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Ultrasound, Computed Tomography and Magnetic Resonance Imaging in Patellar Tendinitis

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This prospective study describes the ultrasound, computerized tomography and magnetic resonance imaging findings in 16 cases of patellar tendinitis. In all cases tendon enlargement and reduced echogenicity were visible on ultrasound. Computerized tomography demonstrated enlargement of the tendon with reduced attenuation of the central portion. Magnetic resonance imaging showed focal tendon enlargement in all patients with high signal lesions in 88% of cases. This study has shown that patellar tendinitis may be identified with all three modalities. Ultrasound is recommended as the initial investigation in the assessment of patients with this condition. Davies, S.G., Baudouin, C.J., King, J.B. & Perry, J.D. (1991). *Clinical Radiology* **43**, 52–56. Ultrasound, Computed Tomography and Magnetic Resonance Imaging in Patellar Tendinitis

Patellar tendinitis is an inflammatory condition of the infrapatellar tendon which is seen most commonly in athletes who participate in sports where explosive extension of the knee joint occurs, e.g. in activities such as jumping, running and kicking (Grossman and Nicholas, 1977; Nance and Kaye, 1982). This affliction has been termed 'Jumper's Knee' when confined to the patellar pole (Blazina *et al.*, 1973; Roels *et al.*, 1978) and may severely curtail sporting activity in those affected.

Typically the athlete experiences an insidious onset of aching in the knee, centred over the lower pole of the patella, which usually resolves with rest. As the condition progresses aching may be present at the onset of activity, disappear with further exercise but reappear at rest. In more severe cases the aching is more persistent and is present throughout activity and seriously limits performance.

On examination, there is tenderness of the inferior patellar pole and the adjacent tendon. The latter may be associated with localized swelling. Management of confirmed cases of patellar tendinitis begins with simple measures such as rest and physiotherapy (Grossman and Nicholas, 1977). In more persistent cases injection of steroid around the tendon may be employed. In some cases not responding to these measures surgery may be performed (Mourad *et al.*, 1988).

High resolution ultrasound is recognized as a means of examining the patellar tendon (Fornage *et al.*, 1984; Laine *et al.*, 1987; Fornage and Rifkin, 1988; Harke *et al.*, 1988), enabling the diagnosis of patellar tendinitis to be confirmed. Only limited reports of the use of computerized tomography (CT) (Mourad *et al.*, 1988) and magnetic resonance imaging (MRI) (Bodne *et al.*, 1988) have appeared. This study reports our experience using all three imaging modalities in every patient.

PATIENTS AND METHODS

Sixteen patients with history and examination compatible with patellar tendinitis were referred for ultrasound, CT and MRI examinations (age range 21–46 years; mean 29.8 years). The average duration of symptoms before imaging was 1.9 years (range 0.5–3 years). Six patients had received an injection of steroids prior to imaging. The activities undertaken by the patients were running (7), football (5), jumping (1) and other (3). Following these investigations 15 patients underwent surgery and one patient was managed conservatively.

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The ultrasound examinations were performed on a Diasonics DRF 200 Scanner using a 7.5 MHz probe incorporating an integral water bath. Examination was most easily accomplished in the sagittal plane as this allowed easy identification of the two points of insertion of the tendon (the apex of the patella and the tibial tuberosity). The normal tendon was identified as a linear structure with echogenic walls (paratenon) and an internal speckled pattern arranged longitudinally, due to the collagenous fibrillar structure of the tendon (Fig. 1). The tendon itself is slightly hypoechoic with respect to the surrounding soft tissues. Care must be taken to orientate the probe exactly parallel to the tendon otherwise its insertions may appear falsely hypoechoic (Fornage, 1987). Transverse imaging was performed to confirm the findings. The maximum width of the tendon, as seen on the sagittal view was recorded.

The CT examinations were performed on a Phillips-350 Tomoscan. Contiguous 4.5 mm sections from apex of patella to tibial tuberosity were taken. Viewing was performed on soft tissue settings (window width 400 HU, window level 40 HU). The normal patellar tendon is a thin curvilinear structure of relatively high attenuation (120 HU) (Fig. 2). The maximum antero-posterior width of the abnormal, low attenuation, region was recorded.

MRI was performed on a 0.15 Tesla Picker Prototype system, using a 16 cm diameter cylindrical receive coil. Eight millimetre thick saggital images were obtained using four sequences in all patients.

1 T1 weighted spin echo (TR 544 ms, TE 44 ms)
2 T2 weighted spin echo (TR 1500 ms, TE 80 ms)
3 A short TI inversion recovery (STIR) sequence (TR 1500 ms, TE 44 ms, TI 100 ms) to suppress the signal from fat.
4 T1 weighted partial saturation (TR500 ms, TE 22 ms)

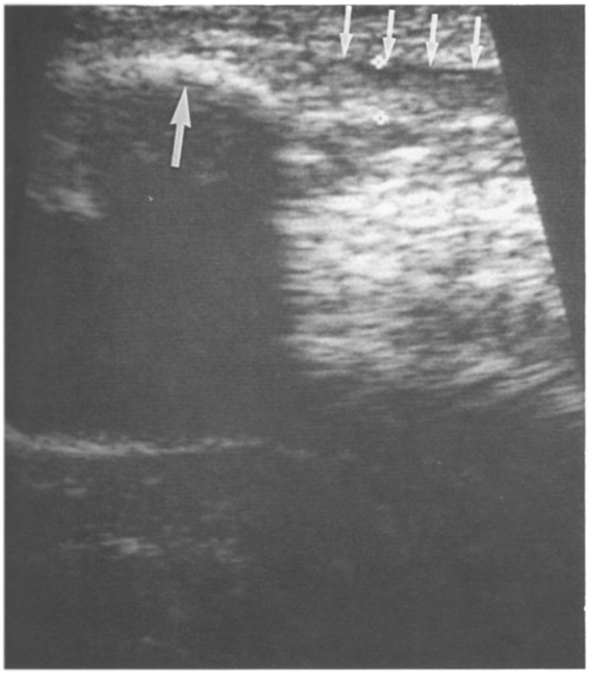

Fig. 1 – Ultrasound scan (saggital) of the insertion of the normal patellar ligament (small arrows) into the patella (large white arrow).

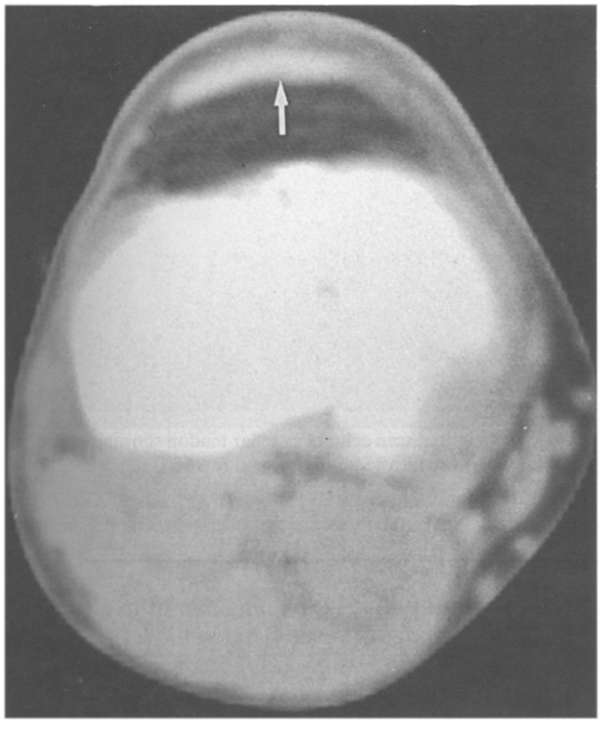

Fig. 2 – CT scan of the normal patellar ligament (white arrow).

Eight millimetre thick transverse sections were obtained using at least one of these sequences at the region of interest.

Three male volunteers with no history of knee disorder were scanned as controls using these four sequences. The normal patellar tendon is of low signal intensity on all sequences due to the lack of mobile protons. It is of uniform thickness (Fig. 3). Measurements of the maximum diameter of focal high signal on any sequence were recorded.

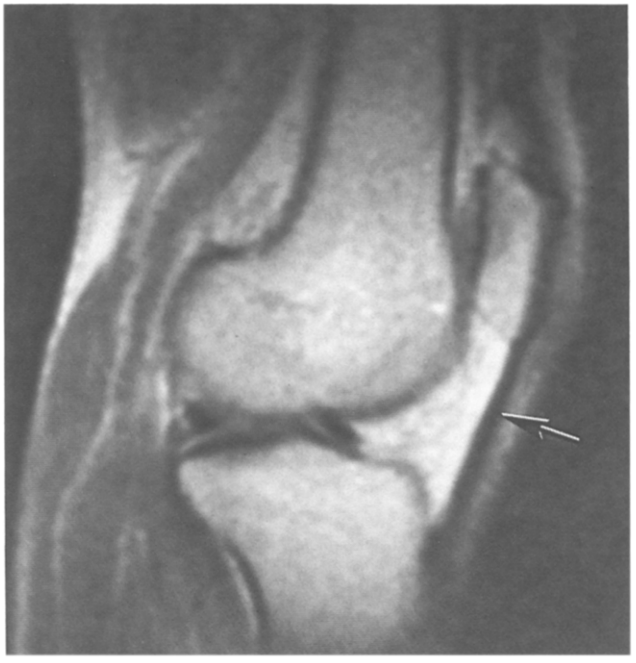

Fig. 3 – Saggital T1 weighted spin echo image of a normal patellar tendon (arrow).

RESULTS

In 14 cases ultrasound demonstrated thickening of the tendon at its upper insertion (when compared with the normal opposite side) (Fig. 4). In one case expansion was present at the mid-point of the tendon and in one case there was expansion at the tibial insertion. In addition all symptomatic tendons demonstrated a disruption of the normal internal echopattern associated with a reduction of echogenicity at the point of maximal thickening. In some cases there were more confluent areas of reduced echogenicity. In the more severe cases tendinous thicken-

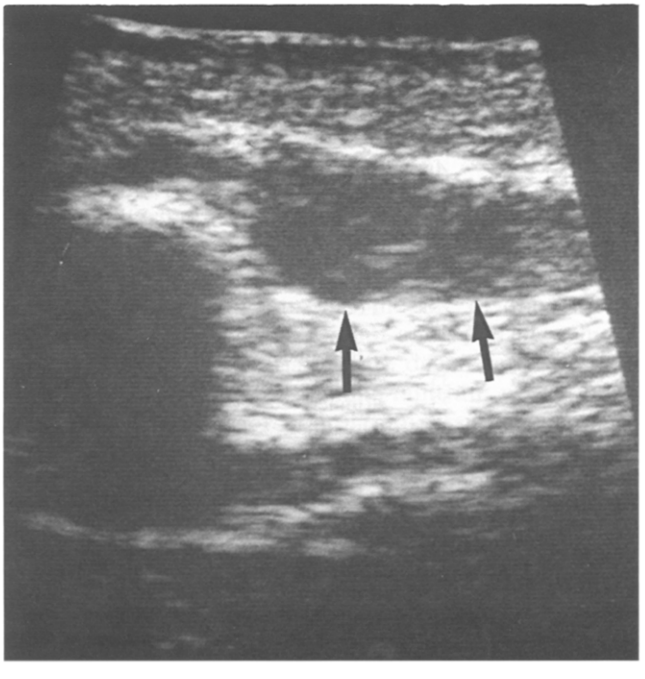

Fig. 4 – Ultrasound of an abnormal patellar tendon with enlargement and reduced echogenicity of the tendon (arrows).

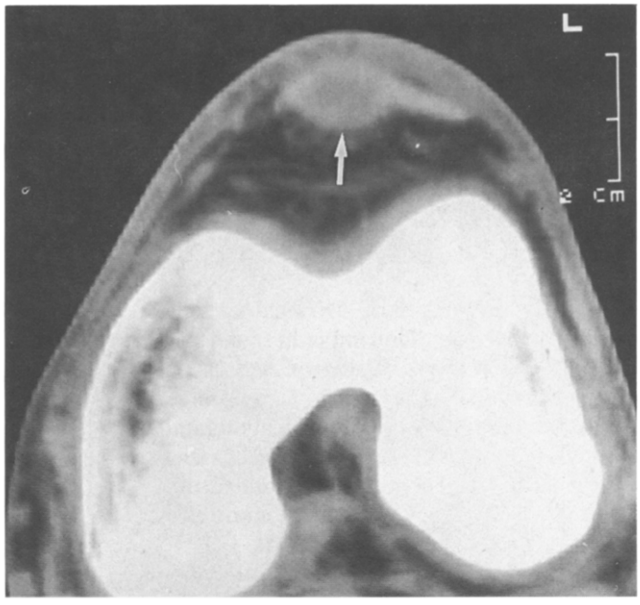

Fig. 5 – CT scan of an abnormal patellar tendon with a central area of expansion and reduced attenuation (arrow).

ing and reduced echogenicity extended throughout the length of the tendon.

CT examination was positive in all 16 cases. The typical appearance was that of a central tendinous expansion at the insertion to the lower border of the patella and progressing for a variable length down the tendon (Fig. 5), except in the two cases described above where in one, expansion was at the mid-point of the tendon, and in the other at the tibial insertion. The expansion of the tendon was in a posterior direction and had a clearly defined posterior border. The central expansion had an attenuation value of 79 HU in attenuation compared with the normal value of 120 HU. There was no correlation between the size of the lesion and its attenuation value. A comparison of the ultrasound and CT results demonstrated good correlation with regard to the site of lesion. With respect to size of lesion, in six (40%) cases there was good correlation and in nine (56%) cases ultrasound estimated the size of the lesion to be smaller than on CT (Table 1).

Focal thickening of the patellar tendon was seen in all 16 patients investigated by magnetic resonance imaging but was graded as only mild expansion in two subjects. In these two cases the ultrasound findings were equivocal, and CT findings positive. In 14 patients the focal thickening was immediately inferior to the patella, in one at the insertion of the tendon into the tibia, and in one patient mild expansion was seen at mid-tendon level.

There was focal signal abnormality within the tendon in 14 patients, which was infrapatellar in 13 and at the tibial insertion in one (Fig. 6). No focal signal change was seen in the two subjects with mild focal expansion of the tendon (one infrapatellar and one mid-tendon). Focal signal change was demonstrated as high signal abnormality on all four sequences used (Figs 7*a–d*, 8). The rate

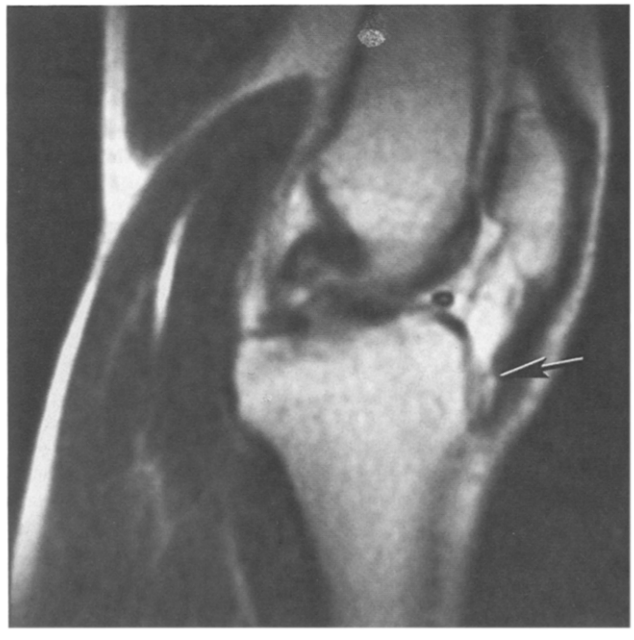

Fig. 6 – T2 weighted spin echo of patellar tendon showing expansion at the tibial insertion with focal high signal (arrow).

Table 1 – Summary of ultrasound, CT, MRI and clinical findings

Case	*Age*	*Sport*	*Side*	*Steroids*	*Duration (years)*	*Size of focal lesion*				*MRI +ve sequences*
						US	*CT*	*(HU)*	*MRI*	
1	26	Football	L	+	1	+	+		+	T2 STIR PS
2	22	Football	L	+	3	+	++	88	+	STIR PS
3	23	Football	L	o	3	++	++	71	+++	T1 T2 STIR PS
4	40	Jogging	R	+	1	+	++	66	++	STIR PS
5	24	All Round	R	+	3	±	+		–	Thickening only
6	33	Squash	R	o	1	++	++		+++	T1 T2 STIR PS
7	23	Runner	R	o	2	+	++	86	++	T1 T2 STIR PS
8	21	Decathlon	L	o	1	+	+		++	T2 STIR PS
9	39	Squash	R	o	2	+	+	60	+	T1 T2 STIR PS
10	36	Football	R	o	1	±	+	104	+	STIR PS
11	26	All Round	L	o	2	++	+	82	++	T2 STIR PS
12	27	Rugby	L	+	3	+++	+++	68	+++	T1 T2 STIR PS
13	42	Runner	R	o	0.5	+	++	78	++	T1 STIR PS
14	28	Runner	L	+	3	±	+	65	–	Thickening only
15	46	Runner	L	o	1	+	++		++	T1 STIR PS
16	41	Runner	R	o	1	+	++	98	+++	T1 T2 STIR PS

+, 0.5–1.0 cm
++, 1.0–1.5 cm
+++, 1.5+
} maximum antero-posterior width of abnormality

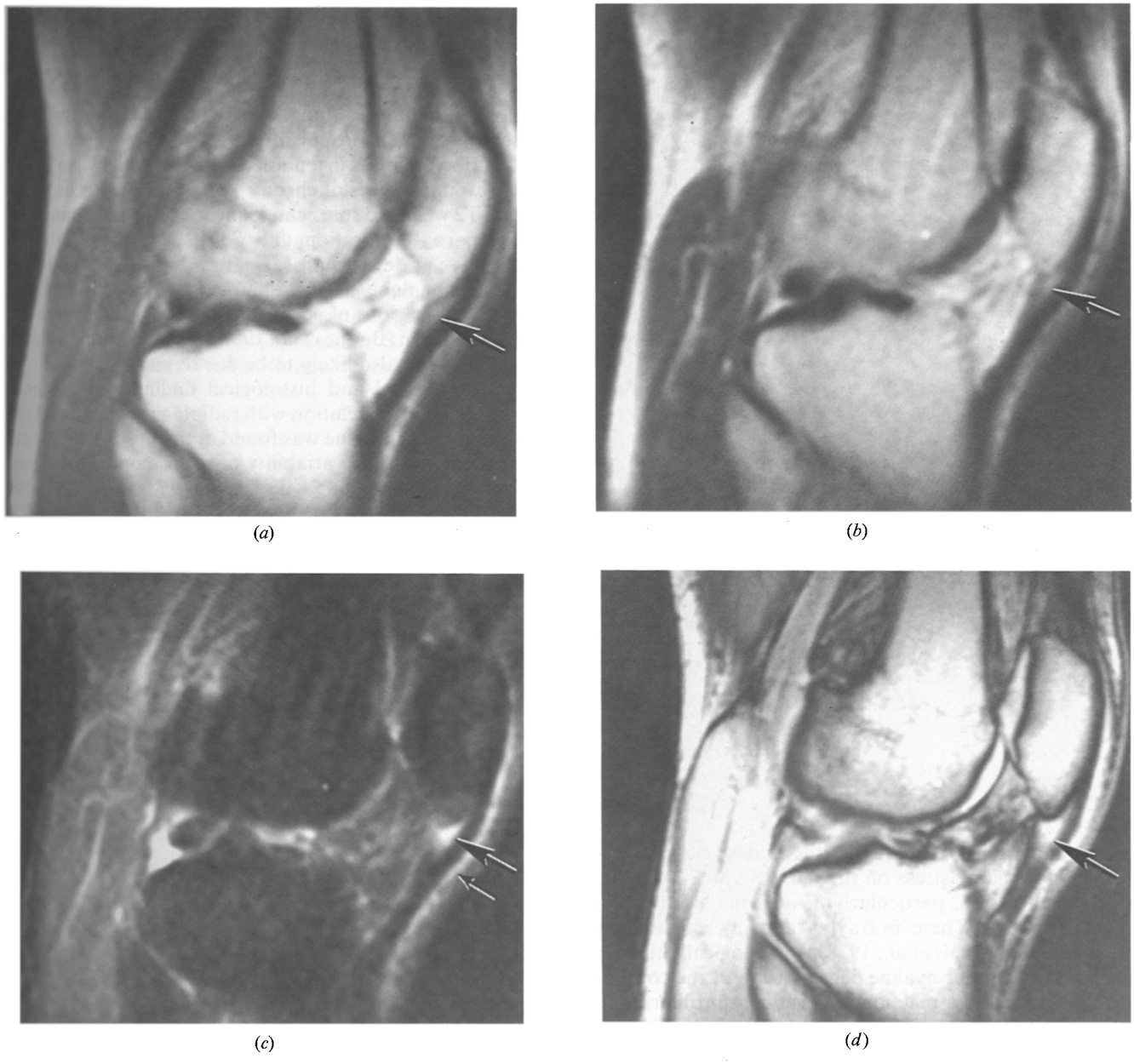

Fig. 7 – (*a*) T1 weighted spin echo. (*b*) T2 weighted spin echo. (*c*) STIR. (*d*) Partial saturation. Patellar tendinitis. High signal areas are seen within the tendon on all four sequences (large arrow). High signal is seen in the subcutaneous fat on the STIR sequence (small arrow).

of detection of focal signal abnormality using the different sequences is shown in Table 2.

In all 14 cases where focal signal change was seen this was present on the STIR and partial saturation images. However, focal signal change was only demonstrated in 57% of these 14 cases in which it was present by the T1 weighted spin echo, and 64% of cases using the T2 weighted spin echo. Thus imaging the patellar tendon using only T1 and T2 weighted spin echo sequences would fail to show a large number of instances of focal signal change.

The partial saturation was judged to be the optimal sequence for detecting signal intensity change in 10 patients.

Signal change in the fat anterior to the tendon was seen in eight patients (Fig. 7*c*) and posterior to the tendon in one patient. Both patients who had previously undergone surgery to the tendon had changes anteriorly. There was no definite correlation of signal changes in fat surrounding the tendon following treatment with steroid injections. Similarly no abnormality was identified on ultrasound or CT in those who had received steroid injections.

In the 15 cases that underwent surgical exploration abnormal tissue was found at the site of abnormality demonstrated on CT, ultrasound and MRI. The histological findings were variable with degenerative change, perivascular inflammatory cellular infiltrate, neovascularization and nodules of granulation tissue occurring in different specimens in varying proportions.

Table 2 – The incidence of focal abnormality detected on different sequences (n = 14)

	Number of scans	*Percentage*
SE 544/44	8	57
SE1500/80	9	64
STIR	14	100
PS 500/22	14	100

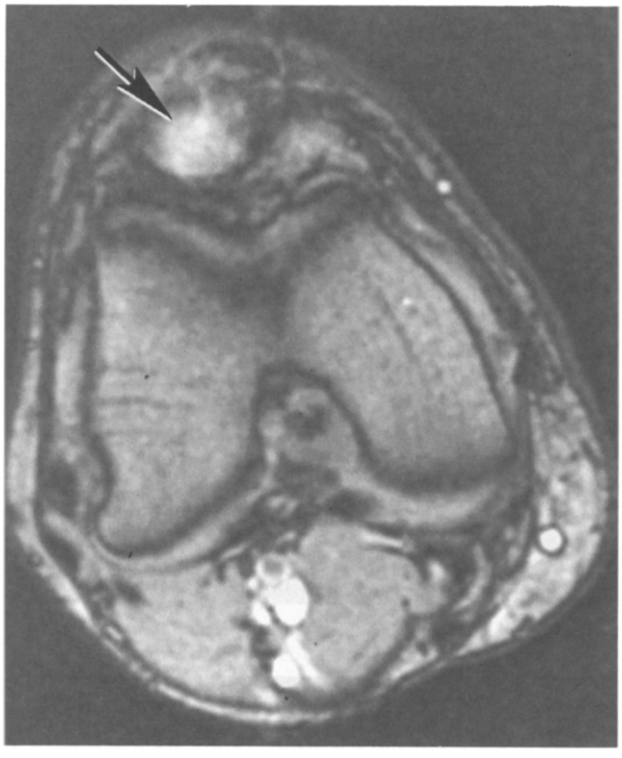

Fig. 8 – Transverse partial saturation image showing high signal within the patellar tendon (arrow).

DISCUSSION

Chronic patellar tendinitis is thought to be a consequence of repeated stress on the tendon which results in focal degeneration, particularly at its point of insertion into the patella. There is fraying and microtearing of collagen fibres (Roels *et al.*, 1978). Pathologically there is fibrinoid, mucoid or hyaline degeneration of the connective tissue. A cellular reaction with vascular proliferation, oedema and increase in volume of the tendon occurs (Fornage and Rifkin, 1988). The resultant tendon is fragile and subject to further partial tearing. In the chronic phase there may be deposition of calcium. The cellular turnover in relation to the tendon leads to a secondary involvement of adjacent bony attachments which gives rise to a 'hot spot' at the apex of the patella on isotope bone scanning (Khan and Wilson, 1987).

The ultrasonic changes of swelling and reduced echogenicity may be interpreted as representing the inflammatory process. The more confluent areas of hypoechogenicity could represent small partial tears (Harke *et al.*, 1988). The observation that in the more severe cases abnormality extended from apex of patella to mid and even lower patellar tendon in continuity is an observation not recorded in a previous study of nine cases (Mourad *et al.*, 1988).

In contrast to the variation in appearances afforded by the better spatial resolution of ultrasound, the CT findings were uniform. Fourteen cases demonstrated focal expansion, of reduced attenuation (79 HU), at the upper insertion of the tendon. CT provided an easy means of confirming the diagnosis.

Magnetic resonance imaging demonstrated focal tendon thickening in all patients with a focal signal change seen in a high proportion (88%). Bodne *et al.* (1988) described changes in tendon thickness and signal intensity in seven instances of chronic patellar tendinitis using T1 and T2 weighted spin echo sequences. We have found that the partial saturation and STIR sequences are more sensitive at detecting focal signal change than spin echo sequences alone. Signal intensity changes are thought to be due to regions of necrosis, inflammation and synovial proliferation (Bodne *et al.*, 1988). Changes seen within fat on MRI are also likely to be due to inflammation.

The surgical and histological findings have demonstrated good correlation with radiological abnormality in that abnormal tissue was found at the site of radiological abnormality. The variability of microscopic histological findings is in keeping with a previous study (Mourad *et al.*, 1988).

In summary, all three modalities were able to demonstrate changes in patellar tendinitis, with good correlation for site of lesion. CT provided an easy method of confirming the diagnosis, but with the drawback of using ionizing radiation. MRI has the advantages of a technique which provides good soft tissue contrast and direct saggital imaging. Ultrasound, however, is recommended as the initial diagnostic investigation because once familiarity has been gained it is a quick and easy means of confirming the diagnosis. CT and/or MRI should be reserved for difficult cases and those where uncertainty exists after ultrasound.

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