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The anterolateral ligament and the deep structures of the iliotibial tract: MRI visibility in the paediatric patient

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ABSTRACT

Purpose: To assess the visibility of both the anterolateral ligament (ALL) and the deep structures of the iliotibial tract (ITT) by means of MRI in paediatric patients. To determine reproducibility for such measurements.
Methods: Knee MRI data from patients aged <18a without lesions of the capsule or ligaments, fractures, bone edemas, foreign material or motion artifacts were analyzed by two musculoskeletal radiologists separately and twice. The visibility of the different parts of the ALL was determined (femoral, meniscal, tibial parts). Similarly, the visibility of the different parts of the deep ITT was determined: deep attachments of the ITT to the distal femur (insertion near septum, supracondylar insertion and retrograde insertion) and capsulo-osseous layer of the ITT.
Results: We studied 61 cases (36 female, 25 male). Age was 15 years (±2.3). Interobserver agreement was high. Cohen's Kappa was 0.864 (95%CI: 0.715–1.000) for the tibial part of the ALL and 1.0 for the femoral part of the ALL. For the deep attachments of the ITT to the distal femur Kappa was 0.828 (95%CI: 0.685–0.971). Regarding intraobserver agreement, Cohen's Kappa was 1.0 for the femoral part of the ALL and 0.955 (95%CI: 0.867–1.000) for the tibial part of the ALL. For the deep attachments of the ITT to the distal femur Cohen's Kappa was 0.896 (95%CI: 0.782–1.000).
Conclusion: On the basis of our findings it is concluded that the presence of the anterolateral structures of the knee can be determined by MRI in a pediatric population with substantial inter- and intraobserver agreement. This is true for both the ALL and the deep structures of the ITT.
Level of evidence: Diagnostic study – Level 3.

Introduction

Since 2013 there has been a surge in interest in the anterolateral extra-articular soft tissues of the knee. In particular, the anterolateral ligament (ALL) was popularized [3]. This triggered several investigations into ALL traceability during cadaver dissection [3,4,7,24,26,27,31], the stabilizing function of the ALL [15,22,24,28,30] and the visibility of the ALL via magnetic resonance imaging (MRI) [2,10,32]. The latter studies dealt either with visibility of the ALL in the healthy knee or with concomitant ALL injury in the setting of anterior cruciate ligament ruptures or both. However, the above-mentioned studies did not particularly focus on paediatric orthopaedic patients although this is a special field, e.g. in ligament reconstruction procedures.

Another shortfall of the current scientific knowledge is as follows. Some doubted the relevance of the ALL for anterolateral knee stability [14] and emphasized the role of the deep portions of the iliotibial tract (deep attachments of the ITT to the distal femur, capsulo-osseus layer of the ITT). Those studies were published much earlier [13,19,23,33]. There is on-going controversy about whether the ALL or the deep ITT structures play a key role in anterolateral knee stability. However, previous research investigated only the visibility of the ALL by means of MRI (between 51% and 98%) [2,10,32], while no such investigations were performed for the deep structures of the ITT.

Due to the above-mentioned deficits in current scientific knowledge, this study aimed to investigate MRI visibility of the anterolateral structures of the knee (both ALL and deep ITT) in the paediatric setting. It was hypothesized that Cohen's Kappa

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values for intra- and interobserver reproducibility would be seen to be above 0.70, indicating substantial agreement between the ratings [18].

Patients and methods

After obtaining the approval of the ethics committee of the medical university the following retrospective analysis was performed. MRI data sets in the PACS were accepted from patients aged <18 years. Excluded were cases with lesions of the capsule, ligaments, fractures, bone edemas/contusions, foreign material or motion artefacts. Also excluded were cases with MRI protocols other than the following.

Patients were examined in supine position using a dedicated 15-channel knee coil. The following sequences were used for our 1.5 T/3.0 T Scanner (Avanto/Skyra, Siemens, Erlangen, Germany): coronal T1-weighted images (TE 10/13, TR 696/522, SL 3 mm); coronal PD-weighted images with fat saturation (TE 40/38, TR 4100/3230, SL 3 mm); sagittal PD-weighted images with fat saturation (TE 39/38, TR 3000/3710, SL 3 mm) and axial PD-weighted images with fat saturation (TE 31/37, TR 3010/3100, SL 3.5/3 mm).

Two musculoskeletal radiologists (HB, KC) with dedicated MRI experience performed picture analysis with always the same software (Impax EE, Agfa Health Care N.V., Mortsel, Belgium). Before commencing the picture analysis part of the study the two radiologists were instructed in personal cadaver dissection by a specialist in that field (KC). The ALL and the deep structures of the ITT were dissected.

All below-mentioned analyses were done separately by each observer. To also allow calculation of intra-observer agreement, each observer performed the analyses twice (>2 weeks interval).

To determine visibility of the ALL the analysis was performed similar to previous research [10,32]: We searched for a structure originating from around the lateral femoral epicondyle, running anterodistal (with facultative fibers to the lateral meniscus; bifurcation point) and inserting on the anterolateral tibia (laterally passing the lateral inferior geniculate vessels). Three parts of the ALL were defined and their presence assessed on a yes/no basis: a) femoral part, b) meniscal part, c) tibial part of the ALL (Figs. 1 and 2). The investigators assessed the ALL as present only when clearly seen on both axial and coronal sequences under direct cross-referencing of images.

The deep attachments of the ITT at the distal femur (Kaplan fibers) were assessed on a 'yes/no' basis (Fig. 3). In addition, it was intended to also distinguish between the three sub-structures (insertion near septum, supracondylar insertion and retrograde insertion) [13,19]. The presence of the capsulo-osseous layer of the ITT was also assessed on a 'yes/no' basis (deep fibers starting from the area of the Kaplan fibers and running to the anterolateral tibia, midway between Gerdy's tubercle and the fibular head [13,19,23,33].

A consensus meeting of the two radiologists was conducted to revise discrepant findings. Descriptive statistics for visibility of the above-mentioned structures are given for the consensus rating. Cohen's Kappa and 95% confidence intervals (95% CI) were determined as a measure of inter- and intra-observer reproducibility. A value of 0.70 for Cohen's Kappa was taken as the threshold for substantial reproducibility [18]. Sample size considerations are based on power analysis for a Pearson correlation as an approximation for Cohen's Kappa coefficient. Power analysis for Cohen's Kappa was not available in common power analysis software packages. An observed correlation coefficient of 0.831 in a sample of 60 cases was sufficient to demonstrate exceedance of the

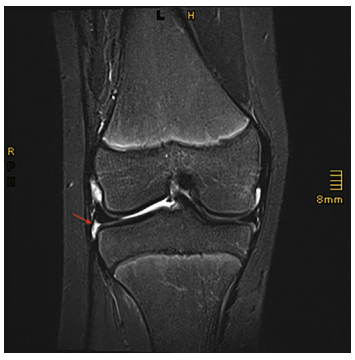

Fig. 1. Frontal plane view of the *tibial* part of the anterolateral ligament of an 11-year old female participant.

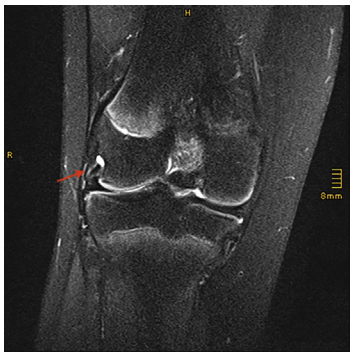

Fig. 2. Frontal plane view of the *femoral* part of the anterolateral ligament of an 12-year old female participant.

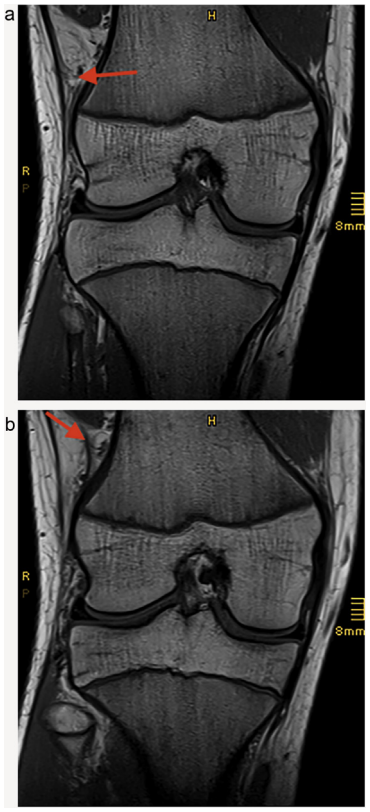

Fig. 3. a + b. Frontal plane views of the deep attachments of the ITT to the distal femur in a 14-year old male participant.

0.70 threshold with alpha = 0.05 and beta = 0.20 (one-sided). Power analysis was done with G*Power 3.1.9.2.

Results

Our study population consisted of 61 cases (36 female, 25 male). Age was 15 years (±2.3). In 72.1% of the cases the femoral part of the ALL was visible in the MRI. Visibility of the meniscal part and the tibial part of the ALL was 0% and 78.7%, respectively. The deep connections of the ITT to the distal femur were detected in 62.3% of the cases. However, it was not possible to further distinguish these fibers as 'insertion near septum', 'supracondylar insertion' or 'retrograde insertion' in any of the patients. Visibility of the capsulo-osseous layer of the ITT was 0%.

Interobserver agreement was high. Cohen's Kappa was 0.864 (95%CI: 0.715–1.000) for the tibial part of the ALL and 1.0 for the femoral part of the ALL. As stated above, in none of the patients were either of the two observers able to detect the meniscal part of the ALL (100% absolute agreement) and therefore it was not possible to calculate Cohen's Kappa for that variable. For the deep attachments of the ITT to the distal femur Kappa was 0.828 (95%CI: 0.685–0.971). As the capsulo-osseous layer of the ITT was not visible for either observer in 100% of the cases, it was also not possible to calculate Cohen's Kappa for that parameter. For each of the investigated parameters absolute agreement between the observers was at least 90% (Table 1).

Regarding intraobserver agreement, Cohen's Kappa was 1.0 for the femoral part of the ALL, 0.955 (95%CI: 0.867–1.000) for the tibial part of the ALL and not quantifiable for the meniscal ALL part (as a result of 100% invisible cases). For the deep attachments of the ITT to the distal femur Cohen's Kappa was 0.896 (95%CI: 0.782–1.000). As the capsulo-osseous layer of the ITT was not visible in 100% of the cases, it was also not possible to calculate Cohen's Kappa for that parameter. For each of the investigated parameters absolute agreement between the two time points was at least 95% (Table 1).

Discussion

The most important findings made in this study were that the incidence of the anterolateral structures of the knee in a pediatric population (ALL, deep structures of the ITT) were able to be assessed with high inter- and intraobserver agreement by means of MRI. Inter- and intraobserver agreement was above 90% and 95%, respectively (Kappa values 0.828–1.0 and 0.896–1.0, respectively). We therefore consider this to be confirmation of our hypothesis concerning substantial agreement.

Several previous studies have dealt with MRI visibility of the ALL so far (Table 2) [5,8–10,16,17,20,25,32]. However, all those studies reported on adult populations with mean ages between 28.71 and 45.3 years. To our best knowledge no previous studies have investigated the visibility of the ALL in the young, although this is a very special area in the clinical and scientific fields of ligament reconstruction procedures (e.g. ACL). In the absence of studies reporting MRI visibility of the ALL in pediatric patients the above-mentioned studies of MRI visibility in adults were analysed. It appears that only three of the nine studies reported interobserver reproducibility [9,10,32]. They reported Kappa values between 0.7 and 1.00. Surprisingly, only one of the above-mentioned studies reported intraobserver reproducibility (between 0.77 and 0.93) [9]. These values are in good congruence with our findings on reproducibility. We also attempted to compare our descriptive values for incidence of the different parts of the ALL with the findings of the above-mentioned studies. However, only three previous studies differentiated between the different parts of the ALL [8,10,20]. Our visibility of the femoral part of the ALL in 72.1% and the tibial part in 78.7% was well consistent with previous studies. However, incongruence still prevails with regard to the meniscal part of the ALL that was detected much more often in the above-mentioned three studies among adults. The reason for this discrepancy remains unclear.

When it comes to MRI visibility of the deep structures of the ITT, it would seem that no previous researchers investigated that issue, not in adult or pediatric patients. This is somewhat surprising because these structures were described from an anatomic and biomechanical point of view many years ago and were considered important for anterolateral knee stability [13,19,23,33]. As mentioned above, we determined high agreement also for MRI visibility of the deep structures of the ITT. The deep attachments of the ITT to the distal femur were detected in 62.3% of the cases. Unfortunately, it was not possible to further distinguish these fibers as 'insertion near septum', 'supracondylar insertion' or 'retrograde insertion', as introduced by Lobenhoffer [19].

The following limitations of the study are acknowledged. This was a retrospective study with the weaknesses typically associated with such studies. Although we excluded patients with lesions of the capsule, ligaments, fractures, bone edemas etc. (see above), it would have been even better to include subjects with no knee complaints whatsoever. The subjects included in our retrospective analysis were well free of the above-mentioned lesions, but must have had some knee complaints or they would not have undergone MRI.

Strengths of our study are as follows: 1) for the first time MRI visibility of the ALL was assessed in the young, 2) for the first time MRI visibility was also assessed for the deep structures of the ITT (in the young), 3) inter- and intraobserver reproducibility were determined (neglected by most previous studies in adults). In synopsis, authors feel that the study at hand substantially expands current scientific knowledge in the high-turnover research field of anterolateral knee stability.

The findings are considered to be of high clinical relevance. This is because injuries of the anterolateral structures often accompany

Table 1
Inter- and intraobserver reproducibility results for the different parts of the ALL (femoral, meniscal, tibial) and the deep ITT structures (deep attachments of the ITT to the distal femur, capsulo-osseous layer of the ITT).

Cohen's Kappa Rater Agreement	Interobserver		Intraobserver (pooled ratings)	
	Kappa (95% CI)	Absolute Agreement	Kappa	Absolute Agreement
ALL femoral	1	100%	1	100%
ALL meniscal	not calculated	100%	not calculated	100%
ALL tibial	0.864 (0.715–1.000)	95.1%	0.955 (0.867–1.000)	98.4%
deep attachments of the ITT to the distal femur	0.828 (0.685–0.971)	91.8%	0.896 (0.782–1.000)	95.1%
capsulo-osseous layer ITT	not calculated	100%	not calculated	100%

95%CI: 95% confidence interval.

Table 2
Previous publications investigating ALL visibility by means of MRI. Previous studies investigated exclusively adult patient populations, as can be seen from the mean age values.

author	year	age	n	ALL visibility	reproducibility
gossner	2014	38.9	30 randomly picked	73.3%, no distinction between different ALL parts	
helito	2014	not reported	39 healthy	femoral ALL: 89.7% meniscal ALL: 94.8% tibial ALL: 79.4%	inter-observer kappa: 0.843–1.000
taneja	2015	40	70 randomly picked	51% (40% partly, 11% completely)	inter-observer kappa: 0.7
porrino	2015	range: 18-59 (mean not reported)	53 healthy	100%, no distinction between different ALL parts	
kosy	2015	45.3y	100 healthy	completely: 57%, partly: 94%	
helito	2015	32.5	33 healthy	femoral ALL:69.6% meniscal ALL: 75.7% tibial ALL: 39.3%	
macchi	2016	37.5y	50 healthy	femoral ALL: 80% meniscal ALL 66% tibial ALL: 80%	
klontzas	2016	28.71	26 healthy	92.3%	
helito	2015	n/a	13 cadavers	100%	intraobserver r: 0.77–0.93 interobserver r: 0.85–0.90

ALL: Anterolateral Ligament.
n: number of participants.

ACL ruptures and because the question whether and how the anterolateral structures should be addressed at the time of ACL reconstruction [1,12,21,29] is currently the subject of debate in the literature. Moreover, knowing how the anterolateral structures appear in MRI of a healthy knee is the basis for assessing injuries of those structures by MRI. Previous research dealt with the issue of ALL co-injury rates in patients with ACL rupture, but again only in adult patients [2,6,11]. Moreover, those studies neglected the deep structures of the ITT that also play a key role in anterolateral knee stability.

Conclusions

On the basis of our findings we conclude that the presence of the anterolateral structures of the knee can be determined by MRI in the pediatric population with substantial inter- and intra-observer agreement. This holds for both the ALL and the deep structures of the ITT.

Conflict of interest statement

There were no financial or personal relationships present which could have lead to a conflict of interests.

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