

# Is there a relationship between anterior knee pain and femoral trochlear dysplasia? Assessment of lateral trochlear inclination by magnetic resonance imaging

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**Abstract** It may be very difficult to diagnose the pathology in patients with anterior knee pain. Patients with chronic anterior knee pain have been reviewed for the study. Our aim was to delineate the presence of subtle trochlear dysplasia by measuring lateral trochlear inclination (LTI) in axial magnetic resonance imaging (MRI) scans. While there were 109 knees in the study group with anterior knee pain (AKP), control group consisted of 74 knees without AKP. The LTI measurements were performed at the level of proximal cartilaginous area of trochlear groove in axial scans. The condition was termed to be trochlear dysplasia when LTI was below  $11^\circ$ . Parameters in both groups were statistically analyzed and compared for their association with LTI. There was no significant difference between LTI values of male and female subjects in each group. The mean LTI values in anterior knee pain and control groups were  $17.32^\circ$  and  $21.5^\circ$ , respectively, and the difference was statistically significant ( $P < 0.05$ ). The ratio of knees with trochlear dysplasia was 16.5% in AKP group, which was only 2.7% in control. In the AKP group, the ratio of trochlear dysplasia was significantly high ( $P < 0.05$ ). Although trochlear dysplasia has been generally detected in cases with patellar instability, this study revealed that the

frequency of this finding in patients with other causes of anterior knee pain was also considerably high. Measurement of lateral trochlear inclination in axial MRI scans with radiologic assessment seems to be a valuable diagnostic criterion, especially in patients in whom etiology of anterior knee pain could not be identified.

**Keywords** Femur/abnormalities · Knee joint/pathology · Magnetic resonance imaging · Joint diseases/diagnosis · Trochlear dysplasia · Patellofemoral syndrome

## Introduction

Anterior knee pain (AKP) is a common complaint encountered in clinical practice. While it harbors various factors within scope of its etiology, one of the most common causes is known to be patellofemoral alignment disorders. It may not be possible to establish an accurate diagnosis by medical history and physical examination. In order to show the malalignment objectively, various imaging methods such as radiography, computed tomography, and magnetic resonance imaging (MRI) have been described along with the angle measurements associated with those modalities [7–9, 12, 14, 20].

Dysplasias and anatomic anomalies in soft and osseous tissues forming the extensor mechanism cause patellofemoral alignment disorders [4, 9, 20]. Femoral trochlear dysplasia, which is one of those anomalies, has been generally shown on direct knee radiographs of cases with patellar instability [4, 18]. Carillon et al. [2] described a lateral trochlear inclination (LTI) angle, suggesting trochlear dysplasia on transverse MRI sections of knee. They have shown this value as below  $11^\circ$  particularly in cases with patellar instability. In the present study, it was

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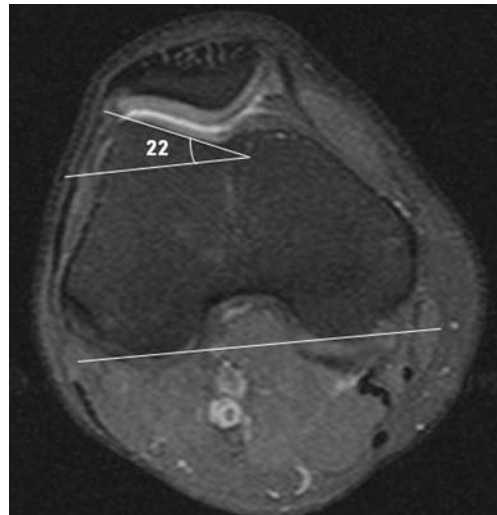
hypothesized that there was no significant difference between AKP and control groups in terms of mean LTI values. Trochlear dysplasia was investigated by assessment of lateral trochlear inclination angle on transverse sections of knee MRIs performed for differential diagnosis of 109 cases followed-up for AKP and 74 controls without AKP.

## Materials and methods

MRI was employed for differential diagnosis of cases below 40 years of age who had undergone clinical and direct radiographic assessment in our outpatient clinic with the complaint of AKP. After physical examination and radiographic evaluation, cases with excessive femoral anteversion, valgus deformity in knee, subtalar pronation deformity of foot, patellar tendinitis, Hoffa disease, synovial hypertrophy, plica syndromes and knee osteoarthritis affecting patellofemoral, medial, or all of the three compartments were excluded from the study. Moreover, MRI of cases with history of patellar dislocation and subluxation were not included in the study group as well. Cases suffering from AKP without any apparent etiology and specific diagnosis despite clinical and radiologic examinations, constituted the study group (group AKP). Images of patients who had been diagnosed to have meniscus tears or ligament lesions following a traumatic episode and who had no knee pain complaint prior to this trauma were collected for the control group. Cases of control group were picked up at similar ages with the patients in group AKP.

Knees were placed into a standard coil and MR imaging was performed with 1.5-Tesla Philips Gyroscan Intera scanner (Philips Medical Systems, Best, Holland). Proton density weighted (PDW) fat-suppressed images were obtained with 3-mm-slice thickness in axial plane. As described by Carillon et al. [2], measurements were carried out on the first cranio-caudal transverse PDW sections exhibiting cartilage over lateral trochlear facet with the help of a computer software (Easyvision, software program, Philips). A tangential line was drawn to the subchondral bones at posterior portion of both femoral condyles. Then, another tangential line was drawn to the subchondral bone of lateral trochlear facet. Lateral trochlear inclination (LTI) was measured as the angle between those two lines (Fig. 1).

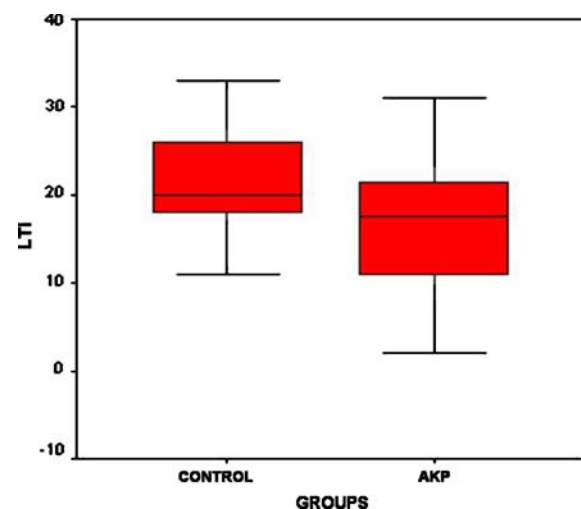
In the present study, while Student's *t* test was employed for comparison of the average LTI values of AKP and control groups along with differences between the groups with regard to age and gender, Chi-square test was used to carry out a statistical comparison for presence of trochlear dysplasia.



**Fig. 1** The LTI of a 28-year-old woman without AKP in axial MR section was 22°

## Results

In the present study, 183 knee MRI axial sections of 161 cases (22 bilateral) were included. Measurements were carried out on MRI sections of 109 cases with AKP of unknown etiology and 74 sections of controls. While study group consisted of 68 female knees (mean age, 29; average angle, 17.35°) and 41 male knees (mean age, 30; average angle, 17.20°), control group included 40 female knees (mean age, 28; average angle, 21.54°) and 34 male knees (mean age, 29; average angle, 21.4°). There was no statistical difference between groups regarding gender and age ( $P > 0.05$ ). Moreover, average LTI values were similar to one another



**Fig. 2** The LTI value was below 20° in the 75% of the AKP group while it was over 20° in most of the subjects of control group

**Table 1** Average LTI values of male and female subjects in AKP “anterior knee pain” and control groups

Groups		Age Mean (range)	LTI (mean)	SD
Female	AKP group ( <i>n</i> = 68)	29 (14–40)	17.4°	7.5
	Control group ( <i>n</i> = 40)	28 (18–40)	21.5°	5.7
Male	AKP group ( <i>n</i> = 41)	30 (16–40)	17.2°	5.4
	Control group ( <i>n</i> = 34)	29 (19–40)	21.4°	5.9
Total	AKP group ( <i>n</i> = 109)	29.7	17.3°	6.5
	Control group ( <i>n</i> = 74)	27.5	21.5°	5.7

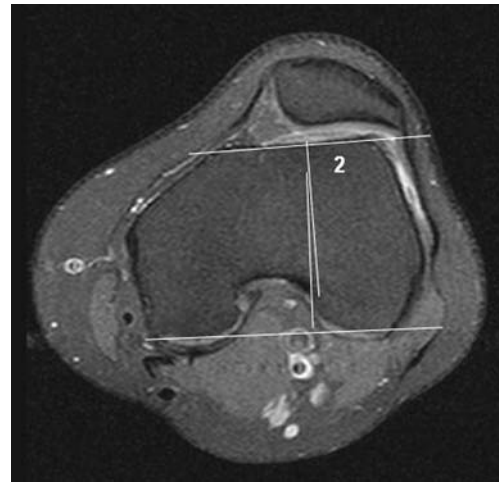
**Table 2** The frequencies of trochlear dysplasia in AKP and control groups and distribution according to sex

	Female	Male	Total
AKP group ( <i>n</i> = 109)	12	6	18 (16.5 %)
Control group ( <i>n</i> = 74)	2	0	2 (2.7 %)

within groups as well. Student’s *t* test revealed a significantly lower average LTI rate in AKP group than that of control group ( $P < 0.05$ ) (study group, average LTI: 17.32°; control group, average LTI: 21.5°) (Fig. 2). Overall, average LTI for 183 knees was 19° (range, 2°–33°; SD, 6.5) (Table 1). Carrillon et al. [9] described trochlear dysplasia as the condition of knees with  $LTI \leq 11^\circ$  in cases of patellar instability. In the present study, we found trochlear dysplasia in 18 (16.5%) knees (LTI: range, 2°–11°; average, 8.9°) belonging to AKP group and 2 (2.7%) knees in control group (Table 2). Trochlear dysplasia incidence was significantly higher in AKP group ( $P < 0.05$ ) (Fig. 3). No case showing a LTI angle of 0° or negative value, was found in the groups.

## Discussion

Trochlear dysplasia has been often shown in knee radiographs of cases exhibiting instability complaint due to recurrent patellar dislocation or subluxation [4, 5, 18]. Dejour et al. [4] described “crossing sign” which is seen on 96% of whole lateral knee radiographs, and specific for trochlear dysplasia in cases with patellar instability. Patients with patellar instability commonly present with AKP complaint; presence of dislocation or a trauma in the history, may facilitate establishing a diagnosis. However, it is not easy to recognize knees with patellar instability which do not have a dislocation or subluxation history, and present with absence of trauma [2, 14, 15, 20]. Dejour [4], in his study, reported a 18% positive rate for this finding in AKP cases. In order to identify the “crossing sign” on radiographs, knee should be given a true lateral position

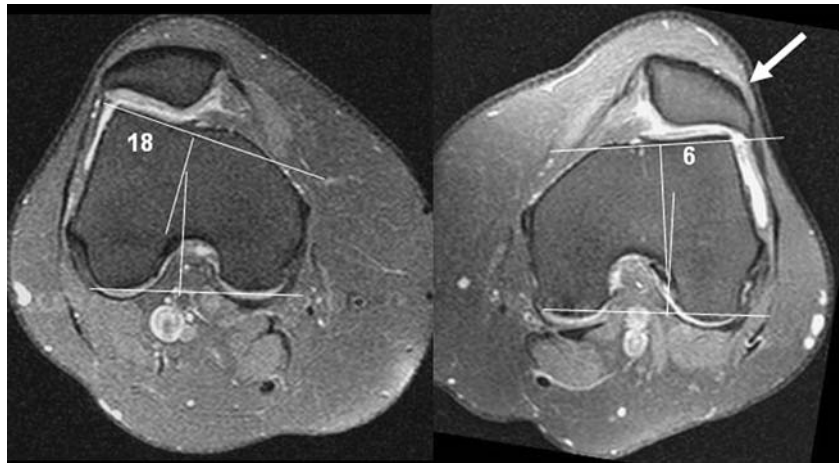
**Fig. 3** In axial MR section of 22-year-old male patient with AKP LTI was 2°. The lateral trochlear facet is almost at the same level with the medial facet which represents severe trochlear dysplasia

along with fluoroscopy. Moreover, classification of the trochlear dysplasia on radiographs to determine the severity level, was shown to be a difficult issue [3, 21]. During whole lateral knee radiography, even a 5° rotation mistake has been reported to cause false positive or negative values for trochlear dysplasia [16]. Because the dysplastic area on the trochlea is commonly localized at the anterior or proximal aspects, this dysplastic area may not be seen on tangential patellar radiographs taken at 30° or lower flexion [5]. Because patella is reduced to trochlear groove while knee is above 30° flexion, tangential patellar radiographs may lead to false negative results in patellofemoral alignment disorders [17, 24]. In conclusion, it is hard to discern trochlear dysplasia on direct knee radiographs.

Carrillon et al. [2] found a significant difference regarding LTI angles between the two populations in their study carried out on MRIs of 30 patients with patellar instability and 30 control subjects. In the present study, average LTI value was 6.17° (SD, 4.76) for cases with patellar instability (PI) and 16.93° (SD, 4.76) for the control group. They took LTI threshold value as 11° in cases with patellar instability; accordingly in the present study, a LTI value below 11° was regarded to be suggestive of trochlear dysplasia and it was believed to be of discriminative value for characterizing patellar instability from other pathologies. Advanced instability forms exhibited 0° and negative values of LTI. Authors suggested investigation of LTI values, particularly for subclinic forms presenting without patellar instability findings.

The subclinic form of patellar instability reported by Carrillon et al. [2] may be a case of AKP, resistant to conservative therapy, without any patellar dislocation or subluxation. In the present study, in order to represent this

**Fig. 4** The bilateral axial scan of knees in a 30-year-old female patient who had AKP of left knee; left LTI, 6° and right LTI, 18°. *Arrow* shows the association of the trochlear dysplasia with patellar tilt



group, we included patients below 40 years of age who were being followed-up for AKP. The fact that approximately 75% of cases with anterior knee pain had lower average LTI rates than those of controls, confirmed this hypothesis. Furthermore, we determined the presence of trochlear dysplasia rate among AKP group as 16.5%, which was a remarkable value. McNally et al. [19], investigated dynamic and static knee MRIs of 474 cases due to AKP, resistant to conservative treatment. The dynamic MRI revealed patellar subluxation or tilt results suggestive of extensor mechanism malalignment in 40% of cases. However, no information was provided on the presence of trochlear dysplasia. Although our study was not a dynamic one, axial static MRI sections revealed patellar tilt in 14 (77.7%) of the 18 cases with trochlear dysplasia. Patellar tilt was normal in the remaining 4 cases (Fig. 4). However, routine tangential knee radiographs had no signs of patellofemoral malalignment. This result indicates the need for further investigation of cases with patellar tilt, particularly for associated trochlear dysplasia.

The differences in anatomical structure of the trochlear groove in cases with patellofemoral instability were shown to be short, wide, and low lateral condyle and reduced height of trochlear groove [4, 5, 13]. The unsuccessful results of surgical procedures such as lateral retinacular release, proximal and distal soft tissue repair, and tuberositas tibia transfer, applied to correct the patellofemoral malalignment, were believed to occur due to presence of an advanced dysplasia, particularly in the extensor mechanism [1, 11]. An *in vitro* biomechanical study investigating the influences of trochlear dysplasia over patellofemoral stability showed lateral trochlear facet inclination as a very important factor among other structures stabilizing the patella [23]. Recently, surgical treatment of cases with trochlear dysplasia carried out by trochleoplasty methods which reduce the height of the groove, increase the lateral trochlear height and provide a patellofemoral conformity, has given rise to successful results [6, 10, 22, 25].

In the present study, since we could not take lateral knee radiographs conforming with the described criteria, we were not able to evaluate the “crossing sign” adequately. Computed tomography (CT) scans have been used for measuring lateral trochlear inclination [10]. However, when possible etiologic factors of anterior knee pain is the concern, MRI seems to be more useful than CT to make specific diagnoses. Detailed CT evaluation of the knee on the other hand subjects the patient to high doses of ionizing radiation. We preferred to use MRI, which is a costly method, for differential diagnosis of chronic AKP cases. In conclusion, incidence of trochlear dysplasia on MRI axial sections was found to be as high as 16.5%.

For differential diagnosis of AKP cases with unknown origin or patellofemoral malalignment, trochlear dysplasia may be revealed by examining the lateral patellar inclination angle particularly on appropriate axial knee MRI sections.

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