Relationship between tibial spine size and the occurrence of osteochondritis dissecans: an argument in favour of the impingement theory

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Abstract

Purpose Pathophysiology of osteochondritis dissecans (OCD) of the medial femoral condyle remains uncertain. Specifically, the relationship between the size of the anterior tibial spine (ATS) and the presence of OCD has not been explored. The purpose of this study was to evaluate the relationship between ATS size and the occurrence of OCD.

Methods Seventy-nine children between 8 and 17 years of age were included in two groups: OCD ($n = 37$) and control ($n = 42$). The groups were matched in terms of age, gender, BMI and weight. Two independent observers performed an MRI analysis of the size of the tibial spine and intercondylar notch relative to the size of the respective epiphyses. For this study, the "*S* ratio" was calculated by dividing the height of the tibial spine by the height of the tibial epiphysis. The "*N* ratio" was calculated by dividing the height of the notch by the height of the femoral epiphysis. These two ratios for both groups were compared using Student's *t* test.

Results The mean value of the *S* ratio in the OCD group was 0.39 ± 0.06; the mean value of the *S* ratio in the control group was 0.32 ± 0.03 ($P = 0.004$). The mean value of the *N* ratio in the OCD group was 0.70 ± 0.08; the mean value of the *N* ratio in the control group was 0.70 ± 0.07 (n.s.).

Conclusion This study's findings confirm our hypothesis that patients with OCD have a more prominent tibial spine than in patients without OCD.

Level of evidence IV.

Keywords Medial tibial spine · Osteochondritis dissecans · Knee · Impingement

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Introduction

Several hypotheses have been put forward to explain the occurrence of osteochondritis dissecans (OCD) in the knee [11, 29]. These include mechanical, vascular, genetic and inflammatory causes, along with ossification disorders [2, 4, 9, 13, 19, 20, 26]. But none of these theories is universally accepted [13, 14, 17].

In 1933, Fairbanks et al. [7] suggested that OCD was due to "a violent rotation inwards of the tibia, driving the tibial spine against the inner condyle". Smilie et al. [23] had also proposed in 1957 that OCD was related to impingement between the anterior tibial spine and the lateral facet of the medial condyle. However, in both cases, the authors' statements were not supported by scientific work. This concept of impingement between the anterior tibial spine is consistent with the repeated microtrauma aetiology proposed by various groups [2, 26, 27]. Moreover, the microtraumatic aetiology has been described for other OCD locations [12, 18].

This study originated from observations of several OCD cases from our personal experience (Fig. 1). It led us to hypothesise that impingement between the anterior tibial spine and the medial femoral condyle is a predisposing

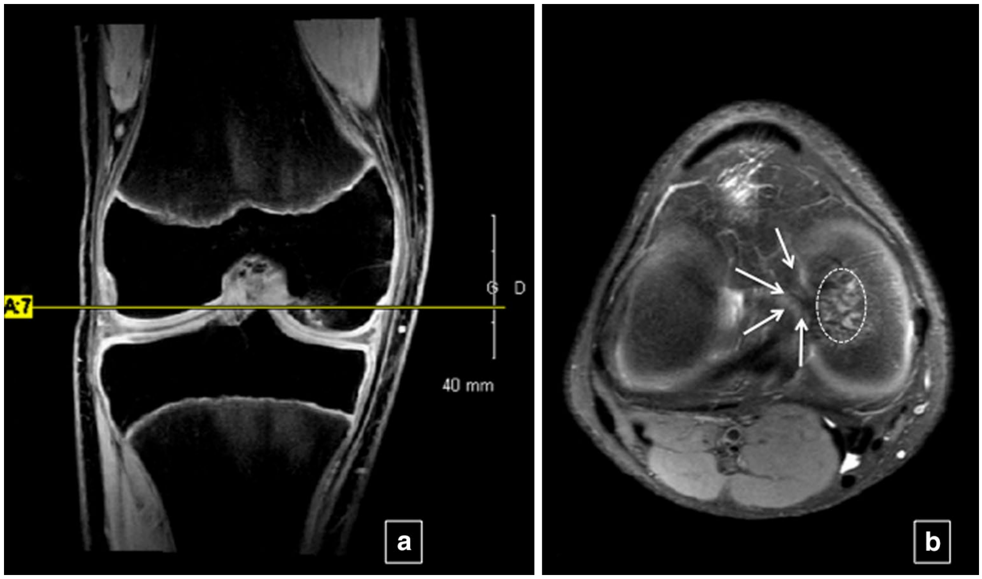

Fig. 1 MR arthrography, with coronal (**a**) and axis (**b**) slices centred over the tibial spine, showing contact between the anterior tibial spine (*white arrow*) and an area of osteochondritis in the medial femoral condyle (area surrounded by *dashed lines*)

factor for the occurrence of OCD. The purpose of this study was to compare the morphology of the anterior tibial spine in OCD patients to matched controls. This information may help us better understand the pathophysiology of this disease.

Materials and methods

All the patients who sought treatment at our facility between 2010 and 2013 for unilateral, isolated medial OCD evaluated by MRI were included. MRI is a part of our regular management after a 6-month history of pain refractory to conservative treatment. Patients presenting with multiple lesions, with lesions on the lateral condyle or with secondary lesions were excluded; patients with a history of long-term corticosteroid therapy were also excluded. The control group consisted of patients who had MRI records in our facility's imaging database and for whom the MRI images were deemed free of visible lesions by a paediatric radiologist specialising in musculoskeletal imaging. These MRI examinations had been carried out to assess traumatic and non-traumatic knee pain.

Of the 37 patients included in the OCD group, the left knee was involved in 20 cases and the right knee in 17 cases. There were 14 girls and 23 boys. The mean age at the time of diagnosis was 14.3 years ± 2.5 (8–17). The mean weight was 57.9 kg ± 19, the mean height was 168 cm ± 12 and the mean BMI was 21.3 kg/m^2 ± 3.4. The control group consisted of 42 healthy patients who were matched in terms of age, gender, weight, height and BMI to members in the OCD group. These two groups were comparable (Table 1).

Table 1 Characteristics of the two cohorts. The mean and standard deviation are given for each variable

	OCD ($n = 37$)	Normal ($n = 42$)	*p* value
Sex ratio (F/M)	1	1	
Age (years)	14.3 ± 2.5	14.5 ± 2.4	n.s.
BMI (kg/m^2)	21.3 ± 3.4	21.1 ± 3.7	n.s.
Weight (kg)	57.9 ± 19	55.5 ± 21	n.s.
Height (cm)	168 ± 12	168 ± 12	n.s.

MRI images were obtained with a 3T MAGNETOM® Skyra unit (Siemens, Erlangen, Germany). The coronal slice in which the entire height of the anterior tibial spine was visible was used for the analysis. The joint line, or bimeniscal axis, was defined by tracing a line through the inner corner of the free edge of both menisci. The smallest distance between the bimeniscal axis and the top of the tibial spine was defined as distance "A". Distance "B" was defined as the smallest distance between the top of the anterior tibial spine and the proximal tibial growth plate (inferior border). Distance "C" was defined as the smallest distance between the bimeniscal line and the roof of the intercondylar notch across from the anterior tibial spine. Distance "D" was defined as the smallest distance between the bimeniscal axis and the distal femoral growth plate (superior border). All the measurements were made taking into account the cartilage border.

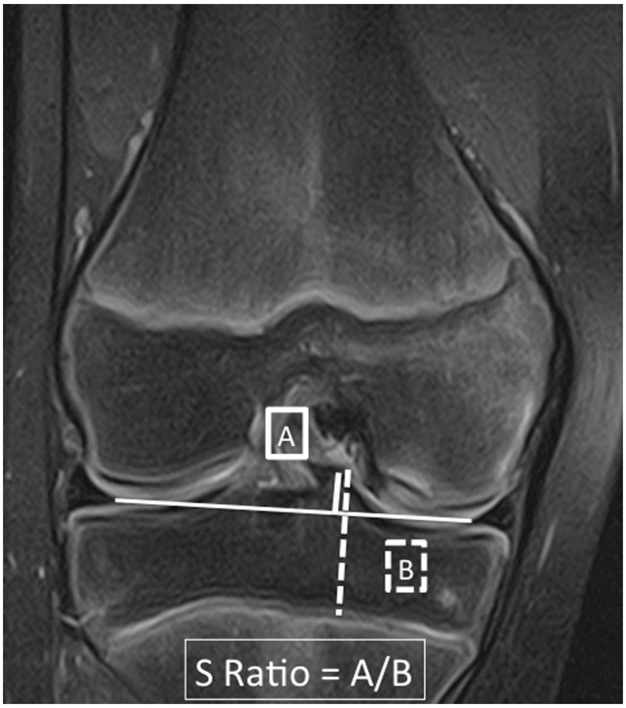

Fig. 2 Calculating the *S* ratio. *The horizontal line* corresponds to the bimeniscal axis. The continuous *vertical line* (*A*) represents the distance between the *top* of the anterior tibial spine and the bimeniscal axis. *The dashed vertical line* (*B*) represents the distance between the *top* of the tibial spine and the proximal tibial growth plate (*inferior border*). *S ratio* = *A*/*B*

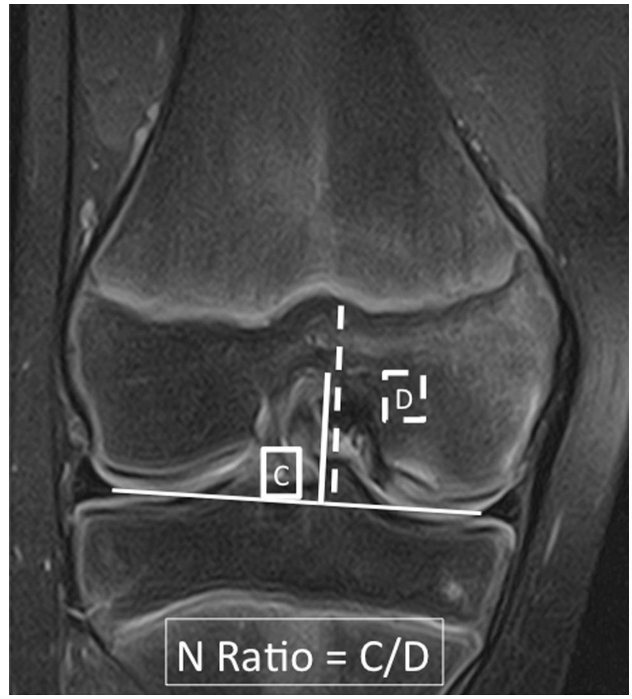

Fig. 3 Calculating the *N* ratio. The *white horizontal line* corresponds to the bimeniscal axis. The *continuous vertical line* (*C*) represents the distance between the bimeniscal axis and the roof of the intercondylar notch across from the anterior tibial spine. *The dashed vertical line* (*D*) represents the distance between the bimeniscal axis and the distal femoral growth plate (*superior border*). *N ratio* = *C*/*D*

Ratios were calculated to account for variations related to age and height. The height of the anterior tibial spine (A) relative to the height of the proximal tibial epiphysis (B) was calculated and named the "*S* ratio" (Fig. 2). The height of the intercondylar notch (C) relative to the height of the distal femoral epiphysis (D) was calculated and named the "*N* ratio" (Fig. 3). Two observers performed all the measurements once and then repeated them three weeks later.

This case–control study was approved by our healthcare facility's institutional review board (CHU Toulouse approval number 01-0115).

Statistical analysis

Descriptive statistics (mean, median, minimum, maximum and standard deviation) were generated for all continuous variables. The demographics of both groups were compared using Student's *t* test. Student's *t* test was used to compare the ratios for the two groups. Intra- and inter-observer reproducibility rates were measured with intraclass correlation coefficients (ICC) between two measurements made by the first observer (intra-observer reproducibility) and between two measurements made by the two observers (inter-observer reproducibility).

The number of subjects to be included in order to show a 0.05 point difference in the mean *S* ratio between the OCD and control groups was calculated based on a preliminary analysis of the first 10 cases, which revealed a common standard deviation of 0.07 (OCD: 0.08; control: 0.05). At least 34 patients were needed in each group to be able to detect this difference with a power of 90 % and an alpha risk of 5 %. Analysis was carried out using Stata SE v11.0 software (StataCorp, College Station, TX, USA).

Results

The mean value for the *S* ratio in the OCD group was 0.39 ± 0.06 (range 0.22–0.47). The mean value for the *S* ratio in the control group was 0.32 ± 0.03 (range 0.17–0.38). This difference was statistically significant ($P = 0.004$). The mean value for the *N* ratio in the OCD group was 0.70 ± 0.08 (range 0.55–0.82). The mean value for the *N* ratio in the control group was 0.70 ± 0.07 (range 0.54–0.80). The two groups had similar mean values for the *N* ratio (n.s.) (Fig. 4).

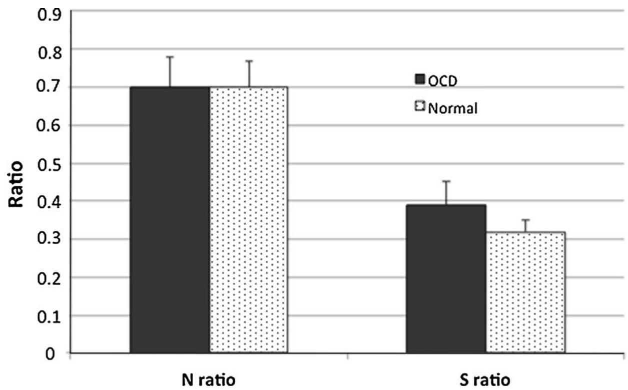

Fig. 4 Mean values and standard deviation of the two ratios for the two groups. The *N ratio* is similar for the two groups but the *S ratio* is greater in the OCD group

Reproducibility

Intra- and inter-observer reproducibility ranged from 0.87 to 0.93. The inter-observer ICC for the *S* ratio was 0.93 and the intra-observer ICC was 0.91. The inter-observer ICC for the *N* ratio was 0.87 and the intra-observer ICC was 0.90.

Discussion

The most important finding of this study was that the anterior tibial spine is more prominent in patients with OCD than in control patients without OCD, confirming our hypothesis. In contrast, the two groups had a similar intercondylar notch size.

Fairbanks et al. [7] and Smilie et al. [23] suggested that impingement occurs between the anterior tibial spine and the femoral condyle but never proved it. To our knowledge, this is the first study showing that patients with medial condyle OCD have a different tibial spine size. This information may shed light into the pathophysiology of this disease. It also means that arthroscopic resection of an overly large tibial spine may be a treatment option.

Sturnick et al. [24] have demonstrated that "internal torque applied to the tibia causes the medial femoral condyle to contact and translate up the medial tibial spine". Li et al. [15, 16] have shown that the centre of the contact area on the tibial plateau is located on the spine of the medial compartment during flexion and on the spine of the lateral compartment at every flexion angle measured except for 30°. Furthermore, it was shown that in a load bearing knee, the highest compressive pressures are located on the cartilage of the medial tibial spine [28]. Thus, the risk of repeated contact is greater when the tibial spine is larger. It seems logical that a larger tibial spine could be responsible for repeated microtrauma; this would explain the correlation found between the size of the anterior tibial spine and the presence of OCD in this study.

Wechter et al. [29] also looked into the morphology of the proximal tibia in an attempt to relate it to the presence of OCD. They found the medial tibial slope to be greater in the OCD group. They used an uncommon method to measure the slope in the coronal plane [1, 5, 10, 22]. The medial tibial slope was calculated as the angle between the tibia's anatomical axis and a line connecting the edge of the tibial plateau to the top of the anterior tibial spine. When using this calculation method, the increased slope can be due to a truly greater slope, as well as an unusually prominent anterior tibial spine. Hence, the observed correlation can be attributed to a taller tibial spine that would have increased the medial tibial slope.

MRI was used to study the relationship between ATS morphology and OCD occurrence. MRI provides better spatial resolution and more precise analysis of the growth plate than standard radiographs [3, 8]. In addition, MRI takes into account the thickness of the cartilage, which is not visible on radiographs. We defined the "*S* ratio" and "*N* ratio" to relate the size of the tibial spine or condylar notch to the size of the epiphysis. The point on the growth plate furthest away from the articular surface (inferior border for the tibia and superior border for the femur), that is to say the junction between the growth plate and diaphysis, was used as the boundary. We determined arbitrarily that this boundary was visible, particularly on T2-weighted sequences. We found good intra- and inter-observer reproducibility of these two ratios (0.87–0.93).

Sales De Gauzy et al. [21] have shown that the natural history of osteochondritis in children can result in spontaneous resolution in some cases. Patients who do not heal spontaneously may have this type of impingement. The ratios defined here could be useful in future work when evaluating the results of OCD treatment and for categorising patients.

The current study has certain limitations. First, because of the study design, only an association between ATS size and the occurrence of OCD can be reported; no conclusions about a causal relationship can be made. Secondly, the knee was analysed statically. It was impossible to conduct a dynamic MRI analysis showing contact between the anterior tibial spine and medial condyle. Contact between the tibial spine and femoral condyle during rotational movements has already been revealed [24]. Our findings are based on a preliminary analysis that will need to be confirmed with dynamic analyses and three-dimensional reconstructions. Thirdly, this study provides no insight into the cause of lateral OCD cases, which occur much less often [9]. Some cases are related to the presence of a discoid meniscus [6, 25]. Moreover, the lower limb morphotype could not be resorted. The small number of subjects did not allow us to conduct a multifactorial analysis that takes into consideration additional variables. The relationship between mechanical axis and OCD has previously been described [11].

Conclusion

There is a difference in the size of the anterior tibial spine between patients with OCD and those without. Patients with OCD have a more prominent tibial spine than patients without OCD.

Compliance with ethical standards

Conflict of interest No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

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