The patellar tendon: thickening, internal signal buckling, and other MR variants

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Abstract. We studied the range of appearance of asymptomatic patellar tendons and evaluated the effect of age, weight, joint effusions, and anterior cruciate ligament (ACL) tears on this tendon. One hundred and seventy-three patellar tendons in asymptomatic patients were studied at 1.5 tesla. Sagittal short and long TE images were evaluated in regard to tendon thickness, ratio of thickness of patellar to quadriceps tendons, frequency, location, and severity of intratendon signal, and frequency and severity of tendon buckling. Results were correlated with patient age, sex, weight, the presence of ACL tears, and relative volumes of joint fluid. The mean thickness of the patellar tendon was 0.52 cm. The patellar to quadriceps tendon ratio was 0.72. The patellar tendon frequently (74%) had focal areas of signal apparently within it. This signal was usually subtle, V-shaped (95%), and seen posteriorly in the proximal end of the tendon (82%). Intratendon signal was also seen commonly in the inferior aspect of the tendon (32%). This signal intensity did not increase with greater T2-weighting (99%). Buckling of the patellar tendon was a frequent asymptomatic variant (71%) but was also associated with joint effusions ($p < 0.01$) and ACL tears ($p = 0.01$). Buckling, intratendon signal, and tendon thickness increased with weight and age. Variation of the magnetic resonance appearance of the patellar tendon is frequent. Many of these changes appear to represent subclinical degeneration. Buckling of this tendon also may occur secondary to joint effusions or ACL tears.

Key words: Magnetic resonance imaging - Knee - Patella - Tendon - Anterior cruciate ligament - Joint effusions - Extensor mechanism

Magnetic resonance (MR) imaging of the knee has shown high accuracy in the diagnosis of abnormalities of the menisci, cruciate ligaments, and collateral ligaments [17, 19]. Recently several preliminary studies have described the MRI appearance of disorders of the extensor mechanism of the knee [2, 3, 5, 12]. The most frequent site of these disorders is the patellar tendon [18]. Several findings on MR imaging have been described in these disorders, including patellar tendon thickening [3], intratendon signal [3, 5], and tendon "wrinkling" with complete tears [2].

The normal patellar tendon has been described as straight [24, 25], and as a signal void on all MRI sequences [3, 5, 25]. We have observed findings said to be pathologic (wavy fibers with internal signal) in asymptomatic individuals. In addition, several common disorders of the knee, such as joint effusions and anterior cruciate ligament (ACL) tears, may secondarily affect the appearance of the patellar tendon [4]. In order to aid in the differentiation of asymptomatic variants from disorders of the patellar tendon, we evaluated MR images of this tendon in asymptomatic patients and correlated our results with patient age, sex, and weight, as well as with the presence of effusions or tears of the ACL.

Subjects and methods

We prospectively evaluated MR scans of the patellar tendon of patients without symptoms referable to the extensor mechanism. Since we evaluated clinical patients rather than normal volunteers, three screens were utilized to exclude patients with significant present or prior extensor disorders. The first two screens involved our selection criteria. The last screen was in examination of the images for evidence of anterior soft tissue fluid signal intensity. Patients in whom significant fluid was noted were excluded from data analysis.

We first evaluated the query of the referring physician. Based upon this we excluded patients whose history and physical examination suggested a likelihood of extensor disorder. We subsequently evaluated 200 consecutive patients between December 10, 1991, and March 4, 1992, who were not felt to have an extensor disorder by the referring clinician. These 200 patients also filled out a questionnaire regarding the location, duration, and type of symptoms, the presence of any prior disorders of the knee, and whether they
had had prior knee surgery. On the basis of this questionnaire, 27 of the 200 patients were excluded due to anterior knee pain, a history of patellar tendonitis, direct trauma, or prior knee surgery. The remaining 173 patients formed the study population.

Imaging was performed on a 1.5-tesla MRI unit (Signa, General Electric, Milwaukee) with an extremity coil. The knee was positioned in slight external rotation. Although imaging in several planes was performed, the extensor mechanism was evaluated only on the sagittal images. Axial images were utilized to evaluate the soft tissues adjacent to the retinacula. There were two separate groups of patients with different sets of protocols, since individual MR imaging units had different software available. One group had routine spin echo imaging (2000/20) with a 256 x 192 matrix and with one data acquisition (91 patients). In the second group we performed routine spin echo (1000/20) imaging as well as T2-weighted fast spin echo imaging (6500/76) with a 16-echo train, a 256 x 256 matrix, and with two data acquisitions (82 patients). Pixel size in the routine spin echo sequences was 0.55 mm x 0.73 mm, while in the fast spin echo it was 0.55 mm x 0.55 mm. The imaging in all patients consisted of a 14-cm field of view, 4-mm slice thickness, with 1-mm interslice gap. Axial images were performed with identical T2-weighted imaging parameters, although fat suppression was also utilized. Images were evaluated prospectively by one observer (M.E.S.) blinded to patient age, weight, sex, and the appearance of the ACL.

The sagittal image in which each tendon appeared thickest was selected for the measurement of tendon thickness. Other assessments were made by the evaluation of all sagittal images. The anterior-to-posterior thickness of the patellar tendon was measured on the intermediate weighted (short TE) spin echo sequences. This measurement was made at the midportion of the tendon to the quarter of a millimeter. The anterior-to-posterior thickness of the distal quadriceps tendon was also measured on the same intermediate weighted sequence. The site selected for measurement of the quadriceps tendon was 2–3 mm proximal to its insertion, the most distal aspect where the trilaminar structure (the separation of the layers of the quadriceps by fascial planes) was still visible. Note was also made of any distinct areas of focal thickening of the patellar tendon excluding the insertions.

Any signal within the patellar tendon was quantified and localized in both cranial-caudal (superior, mid, inferior) and anterior-posterior (anterior, posterior, both) planes both on intermediate and T2-weighted sequences. We evaluated intratendon signal in the group who had routine spin echo imaging (91 patients) separately from the group who had fast spin echo (82 patients). This was done to control the possibility that these sequences might image different tissue signal characteristics. All the patients were then grouped together for an additional series of calculations.

"Buckling" was defined as deviation of a tendon from a completely straight contour on all images. Severity of buckling was assessed and graded for both the patellar (Fig. 1) and quadriceps tendons, based subjectively on the number of sagittal images on which buckling was present and by the number and height of the undulations of the tendons.

The anterior-to-posterior diameter of the suprapatellar recess was measured at its widest point on sagittal T2-weighted images as an index of articular fluid volume. An effusion was defined as a horizontal anteroposterior diameter equal to or greater than 1 cm [13]. Both this measurement and the measurement of tendon thickness were made utilizing calibrated callipers with accuracy to less than 0.1 mm and the photographed centimeter scale.

The presence of signal anterior to the patellar tendon on T2-weighted or fast spin echo imaging was also graded. Fluid adjacent to the retinaculum was also graded on the axial images.

The ACL was separately evaluated for MR signs of tear. Patients whose ACLs were shown to be torn by usual MRI criteria [17, 19] had this finding confirmed by a physical examination and/or arthroscopy performed by an experienced orthopedic surgeon. Historical information as well as the presence of a mass-like appearance of the proximal ACL or edema on T2-weighted sequences were used to determine the acuteness of the ACL tear.

All assessments were graded in the following fashion: none, mild, moderate, or severe. Patient age, weight, and sex were obtained from medical records.

**Statistical analysis**

Descriptive statistics of mean age, weight, patellar and quadriceps tendon thickness, as well as the location and severity of intratendon signal were calculated for all patients. The mean ratio of patellar tendon to quadriceps tendon thickness and the number and proportion of patients with differing degrees of tendon "buckling" were also calculated. Differences between the sexes in degree of buckling and intratendon signal were compared using $\chi^2$ analysis for non-parametric data. Differences between the sexes in mean age, weight, widths of the patellar and quadriceps tendons, and thickness ratio were compared using Student's t-test (two-tailed, unpaired; paired for bilateral cases). Differences in the degree of buckling were evaluated according to patient age, weight, and size of effusion using analysis of variance (ANOVA). Differences in severity of buckling were also related to the presence or absence of ACL tears by $\chi^2$ analysis.

Correlations of both age and weight with thickness of midpatellar and distal quadriceps tendons (Pearson-r) and with degree of tendon buckling and intratendon signal (Spearman-r) were also performed.

Nine patients who were examined bilaterally were further evaluated as a subgroup. Bilateral findings on MRI were compared for symmetry using correlation statistics, the Pearson-r or Spearman-r, as appropriate.