Coexistence of Trochlear Dysplasia and Anterior Cruciate Ligament Mucoid Degeneration and Relationship Between Dysplasia Degree and Mucoid Degeneration

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Purpose: Trochlear dysplasia (TD) is a developmental condition and classified in to four types by Dejour. Patients with TD are more likely to have anterior cruciate ligament (ACL) injury. Increased ACL loading caused by TD may result in ACL-mucoid degeneration (MD). The purpose of this study was to evaluate the presence of ACL-MD in patients with TD and investigate whether there was a correlation between ACL-MD and TD grade and tibial tuberosity-trochlear groove (TT-TG) distance.

Materials and Methods: Knee MR examinations of one hundred five patients with TD were included in this study. TD was graded according to Dejour (type A, B, C, and D), and Lippacher classification (low and high grade). TT-TG distance was also measured (15 mm considered as normal). Then ACL was assessed on MRI sequences for MD. Criteria for ACL-MD were thickened ACL with increased signal intensity on all MR sequences.

Results: Among 105 patients with TD, 35 patients (33,3%) had ACL-MD. One-half of the ACL-MD was noted in knees with type A TD (50,0%). According to Lippacher classification, one half of the patients with low-grade dyspslasia had ACL-MD (50,0%). There was also a positive correlation between ACL-MD and TT-TG distance.

Conclusion: TD and patellar instability are significant risk factors for ACL-MD. Due to the high prevelance of ACL-MD with TD we advised the preoperative evaluation of ACL with knee MRI.

Key Words: ACL; Mucoid degeneration; Knee; MRI.

INTRODUCTION

The trochlear groove forms the femoral articular part of the patellofemoral joint (PFJ). The depth and morphology of trochlea affects patellofemoral joint stability during flexion and extension (1–3). Trochlear dysplasia (TD) is a developmental condition in which the distal femur loses its normal concave shape and it is characterized by abnormal trochlear morphology and shallow groove (4). TD was well evaluated and classified into four distinctive types by Dejour (5,6).

Acad Radiol 2022; 29:685–688

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https://doi.org/10.1016/j.acra.2020.07.007

Patients with TD are more likely to have anterior cruciate ligament (ACL) injury (1,2,7). ACL injury may be a potential cause of knee pain and dysfunction before and after TD operation. (7–10). ACL mucoid degeneration (ACL-MD) may be an important cause of knee pain especially in patients who were operated for TD. Arthroscopic evaluation of the ACL during TD operation is not routinely performed in daily orthopedic practice and ACL-MD may not be detected by physical examination. Regarding increased prevalence of ACL injury in patients with TD, clinicians should carefully evaluate ACL before TD operation.

The purpose of this study was to evaluate the presence of ACL- MD in patients with TD and investigate whether there was a correlation between ACL-MD and TD grade and tibial tuberosity-trochlear groove (TT-TG) distance. We hypothesized that ACL-MD are more frequent in patients with TD than normal population.

MATERIALS AND METHODS

The institutional review board approved this retrospective study and waived the requirement for informed consent. One radiologist with 15 years of general radiology experience reviewed the consecutive 1440 knee MR examinations performed at our institution between March 2016 and August 2019. Among them, he identified 125 patients with TD. Postoperative knee MR examinations, presence of partial or total rupture of ACL, presence of previous history of acute trauma, history of rheumatoid arthritis and other rheumatologic diseases, and insufficient MR examinations were excluded. After excluding these cases, 105 patients with TD (56 male and 49 female patients; mean age of 33 years (range, 20−55 years) were included in this study. These MR examinations were evaluated by one musculoskeletal radiologist with 5 years of musculoskeletal radiology experience for grading of TD. TD was graded according to Dejour classification (Dejour type A, B, C, and D) and two-group grading system as the proposed by Lippacher et al.: low grade dysplasia (Dejour type A) and high grade dysplasia (Dejour types B, C, and D) (6−11). Dejour's criteria for TD on axial CT/MRI scans are as follows Type A: fairly shallow trochlea, Type B: flat or convex trochlea, Type C: asymmetry of trochlear facets with a hypoplastic medial condyle and Type D: asymmetry of trochlear facets plus vertical join or cliff pattern.

TT-TG distance was also measured. TT-TG distance measured less than 15 mm considered as normal. Then the ACL was assessed in axial, coronal and sagittal planes. Criteria for a normal ACL were a ligament with low signal intensity with intact fibers from origin to insertion on all sequences. Criteria for ACL-MD were thickened ACL with increased signal intensity on all MR sequences. Both anteromedial and posterolateral bundles of the ACL had to be seen as intact from origin to insertion to exclude partial or complete tears.

MRI Protocol

Unenhanced MRI of the knee was performed using a 1.5-T MR unit (Siemens, Avanto, Erlangen, Germany) with a dedicated knee coil a 20- to 26 cm field of view, and a 4-mm section thickness with a 1-mm gap and a 256 × 320 matrix. Sequences used were sagittal T2 turbo spin echo (TR 2,300, TE 82, FA 150), sagittal proton density with fat saturation (TR 2140, TE 41, FA 150), coronal proton density with fat saturation(TR 2450, TE 41, FA 150), axial proton density with fat saturation (TR 3330, TE 47, FA 150), and sagittal T1 spin echo (TR 307, TE 22, FA 150).

Statistical Analysis

All statistical analyses were performed using IBM SPSS 20.0 (Armonk, NY, IBM corp.). In statistical analysis, Chi-squared test (χ^2) test was used to compare the distribution of categorical data relative to each other. A p value <0.05 was considered statistically significant

RESULTS

Among 105 patients with TD, 35 patients had ACL-MD (Fig 1). One-half of the ACL-MD was noted in knees with type A TD. Most of the normal ACL was present in knees with type A, B, C, and D TD, especially in type C TD (Table 1) (Fig 2).

According to Lippacher classification, one half of the patients with low grade dysplasia had ACL-MD, whereas approximately three quarters of the patients with high grade dysplasia had normal ACL (Table 2) (p value 0.016). There was a positive correlation between ACL-MD and TT-TG distance. While TT-TG distance was increased, the rate of ACL mucoid was also increased (Table 3).

DISCUSSION

The present study showed increased prevalence (33.3 %) of ACL-MD in patients with TD when compared to the incidence of ACL-MD in the general population reported in the literature. The incidence of ACL-MD ranges from 1.8% to 9.2% in literature (10,12,13). We hypothesized that TD and

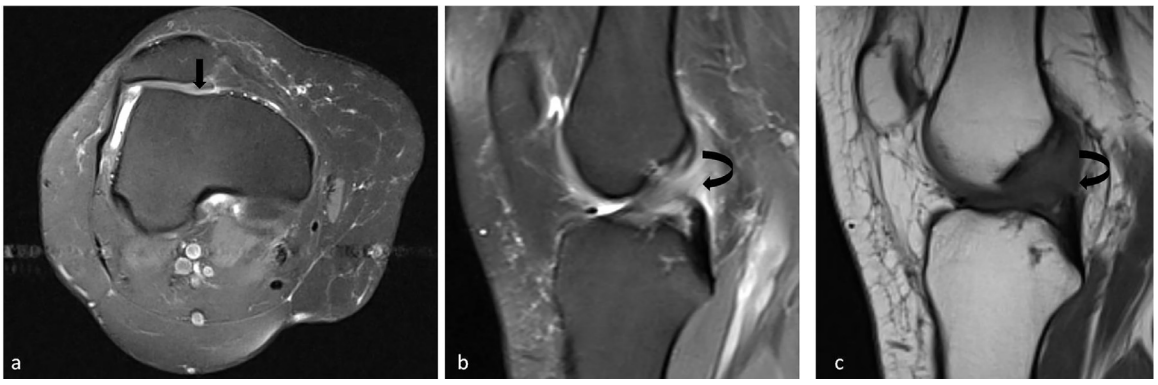

Figure 1. Type A Femoral trochlear dysplasia in 42 year-old-women. (a) axial proton density weighted MRI at 3 cm above the femorotibial joint space. The trochlear groove is shallow (thick arrow). (b) sagittal proton density MRI with fat saturation and **c** sagittal T1 spin echo MRI showing mucoid degeneration of the anterior cruciate ligament (curved arrows).

TABLE 1. Inferences of Distribution Between Mucoid Degeneration of Anterior Cruciate Ligament and Trochlear Dysplasia According to Dejour Classification (Dejour type A, B, C, and D)

ACL MUCOID DEGENERATION	Trochlear Dysplasia Type A	Trochlear Dysplasia Type B	Trochlear Dysplasia Type C	Trochlear Dysplasia Type D	TOTAL
ACL MUCOID DEGENERATION (+)	16 (50%)	9 (29,0%)	9 (23,1%)	1 (33,3%)	35 (33,3%)
ACL MUCOID DEGENERATION (-)	16 (50%)	22 (71,0%)	30 (76,9%)	2 (66,7%)	70 (66,7%)
TOTAL	32 (100%)	31 (100%)	39 (100%)	3 (100%)	105 (100%)

ACL, anterior cruciate ligament.
$\chi 2 = 6{,}10$ p 0.107.

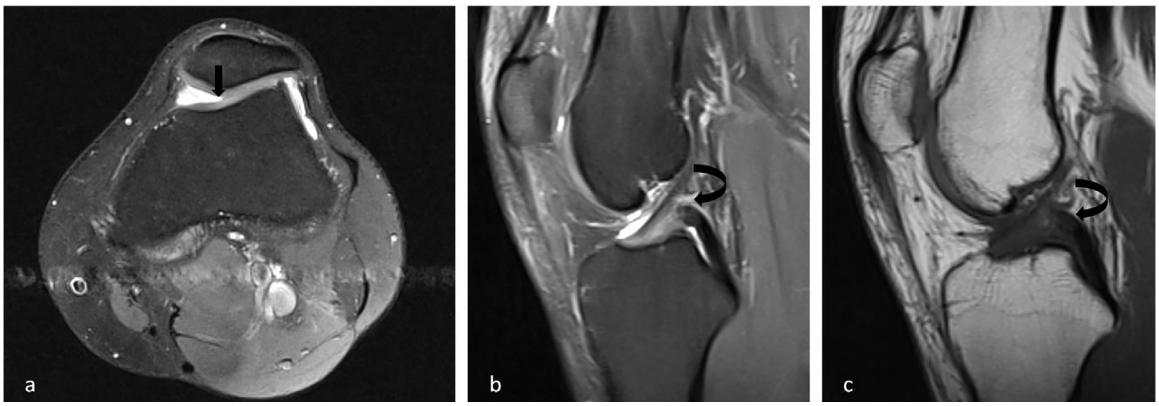

Figure 2. Type A Femoral trochlear dysplasia in 32 year-old- man. (a) axial proton density weighted MRI at 3 cm above the femorotibial joint space and trochlear groove is shallow (thick arrow). (b) sagittal proton density MRI with fat saturationand **c** sagittal T1 spin echo MRI showing normal anterior cruciate ligament (curved arrows).

TABLE 2. Inferences of Distribution Between Mucoid Degeneration of Anterior Cruciate Ligament and Trochlear Dysplasia Classified by Lippacher (Low Grade: Dejour Type A, High Grade: Dejour Type B, C ,and D)

ACL MUCOID DEGENERATION	Trochlear Dysplasia Low Grade	Trochlear Dysplasia High Grade	TOTAL
ACL MUCOID DEGENERATION (+)	16 (50,0%)	19 (26,0%)	35 (33,3%)
ACL MUCOID DEGENERATION (-)	16 (50,0%)	54 (74,0%)	70 (66,7%)
TOTAL	32 (100%)	73 (100%)	105 (100%)

ACL, anterior cruciate ligament.
$\chi 2 = 5{,}75$ p value 0.016.

TABLE 3. Inferences of Distribution Between Mucoid Degeneration of Anterior Cruciate Ligament and TT-TG Distance

ACL MUCOID DEGENERATION	TT-TG Distance< 15 mm	TT-TG Distance15-20 mm	TT-TG Distance>20 mm	TOTAL
ACL MUCOID DEGENERATION (+)	15 (28,3%)	17 (37,0%)	3 (50,0%)	35 (33,3%)
ACL MUCOID DEGENERATION (-)	38 (71,7%)	29 (63,0%)	3 (50,0%)	70 (66,7%)
TOTAL	53 (100%)	46 (100%)	6 (100%)	105 (100%)

ACL, anterior cruciate ligament; TG, trochlear Groove; TT, tibial tubersity.
$\chi 2 = 1{,}62$ p value 0.444.

patellar instability were significant risk factors for ACL-MD. The pathogenesis of ACL-MD remains unclear. One theory suggests that repetitive activities may lead to traumatic disruption of ligament fibers with inadequate repair. This is followed by organization of these fibers into mucoid material. Another theory suggests that ACL-MD is the continuation of mucinous degenerative changes of connective tissue in the knee joint (8–14).

A normal trochlear groove is essential for the normal extensor mechanism function of the knee. In cases with TD as in our patients, increased ACL loading may occur secondary to malfunctioning extensor mechanism caused by shallow trochlear

groove and patellofemoral maltracking (2,3,15). We suggested that this increased ACL load may result in ACL-MD.

Botchu et al. reported that most of the ACL injuries (rupture) were present in knees with the Dejour type A (3). In our study, most of the ACL-MD were noted in knees with the Dejour type A and low grade dysplasia. Botchu et al. thought that the increased incidence of ACL injury in type-A trochlear dysplastic knees was likely to be biomechanical. We also hypothesized that the same mechanism may play a role which results in increased incidence of ACL-MD in type-A trochlear dysplastic knees. Further studies are required to verify this theory.

Ntagiopulos et al. found increased prevalence of TD and patellar instability in patients with ACL injury (7). They considered this increased prevalence as an intrinsic factor. We hypothesized that whatever the type of ACL injury (rupture or MD), the intrinsic cause of injury can be TD.

In patients with ACL-MD, the most commonly associated symptoms were knee pain and limitation of terminal flexion (9). ACL-MD may be an important cause of knee pain especially in patients were operated for TD. This postoperative knee pain caused by ACL-MD may prevent appropriate physical rehabilitation after operation. Arthroscopic evaluation of ACL during TD operation is not routinely performed in daily orthopedic practice. The preoperative evaluation of ACL with knee MRI with attention to the presence of ACL-MD should be advised in patients with TD.

Our study has several limitations. First, there was no control group but we compared our results with previously published data in literature. Second, we had no arthroscopic and/or surgical confirmation of ACL-MD. Third, TD was analyzed with two grading systems (commonly used Dejour grading system) and (two-group grading system introduced by Lippatcher et al.). Fourth, the sample size of type D TD was small.

In conclusion, this study demonstrates that increased prevalence (33, 3%) of ACL-MD in patients with TD. Our results confirmed that TD and patellar instability are significant risk factors for ACL-MD which may be an important cause of postoperative knee pain especially in patients who operated for TD. Due to the high prevalence of ACL-MD with TD, we advised that the preoperative evaluation of ACL with MRI which would be important for patient clinical outcome.

ETHICS COMMITTEE APPROVAL

Etthics committee approval was received for this study from the Ethics Committee of the Bezmialem Foundation University Hospital, Istanbul, Turkey (21/388).

AUTHOR CONTRIBUTIONS

G.T.Y and H.T. conceived of the presented idea.G.T.Y. developed the theory and performed the computations. G.T.Y and H.T. verified the analytical methods. H.T. wrote the manuscript with support from G.T.Y.All authors discussed the results and contributed to the final manuscript.

FINANCIAL DISCLOSURE

The authors declared that this study has received no financial support.

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