The British Journal of Radiology, 83 (2010), 23–27

Correlation of intra-articular osseous measurements with posterior cruciate ligament length on MRI scans

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ABSTRACT. Six patients with a clinical diagnosis of chronic posterior cruciate ligament (PCL) rupture, based on a positive posterior drawer test, had a normal appearance of the PCL on an MRI scan. It is postulated that the PCL had been ruptured but healed in a lengthened state. 12 volunteers with no history of knee trauma underwent an MRI scan of the knee. In this control group ($n=12$), there was a close correlation between the lateral femoral condylar width in the sagittal plane and the PCL length, with a ratio of 2:1 (95% confidence interval (CI) = 1.817–2.095). In the clinically abnormal group ($n=6$), the ratio was 1.49:1 (95% CI = 1.206–1.782) ($p< 0.0005$). In conclusion, the ratio of the lateral femoral condylar width in the sagittal plane to the PCL length is a useful index for diagnosing PCL attenuation and lengthening in the presence of a normal morphological MR appearance.

Received 31 March 2008
Revised 1 February 2009
Accepted 13 February 2009

DOI: 10.1259/bjr/27328610

The posterior cruciate ligament (PCL) is the prime stabiliser of the knee joint and acts as a central axis about which normal rotation occurs [12]. Biomechanical studies have shown that the PCL is the primary restraint to posterior translation [3–5], contributing 95% restraint to tibial displacement [6].

Rupture of the PCL is an uncommon injury occurring after high-energy trauma to the knee. The reported incidence of PCL rupture has varied, with PCL injuries representing between 1% and 44% of all knee ligament injuries in various studies [7–10]. Clinically, this is detected by a positive posterior drawer test or tibial sag. The accuracy of clinical examination for detecting PCL tear is reported to be 96% (sensitivity of 90% and specificity of 99%) [11]. The sensitivity and specificity of MRI in diagnosing acute PCL rupture reaches 100% [12–18], but is only 23% for chronic PCL injuries [19].

We identified six patients with an obvious clinical PCL rupture who had a normal MRI scan. We postulate that, as the ruptured PCL heals in a lengthened state, measurement of absolute PCL length will not give information about the functional status of the PCL. An osseous parameter would give a more reproducible measurement and a ratio may be derived by comparing it to the length of the chronically ruptured PCL. This study was designed to identify an osseous parameter in the knee on the MRI scan that would correlate with PCL length.

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Methods and materials

Six patients (Group 1) with a clinical Grade III PCL rupture were identified retrospectively. These patients had sustained PCL injury over a period of 5 years. The clinical findings were unequivocally positive and were recorded on cine film. The cine films obtained were merely for demonstration purposes and were not used for the purpose of publication. In addition, all patients had stress radiographs of both knees showing that the tibia subluxed posteriorly on the femur. The scans were performed with the patient in the supine position, with the knee in 10° of flexion and 20° of external rotation. Images were obtained in the sagittal plane with 3 mm slices. All of the scans were reported as normal by an experienced musculoskeletal radiologist (S.E.), who was aware of the clinical findings.

A group of 12 volunteers (Group 2) who had no knee symptoms and no history of trauma to the knee were enlisted prospectively. Informed verbal consent was obtained after the nature of study was explained to these volunteers. Clinical examination in this group was normal. A single operator performed MRI scans of the unaffected knees on a pre-arranged day. MRI scan of their knees was performed according to the aforementioned protocol, and the same radiologist reported on the findings.

The scans were measured digitally with a software programme (eFilm Workstation, version 1.8.3®; Merge Healthcare, WI, USA). This software permits accurate readings of DICOM (Digital Imaging and Communication in Medicine) images. The PCL length was measured along a line in the median width of the ligament, from its origin to insertion, on the slice of the scan that showed the entire length of the PCL (see Figures 1 and 3). The lateral femoral condylar width was

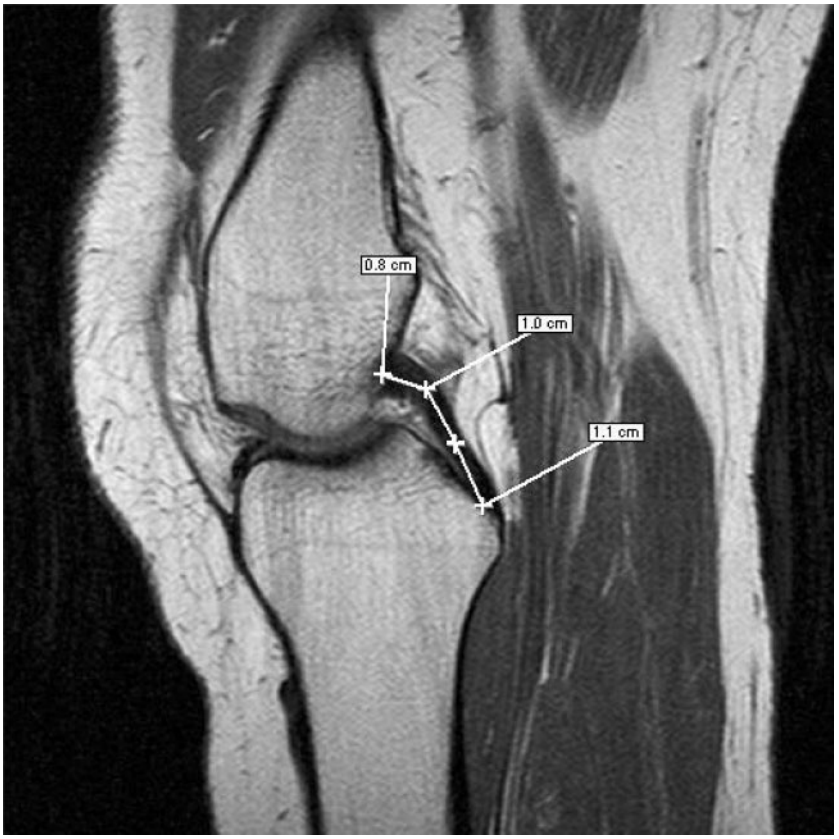

Figure 1. Posterior cruciate ligament (PCL) length measurement: ''normal'' (Volunteer 3). This PCL measures 2.9 cm.

Figure 2. Lateral femoral condyle width in sagittal image: ''normal'' (Volunteer 3).

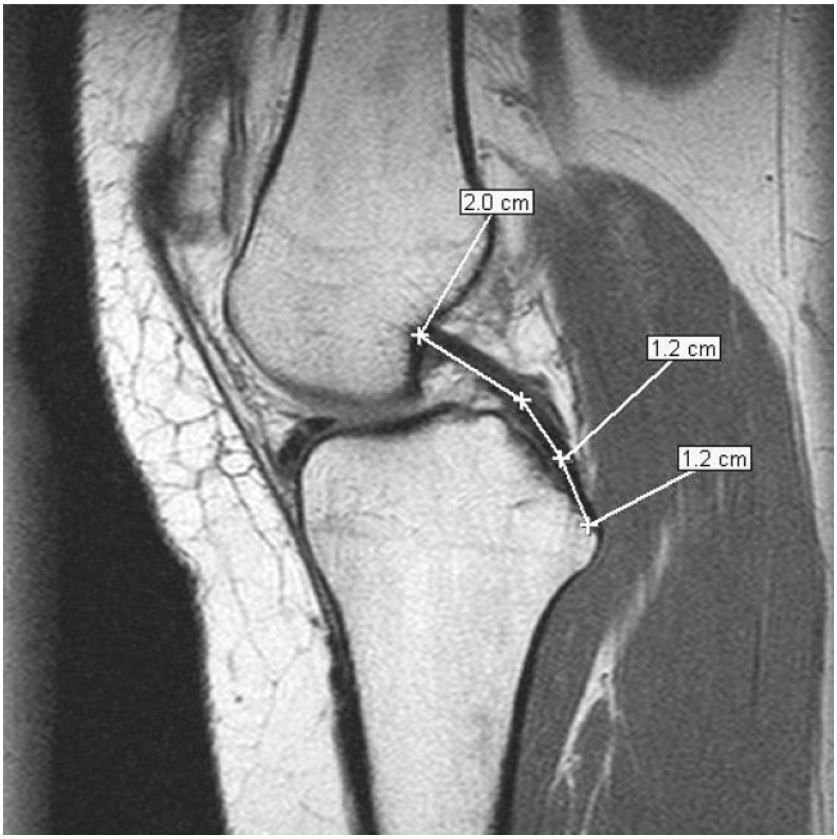

Figure 3. Posterior cruciate ligament (PCL) length measurement: ''abnormal'' (Patient 5). This PCL measures 4.4 cm.

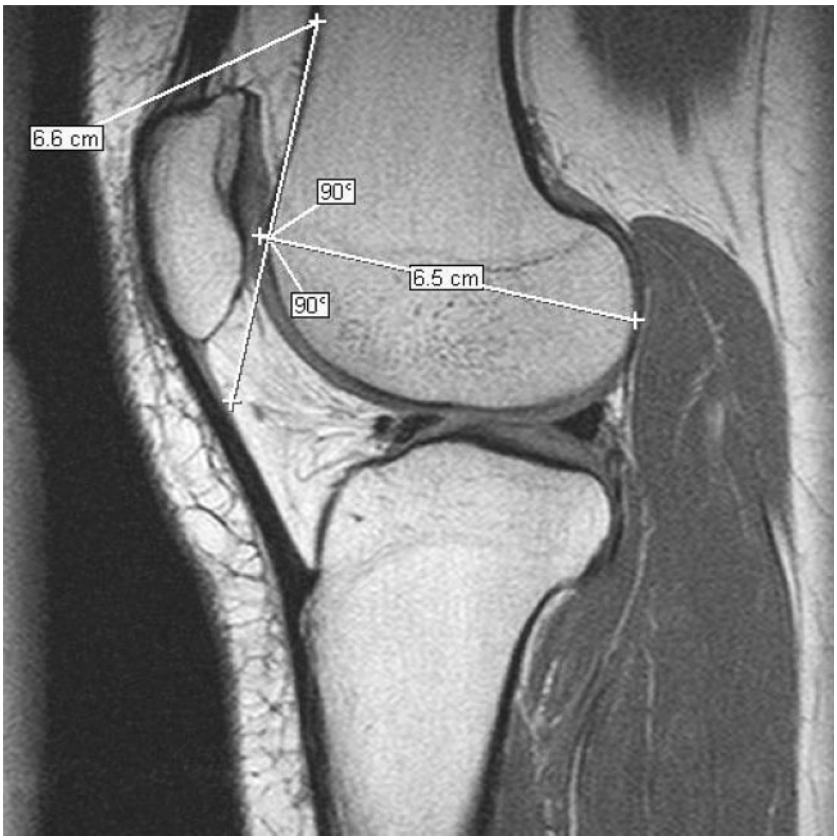

Figure 4. Lateral femoral condyle width in sagittal image: ''abnormal'' (Patient 5).

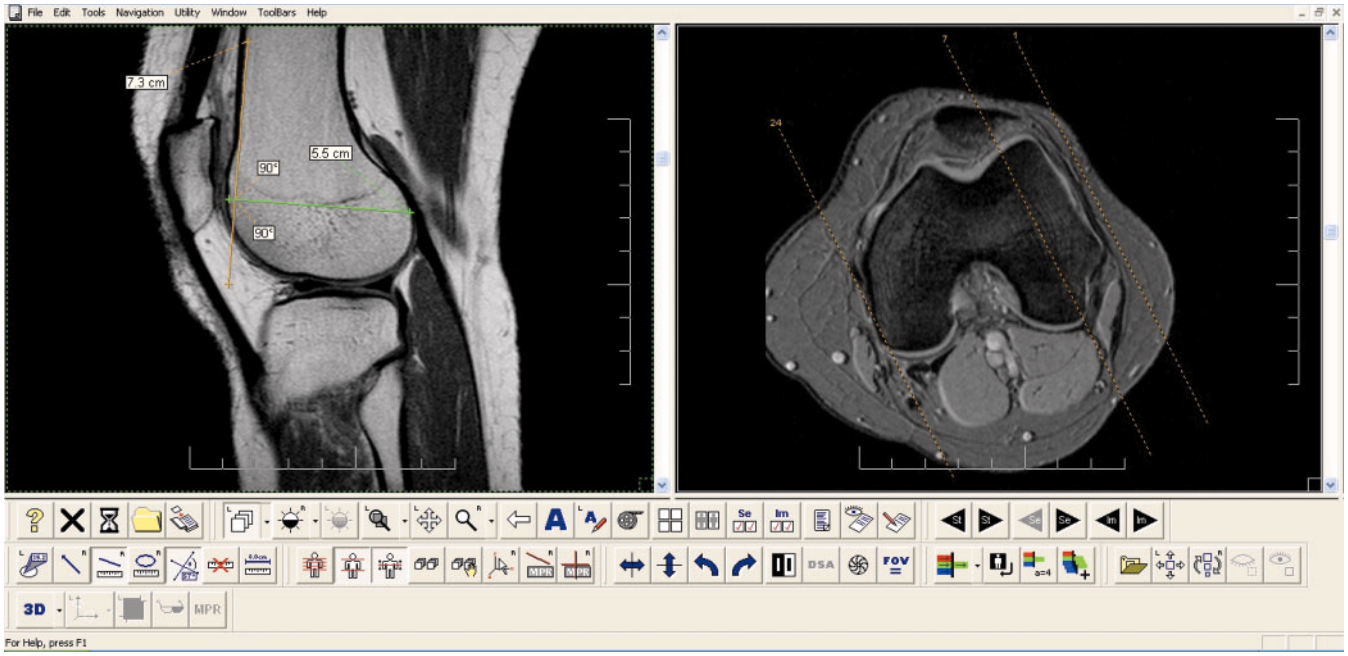

Figure 5. Measuring the lateral femoral condoyle; the widest anteroposterior sagittal slice was chosen (slice 7 in this figure).

measured in the sagittal plane by a line tangential to the physeal scar and perpendicular to the anterior femoral cortex (see Figures 2 and 4). The sagittal slice chosen for measurement of the lateral femoral condoyle was widest in the anteroposterior plane (Figure 5). The ratio obtained between the lateral femoral condoyle width and the PCL length was calculated for each patient and compared between Groups 1 and 2. This ratio was chosen for calculations because the absolute PCL length varies between individuals according to gender and build of the person.

The first radiologist (S.E.) was aware of the clinical findings for qualitative reporting on the status of the PCL, but was blinded to all of the measurements. A second radiologist (N.H.) who was blinded to the clinical status of the two groups repeated all of the measurements.

Statistical analysis was performed using Graph Pad InStat software (Reed Business Information, AZ, USA). The ratios obtained were compared between two groups using an unpaired *t*-test. Normality of data was tested using the Kolmogrov and Smirnov method. Interobserver variations were compared.

Table 1. Ratios between posterior cruciate ligament length and lateral femoral condylar width in two groups

Serial No.	Group 1	Group 2
1	1.233	1.709
2	1.394	2.046
3	1.857	1.943
4	1.483	2.257
5	1.480	2.279
6	1.490	1.829
7		1.982
8		1.752
9		1.830
10		1.879
11		1.685
12		2.279

Results

Table 1 shows the ratio of PCL length to lateral femoral condyle width of individual subjects in the two groups. The mean ratio of lateral femoral condylar width to PCL length in Group 1 was 1.49:1. The minimum ratio was 1.23 and the maximum ratio was 1.86. The 95% confidence interval (CI) was 1.27–1.70 (Table 2).

In Group 2, the mean ratio of lateral femoral condylar width to PCL length was 1.96:1. The minimum ratio was 1.69 and the maximum ratio was 2.28. The 95% confidence interval was 1.82–2.09 (Table 2).

The ratios between the lateral femoral condyle width and PCL length in Groups 1 and 2 show significant statistical difference. The two-tailed *p*-value was 0.0005 ($t=4.359$ with 16 degrees of freedom). The difference between standard deviations in the two groups was not significant. The data passed the normality test using the Kolmogorov and Smirnov method.

The interobserver error between measurements of the two radiologists was not significant. The two-tailed *p*-value was 0.769. The 95% CI of the difference was –0.04237 to 0.03184, with a mean difference of −0.005263 (mean of paired differences).

Table 2. Comparison of posterior cruciate ligament length to lateral femoral condyle width ratios in two groups

	Group 1	Group 2
Mean	1.49	1.96
Minimum	1.23	1.69
Maximum	1.86	2.28
Median	1.48	1.91
95% confidence interval	1.27–1.70	1.82–2.09

Discussion

Conventional interpretation of MRI scans in PCL injury is by morphological appearance. Three normal appearances are identified: arcuate, U-shaped and kinked [14]. MRI is considered to be the most accurate modality for identifying PCL injury in acute cases [12–15] but its sensitivity is comparatively lower in chronic cases [19]. The diagnosis of an acute rupture is apparent from the abnormal morphological appearance of the PCL, including indistinct margins, abnormal thickening, increased signal intensity and focal areas of ligamentous discontinuity [13, 18]. In chronic cases, a torn PCL may reattach to the bone, the covering synovial sheath may repair without PCL healing or the PCL may repair in a lengthened state. In addition, increased signal intensity may be lost in the chronic situation. Shelbourne et al [20] reported that all low- and mid-grade PCL injuries healed and looked normal on follow up MRI scans at 3 months. In addition, the majority of high-grade injuries had healed and, although some had an altered contour, several had a normal contour. Our six cases fall into the latter category, *i.e.* the PCL looks normal but it is lengthened and consequently dysfunctional.

The reduction in the ratio of lateral femoral condylar width to PCL length indicates lengthening of the PCL. Anatomical studies have shown that the PCL averages 32–38 mm in length [2]. In view of the significant variation in knee size in the normal population, absolute PCL length in isolation was regarded as too inaccurate a method for diagnosing PCL injury [20]. In patients who have a clinically suspected PCL rupture, and who have a normal MRI scan, the lateral femoral condylar width should be measured. This will allow accurate correlation of the MRI scan with the clinical findings in cases of chronic PCL ruptures.

Acknowledgment

We acknowledge Dr Neil Hickey, Consultant Radiologist, Connolly Hospital Blanchardstown, Dublin.

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