayed on a monitor in real time. The initial position of displacement was defined as the point where 0.5 N was applied to place the device. The patients were allowed to press a button when they wished to stop further displacement due to pain. The data collection was stopped immediately after the button was pressed. Then, the patients described the magnitude of the maximum pain on a visual analog scale (VAS) consisting of a 10-cm line, with polar descriptions of “none” and “severe, requiring pain pills every few hours” if the maximum pain persisted for a day. The description was converted to a numerical percentage value by simple measurement. Otherwise, lateral displacement was increased until the force reached 22 N or the displacement reached 16 mm.

A regression formula of the force-displacement curve was determined every 1 mm of displacement by a polynomial regression analysis of 20 points (range, 0.2 seconds, 2 mm) (Statcel 2; OMS Publishing, Inc, Tokorozawa, Japan). Then, the compliance of the force-displacement curve was mathematically calculated.

RESULTS AND DISCUSSION

Compliance at 5 mm in displacement showed the highest reproducibility (plot difference of 4.7%) and the highest sensitivity (95%). Among injured knees, compliance was significantly correlated with the activity-related symptoms of the Kujala score (correlation coefficient, -0.61; $P = 0.004$). Compliance at 5 mm of displacement showed the highest sensitivity (95%) and significant correlation with the activity-related symptoms of the Kujala score among injured knees (coefficient of determination, 0.37; $P = 0.004$).

Although the finding that the early compliance represented the subjective diagnosis is novel, these results are not inconsistent with the previous reports. For example, it was reported that a lateral displacing force of 11 N resulted in 3.5-mm displacement in intact knees but 7.0

mm in affected knees. Thus, a displacement of 5 mm could be the point at which the difference in slope is best detected. When 11 N of load was applied, patients 10 of 21 with injured knees had dropped out due to pain, although Fithian et al. reported that no patient exhibited “any discomfort” with the application of 11 N of load that resulted in 11.56 ± 4.7 mm of displacement. Reasons for this difference may include different criteria for tolerance and the profile of the patients. In this study, patients were told to press the button when they wished to stop further displacement due to pain. We did not examine the maximum range of tolerance, but we sought to find a well-tolerated level of displacement. Indeed, we aimed to establish a patient-friendly procedure that did not give patients negative feelings about reexaminations.

We chose a position with the knee extended for the examination because the contribution of the MPFL (Medial patellofemoral ligament) in resisting lateral displacement of the patella is greatest with the knee fully extended and declines rapidly up to 20 degrees of flexion angle. The MPFL is the primary restraint on medial soft tissue. Our current treatment includes simple reconstruction of the MPFL for the patients in this study who had a normal tibial tubercle–trochlear groove distance and a normal patellar height. Thus, we sought to determine the restraint by the MPFL, and the measurement was done with the knee extended.

It is important to be aware of the limitations of this study before proposing the introduction of this new index into clinical practice. First, the diagnosis of chronic patellar stability was based only on a subjective evaluation. Our future work will investigate pre-treatment and post-treatment outcomes to strengthen the case for the clinical application of this new objective index. Also, we emphasize the importance of a thorough physical examination and adequate radiography to determine the profile of patients. The study does not compare the responsiveness of this measure to identify patellar instability to standard clinical tests performed by experts; as such, it is not possible to establish the relevance of the measure to clinical practice at this time.

Despite these limitations, it may be beneficial to introduce an objective index of compliance at 5-mm lateral displacement in the clinical setting, so long as physicians understand its limitations. There is the possibility of this measure being used to evaluate the outcomes of conservative and/or surgical management of patellar instability, for which the proposed methods may be of significant clinical value.

CONCLUSION

It is a novel finding that early compliance at 5 mm of displacement showed a correlation with the subjective diagnosis and symptoms.