Orthopaedics & Traumatology: Surgery & Research 102 (2016) 203–206

Available online at
ScienceDirect
www.sciencedirect.com

Elsevier Masson France
EM|consulte
www.em-consulte.com/en

Original article

Intercondylar notch dysplasia in open-physis anterior cruciate ligament injuries: A case-control study

B. Freychet[a,*], W. Lakhal[a], M. Daggett[b], C. Bonnard[a]

[a] Faculté de médecine et de pharmacie de Tours, CHRU Clocheville, 9, boulevard Béranger, 37044 Tours, France
[b] North Kansas City Hospital, Kansas City University, Kansas City, MO, USA

ARTICLE INFO

Article history:
Received 6 May 2015
Accepted 23 November 2015

Keywords:
Anterior cruciate ligament
Paediatric patients
Intercondylar notch
Notch width index

ABSTRACT

Background: The incidence of anterior cruciate ligament (ACL) tears in children is rising steadily due to a variety of factors including growing participation in sports. A narrow intercondylar notch is an intrinsic risk factor that is well documented in adults but rarely investigated in children. The objective of this study was to evaluate the potential association between a narrow intercondylar notch and ACL tears in children.
Hypothesis: A narrow intercondylar notch is associated with ACL tears.
Material and methods: In a paediatric case-control study, we compared intercondylar notch morphology as assessed by magnetic resonance imaging (MRI) in 49 patients with ACL tears (33 males and 16 females with a mean age of 13.6 years) and 50 controls with normal knees (18 boys and 32 girls with a mean age of 13.8 years). In each participant, posterior tibial slope was measured, as well as the notch width index (NWI) (width of the intercondylar notch over bicondylar width at the same level). In addition, to evaluate anterior impingement, the angle formed by Blumensaat's line and the axis of the tibia (α angle) was measured with the knee extended.
Results: The NWI was significantly lower in the cases than in the controls (0.244 ± 0.02 and 0.263 ± 0.02, respectively; $P < 0.05$). The α angle was also significantly smaller in the cases ($138.74° \pm 4.6°$ vs. $141.30° \pm 7.9°$ in the controls; $P < 0.05$).
Discussion: ACL tears are associated with a small NWI in children. A narrow intercondylar notch is an established risk factor for ACL tears and should be sought routinely to determine whether notch-plasty should be performed during the ACL reconstruction procedure in order to decrease the risk of recurrent ACL tears.
Level of evidence: III, case-control study.

1. Introduction

The incidence of ACL tears in children is rising steadily due to a variety of factors including growing participation in sports and better detection of this injury [1]. The identification of risk factors may lead to interventions capable of decreasing the risk of ACL tears. The extrinsic risk factors are well documented. In contrast, a narrow intercondylar notch is an intrinsic risk factor that has rarely been investigated in children.

Palmer [2] was the first to suggest that a narrow intercondylar notch might increase the risk of ACL tears. A narrow intercondylar notch as assessed by the notch width index (NWI) was significantly associated with ACL tears in several studies [3–12] but not in others [13–15]. Zeng et al. [16] recently reported a meta-analysis of five prospective and 11 retrospective population-based studies conducted chiefly in adults, whose results indicated that a narrow intercondylar notch was a risk factor for ACL tears. Gender had no influence on NWI values in a cadaver study by Tillman et al. [17] or in a magnetic resonance imaging (MRI) study by Anderson et al. [4]. Intercondylar notch volume and ACL volume correlated with each other in a study by Charlton et al. [18]: individuals with smaller notches had smaller ACLs, and notch and ACL volumes differed between men and women. In a study conducted in the US, intercondylar notch size was significantly smaller in whites than in African-Americans, in both men and women [19].

The NWI was first described by Souryal et al. [10] based on standard radiographs. Herzog et al. [13] obtained an improvement in measurement accuracy with MRI compared to standard radiographs. Only three paediatric studies have been published to date [20–22]. Two of them, conducted by Domzalski et al. [20] and Shaw

* Corresponding author.
E-mail address: benjamin.freychet@gmail.com (B. Freychet).

http://dx.doi.org/10.1016/j.otsr.2015.11.017
1877-0568/

Table 1
Sports during which the injuries occurred in the cases with anterior cruciate ligament tears.

Sport	Number of cases	Percentage (%)
Football	11	22
Basketball	5	10
Gymnastics	5	10
Rugby	5	10
Track & Field	2	4
Bicycle-motocross	2	4
Skiing	2	4
Tennis	2	4
Trampoline	2	4
Other	13	26

et al. [21], respectively, showed that a small NWI was associated with ACL tears. In the third study, Kocher et al. demonstrated that the NWI was significantly smaller in patients with midsubstance ACL tears compared to those with anterior tibial spine avulsion fractures [22]. However, the NWI values showed considerable overlap between the two groups, precluding the identification of a cut-off NWI value associated with an increased risk of ACL tears.

The objective of this case-control study was to look for a potential association linking a narrow intercondylar notch as assessed by MRI to ACL tears in children. The study hypothesis was that a narrow intercondylar notch was a risk factor for ACL tears.

2. Material and methods

Knee MRIs of 49 patients who underwent ACL reconstruction to treat traumatic ACL tears between 2000 and 2003 (cases) were compared to the normal knee MRIs of 50 individuals with normal knees (controls). The cases had a mean age of 13.6 ± 1.52, no previous history of knee abnormalities, and no concomitant health conditions (Table 1). The controls had a mean age of 13.8 ± 2.12 years and normal results of a knee MRI performed to assess anterior knee pain or suspected meniscal lesions (Table 2).

All MRIs were analysed using our radiology software (McKesson Radiology™ PACS, San Francisco, CA, USA). If knee extension was less than 180°, the software corrected the knee position. The NWI was measured as described by Souryal and Freeman [3]. We measured the bicondylar width on a coronal fat-saturation image by drawing a line parallel to the joint space and running through the popliteal groove then measuring the distance between the edges of the two condyles. Then, we measured the width of the intercondylar notch on the same line, from one inner edge to the other. The NWI was computed as notch width divided by bicondylar width (Fig. 1). In several studies, NWI measurements showed no interobserver or intraobserver variability [9,23,24].

To evaluate the risk of anterior impingement, another variable was measured, on the most medial sagittal MRI image obtained with the knee extended (Fig. 2). This variable was the α angle subtended by Blumensaat's line and the line through the middle of the tibial shaft. Our hypothesis was that the risk of ACL tears increased

Table 2
Comparison of demographic characteristics between the cases and controls.

	Cases	Controls	Test	*P* value
Total number	49	50		
Age, y Mean	13.6	13.8	Mann-Whitney U	0.35
SD	1.52	2.12		
Gender				
Male	33 (67%)	18 (32%)	Chi^2	0.03
Female	16 (33%)	32 (64%)		
Side				
Right	24	25	Chi^2	0.9
Left	25	25		

Fig. 1. Notch width index (NWI) computed by dividing intercondylar notch width on the A–B line (CD) by bicondylar width on the A–B line (AB).

as the α angle decreased. In addition, because a common finding during ACL reconstruction was an asymmetric Gothic arch configuration of the intercondylar notch (Fig. 3), a spine opposite the anterior part of the notch was looked for on the same MRI image (Fig. 4). Tibial slope was measured on strictly lateral radiographs.

2.1. Statistical analysis

The *t*-test or Mann-Whitney U test was used to compare groups. Values of *P* lower than 0.05 were considered significant.

3. Results

The mean NWI was significantly lower in the cases than in the controls (0.244 ± 0.02 vs. 0.263 ± 0.02, respectively; $P < 0.001$) (Table 3). The α angle was also significantly smaller in the cases than

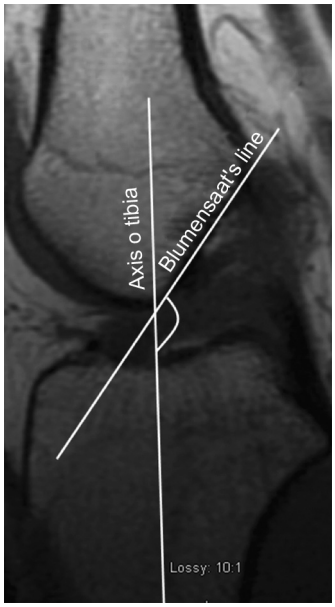

Fig. 2. Alpha angle subtended by Blumensaat's line and the tibial shaft axis.