Acute rotational trauma to the knee: poor agreement between clinical assessment and magnetic resonance imaging findings.

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Acute rotational trauma to the knee – poor agreement between clinical assessment and MRI findings

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Abstract

Objectives: To determine the incidence of anterior cruciate ligament (ACL) injuries in the general population; the pathology associated with a knee sprain verified by magnetic resonance imaging (MRI); and the agreement between clinical findings and MRI.

Material & Methods: Inclusion criterion was an acute rotational trauma to the knee associated with effusion. 159 consecutive patients, mean age 27 years and 36% women, were included after clinical assessment at the orthopedic emergency unit. Patients were referred to an MRI examination (1.0 or 1.5T) performed within a median of 8 days of the initial visit.

Results: The annual incidence of MRI verified ACL injuries was 0.81 per 1000 inhabitants aged 10-64 years. 56% (n=89) of those included had sustained an ACL injury of whom 38% had an associated medial meniscus tear. There was a poor agreement between initial clinical antero-posterior laxity and MRI verified presence of an ACL tear (kappa 0.281). Every second patellar dislocation was diagnosed as a ligament injury.

Conclusion: Our findings indicate that the incidence of ACL injuries is higher than previously described. We also show that the first clinical examination after an acute knee trauma has a low diagnostic value. Further assessment with MRI improves the chances of a correct diagnosis of intra-articular pathology and is recommended in the early phase after a rotational knee trauma.

Keywords

- Adolescent

- Adult

- Anterior cruciate ligament

- Clinical trial

- Humans

- Knee joint

- Magnetic resonance imaging

- Prospective studies

Introduction

The incidence of ACL injuries is reported to be 0.91 per 1000 game hours and year in competitive handball and 18 ACL injuries per 1000 soccer players occur annually (Myklebust, Maehlum, Holm, Bahr 1998; Roos, Ornell, Gärdsell, Lohmander, Lindstrand 1995). There is a gender difference as the incidence of ACL injuries is reported to be 3-4 times higher among women soccer players (Engström, Johansson, Tornkvist 1991; Arendt & Dick 1995; Roos et al. 1995). Reports on the incidence of ACL injuries in the general population are rare. To our knowledge, only one study is available, reporting an annual incidence of 0.3 ACL injuries per 1000 inhabitants in Denmark (Nielsen & Yde 1991).

Knee injuries represent roughly 6% of all acute injuries treated at an emergency department and between 27-48% have been reported to be sports related (Kannus & Jarvinen 1989; Nielsen & Yde 1991; Yawn, Amadio, Harmsen, Hill, Ilstrup, Gabriel 2000; Ansari, Ahee, Iqbal, Swarup 2004). Previous studies have advocated that hemarthrosis of the knee in combination with a rotational trauma indicates a severe ligamentous injury, even when instability is not obviously present at the initial clinical examination (Gillquist, Hagberg, Oretorp 1977; DeHaven 1980; Visuri, Koskenvuo, Dahlstrom 1993; Sarimo, Rantanen, Heikkila, Helltula, Hiltunen, Orava 2002; DeHaven 1980; Noyes, Basett, Grood, Butler 1980; Butler & Andrews 1988; Harilainen, Myllynen, Antila, Seitsalo 1988; Sarimo et al. 2002).

Magnetic resonance imaging (MRI) has made it possible to visualize the knee joint and its ligaments non-invasively. Arthroscopy is still considered to be gold standard and some authors have reported arthroscopy to be superior to MRI for diagnostic use in acute knee injuries (Lundberg, Odensten, Thuomas, Messner 1996; Smith 1996). Conversely, several studies suggested that MRI is as accurate as arthroscopy in detecting ligament and meniscal lesions in the knee joint (Munshi, Davidsson, MacDonald, Froese, Sutherland 2000; Fritz 2003, Winters & Tregonning 2005). Several reports advocate that an MRI often makes it possible for the orthopedic surgeon to avoid unnecessary surgical procedures (Rangger, Klestil, Kathrein, Inderster, Hamid 1996; Rappeport, Mehta, Wieslander, Lausten, Thomsen 1996; Vincken, ter Braak, van Erkell, de Rooy, Mallens, Post, et al. 2002). The use of MRI in knee injured patients with uncertain diagnosis has been shown to improve patient satisfaction as well as patient management (Mackenzie, Dixon, Keene, Hollingworth, Lomas, Villar 1996; Muellner, Nikolic, Kubiens, Kainberger, Mittleboeck, Vecsei 1999; Munshi et al. 2000; Frihagen, Kvakestad, Melhuus, Engebretsen 2002; Fritz 2003). However, there are few reports on the use of MRI in the acute phase of knee trauma.

Yet, other studies suggest that the clinical assessment of instability, if performed by an experienced orthopedic surgeon, is superior, or at least comparable, to assessment with MRI in detecting ligamentous injury (Adalberth, Roos, Lauren, Akesson, Sloth, Jonsson, et al. 1996; Rose & Gold 1996; Kocabey, Tetik, Isbell, Atay, Johnsson 2004) as well as meniscal injury (Rose & Gold 1996; Kocabey et al. 2004). However, well experienced orthopedic surgeons rarely work at the first level of health care where knee trauma is primarily assessed.

The objectives of this study were to: 1) determine the incidence of ACL tears in the general population, 2) present the injuries associated with acute swelling of the knee joint as a result of a rotational trauma as visualized on a subacute MRI, 3) describe the agreement between initial clinical examination and anatomical lesions as visualized on MRI.

Methods

In 2001 the department of orthopedics at Helsingborg Hospital in Sweden implemented a subacute routine MRI assessment of traumatic knee injuries. Physically active individuals regardless of age, with an acute rotational trauma to the knee combined with a rapid effusion fulfilled the inclusion criteria and were referred to a subacute MRI examination. This procedure replaced the traditional radiographic examination if no fracture was clinically suspected. Yet, several patients included in this trial underwent knee radiography but plain x-rays were not assessed in this study. All patients fulfilling the inclusion criteria for a subacute MRI in 2002 were included in this study. It is possible that a minority of patients with an acute rotational trauma to the knee joint demonstrated a fracture, verified by radiography at their initial visit and/or was operated on in the sub-acute phase due to clinical findings and thus was not referred to sub-acute MRI.

All physicians active at the emergency unit in 2002 were familiar with the routines outlined above and received written information describing the inclusion criteria. Since these new routines were implemented in order to help the clinician in the assessment of knee injuries, we believe that the great majority of patients fulfilling the inclusion criteria at Helsingborg hospital entered this study. However, there may be patients fulfilling the inclusion criteria that were not examined at the hospital but by primary care physicians or private clinics. The patients included in this study are nevertheless suggested to be representative of the population, and to represent a minimum number of patients with rotational knee trauma, rapid knee effusion and/or hemarthrosis in the relevant healthcare region and age group.

Assessment

Medical records were reviewed retrospectively by the same investigator. Previous injuries to the index- or contra-lateral knee, activity at injury and presence of hemarthrosis at the primary visit were registered. The clinical findings at the emergency unit were classified as presence or absence of increased anterior-posterior (A-P) knee laxity as well as varus-valgus laxity. For assessment of the A-P laxity either the Lachmann test and/or the drawer sign was used, the varus-valgus stress test was used for assessment of the varus-valgus instability. If knee pain interfered with the clinical examination the test was classified as "unable to perform test". In case of uncertainty of results, information was reported as non-classified. In this study, the International Classification of Diseases (ICD 10) codes for patellar dislocations (S83.0) and isolated meniscal injuries (S83.2) were used by all clinical examiners at the emergency unit. All physicians at the emergency unit were instructed to perform an arthrocentesis of the swollen knee to verify any hemarthrosis prior to inclusion in the study.

Population at risk

The population at risk in the relevant healthcare region was determined through the National Population Registry, the Statistical Central Bureau (SCB). Those at risk were defined as those who were in the same age group as the ACL injured patients (10-64 years) and lived in the geographic area that was covered by the Helsingborg Hospital in 2002. A population of 110 399 individuals were thus included in this analysis.

MRI

MRI was performed within a median of 8 days (0-109) from the clinical visit and within 13 days (1-160) from the trauma. Onehundred and twenty patients (76%) underwent MRI within 2 weeks of the clinical visit.

The MR images were examined by two experienced radiologists with several years of experience of knee radiographs and knee MRI. The analysis protocol provided information about anatomical lesions, bone marrow edema, effusion, fractures, etc. The MRI findings were classified and collected according to the recommendations published by Khanna, Cosgarea, Mont, Andres, Domb, Evans, et al. (2001). Meniscal tears were divided into: horizontal; longitudinal; dislocated; radial; bucket handle; complex; flap tear (Englund, Roos, Lohmander 2003). Injuries to anterior and posterior cruciate ligaments, medial and lateral collateral ligaments, meniscal lesions as well as patellar dislocation and fractures were considered to be acute traumatic lesions in the analysis.

Throughout the study, two different MRI machines were used. A 1.5 T imager (Gyroscan, Intera, Philips) was used with a circular polarized surface coil. The patients were examined with a T2-weighted turbo spin-echo sequence (tSEPdT2) and a T2-weighted turbo short tau inversion recovery sequence (tSTIRT2) in the coronal and in the sagittal views. The sagittal sequence was perpendicular to a line connecting the dorsal aspects of the femoral condyles and the coronal sequence was parallel to that line. The sequence parameters for the tSEPdT2 were: repetition time/echo time (TR/TE) 3335/15-100 ms with two signals averaged, echo train length 8, field of view (FOV) 170x170 mm, section thickness 3 mm with 0.6 mm intersection gap, matrix size 256x256 and acquisition time 4 min 52 s. The parameters for the tSTIRT2 were: TR/TE 2900/60 ms with two signals averaged, echo train length 4, inversion time (TI) 150 ms, FOV 170x170 mm, section thickness 3 mm, intersection gap 0.6 mm, matrix size 256x256 and acquisition time 4 min 30 s. A proton density- and T2-weighted turbo spin-echo sequence (tSE PdT2) was done sagittally, coronally and axially on a 1.0 T imager (Impact, Siemens) with a circular polarized surface coil. The sagittal sequence was perpendicular to a line connecting the dorsal aspects of the femoral condyles, and the coronal sequence was parallel to that line. The sequence parameters for the tSE PdT2 were: repetition time/echo time (TR/TE) 4200/15-105 ms with two signals averaged, echo train length 7, field of view (FOV) 160x160 mm, section thickness 3 mm with 0.2 mm intersection gap, matrix size 224x256 and acquisition time 4 min 34 s.

The two different radiologists did not report any difficulties in the analysis of anatomical lesions or any other clinically relevant differences between the two MRI machines used in this study.

Statistics

Means and standard deviation (SD) were calculated for all continuous variables. The agreement between clinical instability and ligament rupture as visualized on MRI was calculated as a kappa value for correlation (Altman 1991). Incidence was calculated using the number of ACL injuries seen in this study throughout 2002 divided by the number of individuals in the same age group (10-64 years), living in the recruitment area of Helsingborg Hospital during the same year.

Results

159 consecutive patients with a mean age of 28 years (10.9) were included in this study. 102 were male, mean age 28.5 years (10.7), and 57 females, mean age 26.5 (11.4). The right knee was injured in 52%. Aspiration of joint fluid was performed in 52% of the cases (n=83) and in all of those a verified hemarthrosis was collected. Effusion was noted but not aspirated in 43% (n=68) and in only 5% (n=8) information about swelling was reported as non-classified.

Incidence of ACL injuries

The incidence of ACL injuries was 0.81 per 1 000 inhabitants and year for the age group between 10 and 64 years. Seventyfive percent of the patients included in this study were injured during sports activities, and soccer was the most common activity at injury (Table 1).

MRI findings and associated injuries

MRI revealed an average of 1.6 acute traumatic lesions per investigated knee included in this study. Eightynine patients (56%) had a total or partial ACL injury, 25 patients (16%) had sustained a patellar dislocation, 24 (15%) patients had a fracture and 20 patients (13%) had no anatomical pathologies visualized on MRI (Table 2).

Of the 89 ACL injured knees, 27 (30%) had sustained an isolated ACL injury, not associated with any other ligament or meniscal injury. One of the isolated ACL injuries was combined with a patellar dislocation and five were associated with fractures. The medial collateral ligament (MCL) was seen as an associated injury, regardless of severity, in 27 of the cases (30%) and a corresponding injury to the lateral collateral ligament (LCL) was seen in only three cases. The unhappy triad, involving the ACL, MCL and medial meniscus was found in 9 of the cases (10%). 38 of the ACL injured patients (42%) had at least one injury to the medial meniscus compared to 28% in the lateral meniscus. A longitudinal tear was the most common finding in both menisci (Table 3).

Clinical instability vs. ligament rupture

The physician at the emergency unit assessed the A-P laxity in 79 (90%) of the ACL injured knees, with an agreement between the clinical and MRI findings in 50% of these cases (Figure 1). The kappa value for correlation between clinical A-P laxity and ACL rupture as visualized on MRI was poor (0.281) as was the kappa value for correlation between valgus instability and MCL grade II-III (0.351). Only 3 of the 25 patellar dislocations were clinically suspected at the emergency unit visit. Every second patellar dislocation was clinically diagnosed as a knee ligament injury.

Discussion

This study on acute traumatic knee injuries, using MRI for assessment, showed no major differences regarding type and occurrence of anatomical lesions compared with other studies using arthroscopy for assessment. There is sufficient evidence in the literature for the use of MRI in detecting anatomical lesions of the knee, especially when using high-field-strength MRI (Burstein, Fritts, Fischer 1991; Rappeport et al. 1996; Adalberth et al. 1997; Fritz 2003; Winters & Tregonning 2005). All patients included in this study were clinically assessed at the orthopedic emergency unit.

The incidence of ACL injuries found in this study is almost threefold the incidence previously described in a similar and nearby geographic area in Denmark (Nielsen & Yde

1991). One likely reason for this is our definition of people at risk in this study, selected to be individuals in the community at 10-64 years of age, while the Danish study included all ages. According to epidemiological principles for estimating the incidence of sickness, our calculations are based on the true population of patients at risk since there are few reports of ACL injuries in individuals under 10 or over 64 years of age. A further contributing factor to the higher incidence found in the present study is the use of a subacute MRI examination. This procedure detected 33/79 ACL tears not otherwise detected by clinical examination. Several recent MRI studies suggest that 23-35% of patients with symptomatic knee OA, but only 3% of controls, have a previously undetected ACL injury (Hill et al. 2005, Chan et al. 1991, Link et al. 2003). An undetected and thereby untreated ACL injury may increase the risk for symptomatic knee OA development, a risk factor suggested to be under-recognized (Hill et al. 2005). An improved assessment of acute traumatic knee injuries may lead to earlier diagnosis and better treatment. We suggest that the earlier report on ACL incidence was based on several cases of knee sprain where the true diagnosis was missed and thus failed to include all patients with an ACL tear. It is likely that the incidence rate reported in the present study is underestimated, since some patients may have been assessed either at another orthopedic unit or in primary health care, or had not sought medical care.

Three out of four acute knee injuries in our study were sports related and of those 60% were related to soccer. This is almost twice the proportion recently presented in the US (Yawn et al. 2000) where only 36% of all knee traumas were sports related, and Finland (Sarimo et al. 2002) where 38% were sports related. The incidence of traffic accidents and other kinds of non-sports related traumas might be higher in the US but this factor alone is unlikely to explain the differences found. However, one reason could be that Helsingborg hospital traditionally handles most cases of sports related injuries in the region, and knee injuries in particular. In the US, the majority of these injuries would probably have been taken care of by private Sports Medicine clinics.

In agreement with previous studies we show that at least every second ACL injury is associated with a meniscal injury (DeHaven 1980, Noyes et al. 1980, Butler & Andrews 1988). It was reported that in arthroscopically assessed knees the lateral meniscus tear is the most frequent meniscal injury in the knee with an acutely injured ACL, whereas the proportion of medial meniscus injuries increases over time in the ACL deficient knee (Mitsou & Vallianatos 1988; Cipolla, Scala, Gianni, Puddu 1995; Friden, Erlandsson, Zätterstrom, Lindstrand 1995; Nikolic 1998). In contrast, we observed in this MRI-based study that a longitudinal tear to the posterior horn of the medial meniscus was the most frequent associated meniscal injury. The posterior horn of the medial meniscus is difficult to visualize at a routine arthroscopy and a stable longitudinal tear at this location could be even more difficult to find, especially if not using a posteromedial approach, even for a well trained orthopedic surgeon (Rappeport et al. 1996). This may be one reason for the higher frequency of these tears in the present study. Our study suggests that the medial meniscus tear seen at later stages of the unstable knee could represent the progression of a ‘hidden’ post-traumatic longitudinal tear in the medial meniscus.

In this study plain radiography was to be replaced by a sub-acute MRI if no fracture was suspected at clinical examination. Nevertheless, we found 24 (15%) fractures on MRI and the majority of these fractures were minor depressions (n=14). Five osteochondral fractures were seen on MRI and all where associated with patellar dislocations, four had sub-acute arthroscopy. None of the remaining fractures detected by MRI in this study required altered medical treatment or complementary surgery.

A rapidly appearing effusion in the knee joint is a strong predictor for severe intra-articular knee injury (DeHaven 1980; Noyes et al. 1980; Lysholm, Gillquist, Liljedahl 1981), which is supported by our results.

The lack of agreement between clinical finding on knee stability and anatomical lesions as visualized on MRI in this study contradicts previous studies (Adalberth et al. 1996; Rose&Gold 1996; Kocabey et al. 2004). These studies all concluded that MRI provided no added value on the status of the ACL compared with clinical assessment. Kocabey et al. (2004) suggested that clinical examination, if performed by an experienced orthopedic surgeon, is as accurate as MRI in detecting both ligamentous and meniscal injuries. These studies differ in some important aspects from the present study: the clinical examination was performed by an experienced orthopedic surgeon in the quiet phase some five weeks after the knee trauma, and on selected cases. However, an acutely injured knee is more difficult to examine due to pain, and experienced orthopedic surgeons rarely practice at the emergency unit. Further, it is known that an ACL tear visualized on MRI is not always associated with an AP laxity detectable at clinical examination. We have here evaluated the validity of the clinical routines at the emergency unit, where knee injuries are assessed among all other patients with acute conditions related to the musculo-skeletal system. In Sweden, and probably in most European countries, patients with an acute knee injury are primarily assessed at the emergency unit where the need for further evaluation and treatment are decided on the basis of clinical findings. Our study shows that every second patient with an acute ACL injury risks being sent home from the orthopedic emergency unit diagnosed as an uncomplicated knee sprain, if not further assessed by MRI in the sub-acute phase.

Perspectives

We show that the incidence of ACL injuries might be higher than previously described; 0.81 per 1000 inhabitants aged 10-64 and year. The lack of agreement between clinical instability and MRI findings indicates that a large group of patients with severe knee injuries may not receive optimal treatment. In addition, we show that patients with patellar dislocations rarely receive a correct diagnosis on clinical examination. We recommend that patients with a rotational trauma to the knee and swelling within 24 hours should not be sent home unless a plan is made for further evaluation. An early diagnosis of all traumatic knee injuries will facilitate adequate treatment and possibly decrease the risk of knee OA development.

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Fig. 1. The agreement between AP laxity at clinical examination and ACL injury/uninjured ACL as visualized on MRI, N=159.

Table 1. Activity at injury.

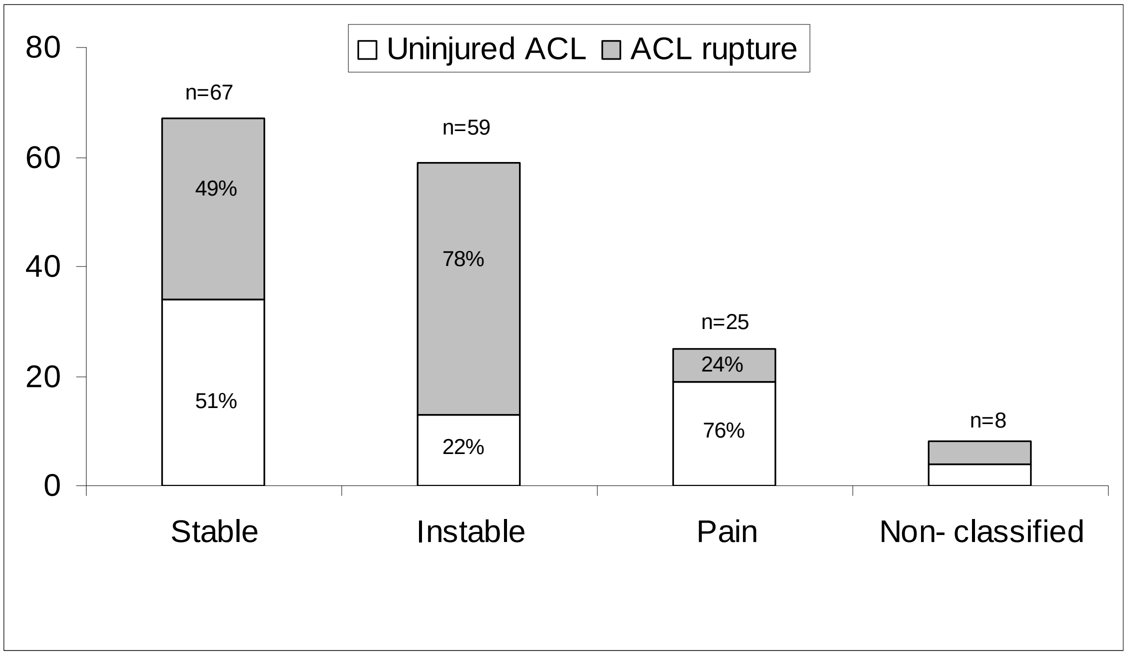
	Total	
	Cases n=159	Percent %
Non sports related	33	21
Unclassified	6	4
Sports related	120	75
Soccer	72	60
Skiing	16	13
Handball	5	4
Horse riding	5	4
Other sports	22	18

Table 2. Injuries to the knee joint as visualized on MRI.

Injury	Cases n=159	Percent %
ACL	*89*	*56*
Total rupture	77	
Partial rupture	11	
Graft rupture	1	
PCL	*3*	*2*
MCL	*39*	*24*
Grade I	14	
Grade II	12	
Grade III	13	
LCL grade I	*4*	*3*
Medial meniscus	*60*	*38*
Ventral horn	8	
Dorsal horn	57	
Middle portion	20	
Lateral meniscus	*36*	*23*
Ventral horn	13	
Dorsal horn	23	
Middle portion	11	
Patellar dislocation	*25*	*16*
Fracture	*24*	*15*
Osteochondral	*5*	
Depression	*14*	
Other	*5*	
No pathological findings	*20*	*13*

Table 3. The different types of meniscal tears associated with ACL injury as visualized on MRI.

Type of meniscal tear	Medial meniscus (n=45)	Lateral meniscus (n=28)
Longitudinal	23	8
Horizontal	7	5
Complex	6	4
Dislocated	5	5
Bucket handle	3	0
Contusion	1	1
Radial	0	5



Uninjured ACL
ACL rupture
80
60
40
20
0
n=67
49%
51%
n=59
78%
22%
n=25
24%
76%
n=8
Stable
Instable
Pain
Non- classified