

Relationship between Mucoïd Degeneration of the Anterior Cruciate Ligament and Posterior Tibial Slope in Patients with Total Knee Arthroplasty

Yoon-Seok Youm, MD, Sung-Do Cho, MD, Hye-Yong Cho, MD, and Seung-Hyun Jung, MD

Department of Orthopedic Surgery, Ulsan University Hospital, Ulsan, Korea

Purpose: The purpose was to analyze the relationship between posterior tibial slope (PTS) and mucoïd degeneration of the anterior cruciate ligament (ACL) in patients with total knee arthroplasty.

Materials and Methods: Four hundred and twenty-four patients (24 males and 400 females; 636 knees) who received total knee arthroplasty for osteoarthritis were included. Their mean age was 68.9 years (range, 48 to 88 years). The patients were classified into three groups according to the status of ACL; normal ACL group (group I), mucoïd degeneration of ACL group (group II) and ruptured or absent ACL group (group III). Plain lateral radiographs were used to measure the PTS and the values were compared among groups.

Results: There were no significant differences with regard to gender, age and left-to-right side ratio among groups ($p > 0.05$). The mean PTS was 9.9° (range, 0.6° to 20.1°) in group I (161 knees), 10.8° (range, 0.2° to 21.8°) in group II (342 knees) and 12.3° (range, 2° to 22.2°) in group III (133 knees), which showed significant differences ($p < 0.001$).

Conclusions: The patients with mucoïd degeneration of the ACL and those with ruptured or absent ACL had greater PTS than those with normal ACL. These findings suggest that an increased PTS may be one of the causative factors for mucoïd degeneration of the ACL.

Keywords: Knee, Arthroplasty, Posterior tibial slope, Anterior cruciate ligament, Mucoïd degeneration

Introduction

Mucoïd degeneration of the anterior cruciate ligament (ACL) has been implicated as one of the factors responsible for knee pain¹⁻⁸. Kumar et al.³ first documented a case of biopsy indicated ACL mucoïd degeneration in 1999. Contrary to the previous reports of the rarity of the lesion, recent studies have revealed relatively high prevalence⁹⁻¹². Etiological factors of mucoïd degeneration of the ACL include repeated trauma to the ACL or degeneration of the ligament, chronic impingement of the ACL,

synovial changes, and influence of anatomical variables such as the intercondylar notch of the knee and posterior tibial slope (PTS)^{9,10,13-17}. In general, conservative treatment is the initial treatment of choice; however, if symptoms do not improve, arthroscopic partial resection of the ACL can be performed^{11,18-20}.

PTS is anatomically associated with anterior tibial translation, and it is positively correlated with anterior tibial translation, resulting in increased load on the ACL^{21,22}. Studies have suggested there is a relationship between PTS and mucoïd degeneration of the ACL and increased posterior slope has been associated with increased risk of ACL injury^{16,17,23,24}.

The purpose of the current study was to investigate the relationship between mucoïd degeneration of the ACL identified during total knee arthroplasty (TKA) and PTS.

Materials and Methods

This study was conducted on a total of 424 patients (636 knees) who underwent TKA under the diagnosis of Kellgren-Lawrence

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Correspondence to: Sung-Do Cho, MD

Department of Orthopedic Surgery, Ulsan University Hospital, 877

Bangeojinsunhwan-doro, Dong-gu, Ulsan 44033, Korea

Tel: +82-52-250-7129, Fax: +82-52-235-2823

E-mail: sdcho@uuh.ulsan.kr

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grade IV osteoarthritis of the knee between May 2007 and February 2011. There were 24 males and 400 females with a mean age of 68.9 years (range, 48 to 88 years). The exclusion criteria were previous surgery on the ipsilateral knee, lower limb deformity, mediolateral ligament instability, revision TKA, and rheumatoid arthritis.

The surgery was performed by the same surgeon (Cho SD) in all patients with a standard midline skin incision and a medial parapatellar approach. Intraoperatively, the presence of ACL degeneration/tear was identified and recorded by the same surgeon (Cho SD). Specimens obtained during surgery were histopathologically reviewed. The ultimate diagnosis of ACL mucoid degeneration was based on the gross observation and histopathological findings. According to the diagnostic results, the patients were divided into three groups: group I, patients with normal ACL; group II, patients with mucoid degeneration of ACL; and group III, patients with ruptured or absent ACL (Fig. 1).

PTS was assessed on the lateral radiograph using the picture archiving communication system (PiView STAR software; Infinitt, Seoul, Korea) by an orthopedist who was blinded to patient data. For the measurement of PTS, the diaphyseal axis of the tibia was established as a line connecting the two points equidistant from the anterior and posterior borders of the tibia, one was immediately inferior to the tibial tubercle and the other was 10 cm more distal to it. A reference line was drawn perpendicular to the diaphyseal axis at the level of the femorotibial joint. Then, another line was drawn by connecting the highest points of the anterior and posterior edges of the medial plateau. The angle between this line and the reference line was defined as the PTS (Fig. 2).

Statistical analysis was performed to determine statistical significance of difference in PTS among groups. A chi-square test was used to compare demographic characteristics among groups, and PTS was compared using the one-way analysis of variance test. The relationship between age and PTS in each group was as-

sessed using the Pearson correlation test. For statistical analysis, SPSS ver. 21.0 (IBM Co., Armonk, NY, US) was used with the significance level set at $p < 0.05$.

Results

Of the total 636 knees, ACL degeneration or tear was not observed in 161 knees (25.3%, group I), mucoid degeneration was observed in 341 knees (53.6%, group II), and the ACL was either ruptured or absent in 133 knees (20.9%, group III). There was no statistically significant difference among the groups with regard to gender, age, and the left-to-right side ratio ($p > 0.05$) (Table 1).

The mean PTS was 9.9° (range, 0.6° to 20.1°) in group I, 10.8° (range, 0.2° to 21.8°) in group II, and 12.3° (range, 2° to 22.2°) in group III, showing statistically significant difference among groups ($p < 0.001$) (Table 2).



Fig. 2. Posterior tibial slope measurement.

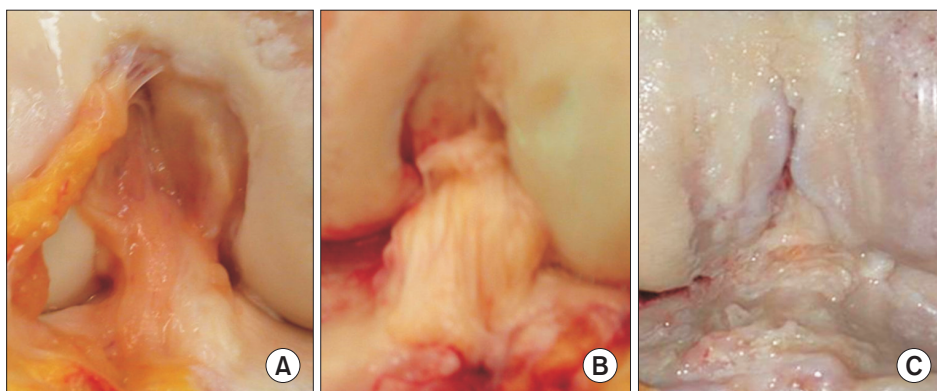


Fig. 1. Intraoperative gross appearance of the anterior cruciate ligament (ACL). Normal (A), mucoid degeneration (B), and rupture or absence (C) of the ACL.

Due to the comparatively low proportion of males in each group, statistical analysis of male-to-female comparison of PTS could not be carried out. Age was found to have no influence on PTS ($p>0.05$).

Discussion

The results of the current study showed increased PTS in the knees with mucoïd degeneration of the ACL or those with rupture or absence of the ligament compared to those with normal ACL.

Mucoïd degeneration of the ACL can be diagnosed based on magnetic resonance imaging (MRI) findings, gross observations, and histopathological examinations. MRI characteristics of ACL mucoïd degeneration include ill-defined and thickened ligament, increased signal intensity and celery stalk sign, and intraoperative

findings include ACL thickening, discharge of mucoïd materials or loss of synovial lining, and impingement in full extension of the knee^{4,9,25,26}. Histopathological indications are increased collagen production and alterations in mucoïd materials^{17,25}. In our study, intraoperative gross findings and histopathological examinations were used for the assessment of mucoïd degeneration of the ACL, and MRI was not carried out.

PTS is measured as the angle between a line perpendicular to the mid-diaphysis of the tibia and a line parallel to posterior tibial inclination. A normal PTS ranges from 7° to 13° although some variations exist depending on the measurement site and method²⁷. Besides, the values on plain radiographs tend to be greater than those on MRI images²⁸. PTS is positively correlated with anterior tibial translation^{21,22}. Based on a review of cadaveric studies and mathematical models, Feucht et al.²⁷ concluded that PTS was positively correlated with anterior translation of the tibia; however, the influence of anterior tibial shift on increased strain in the ACL could be confirmed only in mathematical models, not in cadaveric studies. In spite of this, they conjectured that a steep tibial posterior slope is a risk factor for ACL injuries. Some studies have shown that PTS is greater in the ACL tear group than in the normal ACL group. Similarly, increased PTS was found to be associated with ACL injuries in a multitude of studies^{14,16,24,29}.

Table 1. Demographics

Variable	Group I	Group II	Group III
Age (yr)	67.6±6.7	68.8±7.1	69.4±6.7
Gender			
Male	5	20	7
Female	156	322	126
Side			
Right	86	176	63
Left	75	166	70

Values are presented as mean±standard deviation or number.

Table 2. Posterior Tibial Slope (PTS)

	Group I	Group II	Group III
PTS (°)	9.9±3.4 (0.6–20.1)	10.8±3.5 (0.2–21.8)	12.3±4.3 (2.0–22.2)

Values are presented as mean±standard deviation (range).

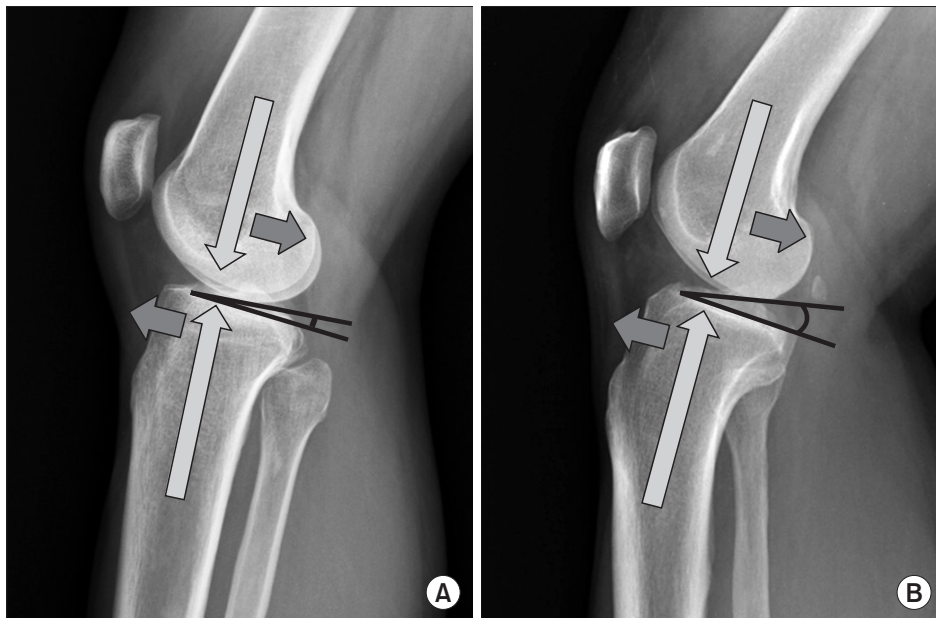


Fig. 3. (A) Relationship between posterior tibial slope (PTS) and anterior tibial translation. (B) Increased PTS may cause increased anterior tibial translation.

Based on the review of the abovementioned studies, we assumed a positive correlation between PTS and anterior translation of the tibia, which predisposes the ACL to biomechanical alterations resulting in constant damage to the ACL and mucoid degeneration (Fig. 3). Jung et al.¹⁷⁾ reported that PTS was significantly greater in the patient group with mucoid degeneration than in the control group. In our study, increased PTS was observed in the mucoid degeneration group (group II) and absent or torn ACL group (group III) compared to the normal ACL group (group I). In addition, the PTS was significantly greater in group III than in group II, suggesting that mucoid degeneration can eventually progress to a tear or loss of the ACL. Therefore, in the absence of clear understanding of the mechanism, we surmise there is a relatively close relationship between PTS and mucoid degeneration of the ACL. It is our understanding that the possibility of ACL injury or mucoid degeneration should be taken into consideration if a steep PTS is observed during clinical examination.

We acknowledge there are some limitations of our study. First, the influence of meniscus on the PTS was not addressed in the analysis because measurements were performed using plain radiographs. Second, other factors that could affect mucoid degeneration were not investigated. Third, we did not attempt to identify the exact mechanism of mucoid degeneration.

Conclusions

The patients with mucoid degeneration of the ACL and those with ruptured or absent ACL had greater PTS than those with normal ACL. These findings suggest that an increased PTS may be one of the causative factors for mucoid degeneration of the ACL.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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