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Correlation of Ultrasound and Magnetic Resonance Imaging with Clinical Outcome After Patellar Tenotomy: Prospective and Retrospective Studies

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Objective: To report the appearances of ultrasound (US) and magnetic resonance imaging (MRI) before and after surgery for chronic patellar tendinopathy and to correlate postoperative appearances with clinical outcome.

Design: A 12-month prospective longitudinal study and a retrospective study, each part using different patients. Prospective study included clinical assessment, ultrasound, and MRI all performed before and 12 months after surgery. Retrospective study included ultrasound and clinical assessment only (i.e., no MRI) 24 to 67 months after surgery.

Setting: Institutional athlete study group in Australia (Victorian Institute of Sport Tendon Study Group).

Patients: In the prospective study, 13 patients (all male; 15 tendons) who underwent patellar tenotomy; in the retrospective study, 17 different patients (18 tendons) who had undergone identical surgery.

Main Outcome Measures: Ultrasound and MRI appearances and clinical assessment at baseline and 12 months after surgery (prospective study). Ultrasound appearance and clinical assessment 24 to 67 months after surgery (retrospective study). Dimensions of abnormal regions on imaging were measured. Clinical assessment included categorical rating and numerical Victorian Institute of Sport Assessment (VISA) score.

Results: In the prospective study, preoperative ultrasound and MRI appearances confirmed the clinical diagnosis of patellar tendinopathy. Postoperative ultrasound and MRI also revealed abnormalities consistent with patellar tendinopathy. Despite this, 11 of 15 (73%) tendons were rated clinically as either good or excellent. Imaging modalities were unable to distinguish tendons rated as good or excellent from those rated poor at 12 months. In the retrospective study, ultrasound images revealed abnormalities despite full clinical recovery. There was no correlation between dimension of ultrasound abnormality and either VISA score or time since surgery.

Conclusion: After open patellar tenotomy, MRI and ultrasound findings remain abnormal despite clinical recovery. Thus, clinicians ought to base postoperative management of patients undergoing patellar tenotomy on clinical grounds rather than imaging findings. At present, there appears to be no role for routine postoperative imaging of patients recovering slowly after patellar tenotomy. However, this is not to suggest that imaging cannot play a role in special circumstances.

Key Words: Magnetic resonance imaging—Patellar tendon—Tendinitis—Tendinosis—Tenotomy—Ultrasound.

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Tendinopathy is a common problem in both orthopedic and family practice.[1] When a reasonable course of conservative management fails, surgery is indicated,[2,3] but ~15 to 25% of patients who have undergone tendon surgery have persistent or recurrent tendon pain,[4–10] and even in the best cases, recovery can take 6 to 12 months.[3,5] Thus, it is not uncommon for patients to report only moderate relief of symptoms and inability to return to their desired activity even 6 to 12 months after surgery.[6] Whether or not imaging modalities can distinguish

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between patients whose recovery is merely delayed and those who are destined to have persistent symptoms and need repeat surgery remains unclear.

Some authors contend that magnetic resonance imaging (MRI) is an excellent tool with which to follow tissue healing after tendon surgery.[11] Others suggest that MRI appearances seldom return to normal after surgery of the Achilles, patellar, or rotator cuff tendons.[3,12,13] Ultrasound also has been advocated as a practical tool with which to follow tissue healing after tendon surgery,[11,14] and it has been used to monitor postoperative healing of the Achilles[15] and patellar[11] tendons. It has also been used to image the healing patellar tendon donor site after anterior cruciate ligament reconstruction.[11,16,17] Although advocates of ultrasound claim it is the best radiologic method for evaluating tendons after surgical repair,[3] Fornage and Rifkin[18] warned that ultrasound evaluation of the tendon for recurrent tendinitis after surgery is not reliable. Thus, some radiologists see a role for ultrasound and/or MRI in predicting clinical outcome after tendon surgery, but others do not.

This conflict of opinion is likely to have arisen because there have been no prospective, longitudinal studies that have systematically correlated imaging appearance with outcome of tendon surgery. Anecdotal evidence has determined clinical practice and thus permitted disagreement.

As the clinical utility of postoperative imaging of tendons has not been formally investigated, we undertook an imaging study in patients who had undergone surgery for chronic patellar tendinopathy. Note that this clinical condition has traditionally been labeled as "patellar tendinitis," but this term is losing favor[19] as the underlying pathologic mechanism is degenerative, not inflammatory.[20] We use the term "patellar tendinopathy" for the clinical condition of activity-related anterior knee pain associated with focal tenderness (both before and after confirmation of tendon abnormality by imaging). Patellar tendinosis is reserved as a pathologic diagnosis when tissue is examined histologically.[20,21]

Our primary aim was to correlate 12-month MRI and ultrasound appearances with clinical outcome after patellar tenotomy using a prospective study design. For clarity, this is described as Part A of the study. Our secondary aim was to correlate longer-term postoperative (2–6 years) ultrasound appearance with clinical outcome using a retrospective study design, and this is called Part B.

PATIENTS AND METHODS

Patients

For the prospective study (Part A), we followed 13 athletes (15 tendons) who had undergone ultrasound and MRI immediately before open patellar tenotomy for patellar tendinopathy. These 13 patients were a subset of 28 consecutive patients who underwent patellar tenotomy and whose histopathologic findings are reported elsewhere.[21] Only patients who lived within 200 km of our institution were approached to undertake this study as it required regular clinical and imaging follow-up. All 13 eligible patients entered the study.

For the retrospective ultrasound study (Part B), we recruited 17 additional patients (18 tendons) who had had open patellar tenotomy performed by one surgeon between 24 and 67 months previously.

The research was approved by the Ethics Committee of the Royal Melbourne Hospital (University of Melbourne). All participants provided written consent before entering the study.

Surgical Procedure and Histopathologic Findings

Twenty-nine of the total 33 tendons (Part A, n = 15; Part B, n = 18) had been operated on by the same surgeon. In all 33 operative cases, a transverse skin incision was made just below the inferior patellar pole. The paratenon was then divided, and the proximal patellar tendon split longitudinally over the area of greatest pathologic involvement, as identified clinically and sonographically (see below). All macroscopically abnormal tendon tissue was resected while leaving the bone-tendon interface untouched (i.e., there was no resection or drilling). After securing hemostasis, the tendon was approximated with 3/0 nylon suture, the paratenon closed with 3/0 vicryl, subcutaneous tissue with 3/0 vicryl, and skin with 3/0 subcuticular vicryl. Steristrips and routine dressings were applied.

All tendons in the prospective study (Part A) and 12 of 18 tendons in the retrospective study (Part B) underwent histologic examination. In all cases examined, histology revealed patellar tendinosis.[20–22]

Clinical Assessment

In the prospective study (Part A), patients were interviewed and examined before and then every 3 months for 12 months after surgery. To determine 24-month postoperative outcome, patients were interviewed by telephone. In the retrospective study, patients were interviewed at the time of ultrasound examination (24–67 months after surgery).

We used two clinical outcome measures in both the prospective and the retrospective studies. The first was an overall rating of postoperative outcome (surgical outcome) according to conventional criteria: excellent, returned to preinjury level of sport without pain, tenderness, or limitation of activity; good, mild pain during vigorous activity, slight tenderness at the involved patellar pole, but no restriction of activity; poor, unable to resume activity without pain or moderate to severe pain and tenderness at the involved region as well as severe restriction of activity. The second rating system was the Victorian Institute of Sport Assessment (VISA) functional score, which quantifies pain and disability in patellar tendinopathy from 0 (maximal disability and pain) to 100 (asymptomatic).[23,24]

Ultrasound Imaging and Analysis

Prospective Study (Part A)

In the prospective study, all tendons were examined sonographically before and 12 months after surgery (range 12–18 months). All ultrasound images were obtained by one radiologist using a high-resolution linear-array 10-MHz ultrasound transducer (Acoustic Imaging Dornier) in both the sagittal and the axial planes. Although the radiologist knew that patients had had patellar tendon surgery, he was blinded to whether or not they had persisting knee pain. The radiologist measured the size of any hypoechoic region in the transverse plane at its maximal dimensions using electronic calipers. The approximate cross-sectional area of each hypoechoic abnormality, at its greatest dimension on the transverse image, was calculated by using the formula for area of an ellipse ($\pi \times AB$).[25] Reproducibility of measurement of the size of the hypoechoic regions on the transverse scan has a correlation coefficient of 0.74 (width), 0.94 (depth), and 0.92 (area) in the hands of this radiologist using this instrument.[26] Results are reported as areas (mm^2) at both baseline (before surgery) and 12-month follow-up and also as percentage change (i.e., difference between follow-up and baseline expressed as a percentage of baseline). As measurement of areas in the sagittal plane is not reliable,[26] it was not undertaken in this study.

Reliability Study (Part A)

When the prospective data collection ended, all preoperative and postoperative imaging examinations were prepared as unmarked images. On two separate occasions, and blinded to the patients' clinical status, the radiologist recorded whether films appeared to represent imaging of tendons before or after surgery, and ranked the 12-month postoperative images in order of increasing abnormality. The radiologic ranking was compared with the clinical ranking (VISA score).

Retrospective Study (Part B)

The ultrasound images for the retrospective study were acquired by the same radiologist using the same protocol but with an HDI 3000 scanner (Advanced Technology Laboratories, Bothell, WA, U.S.A.) equipped with a 12-MHz linear-array scanner. The HDI 3000 scanner was used because our imaging department upgraded its equipment in the interval between the prospective (1994–1997) and the retrospective (1998) study.

Magnetic Resonance Imaging

The MRI studies were undertaken in the prospective, but not the retrospective, study. In eight patients, MRI studies were acquired using high-field (1.5 T) equipment (General Electric, Milwaukee, WI) at our university radiology department immediately before surgery (nine tendons) and a minimum of 12 months (range 12–18 months) after surgery. Only operated knees were examined. Multiple sagittal and axial sequences were obtained using a 3-inch surface coil placed directly over the patellar tendon, as reported elsewhere.[21]

The following sequences were used in this analysis: for T_1-weighted sagittal spin echo imaging, repetition time = 400 msec, echo time = 20 msec, section thickness = 3.0 mm with no gap, field of view = 12 cm, matrix = 256 × 256, signals acquired = 2, imaging time = 3 minutes, 31 seconds; for T_2-weighted sagittal fast spin echo imaging with fat saturation, effective echo time = 110 msec, repetition time = 3,000 msec, echo train length = 8, field of view = 12 cm, section thickness = 3.0 mm with no gap, matrix = 512 × 256, signals acquired = 2, imaging time = 3 minutes, 24 seconds; and for two-dimensional T_2*-weighted sagittal gradient-recalled echo (GRE) imaging, repetition time = 800 msec, echo time = 30 msec, flip angle = 70°, field of view = 12 cm, section thickness = 3.0 mm with no gap, matrix = 256 × 256, signals acquired = 1.5, imaging time = 5 minutes, 10 seconds. Other sequences have not been shown to provide additional information in patellar tendinopathy.[21]

Magnetic Resonance (MR) Analysis

Definitive qualitative and quantitative MR analysis for this study was performed by two board-certified radiologists who were blinded to patients' clinical status throughout analysis. Radiologists began image analysis by independently determining whether the images appeared normal or abnormal. Once this had been done (and they agreed in all cases that images were abnormal), they conferred to choose one sagittal T_1-weighted image that contained the largest region of abnormal signal and recorded the section position (e.g., 12.12 right). They evaluated the T_1 sequence qualitatively and used the section position to select corresponding T_2*-weighted GRE and fast spin echo sagittal sections. The postoperative anteroposterior and superoinferior dimensions of abnormal signal and the anteroposterior tendon depth were measured, and results were compared with the preoperative findings. Results are reported as areas (mm^2) at both baseline (before surgery) and 12-month follow-up and also as percentage change (i.e., difference between follow-up and baseline expressed as a percentage of baseline).

Reliability Study

Each radiologist independently examined the T_2*-weighted GRE sequences alone and ranked tendons according to degree of abnormal signal from most to least. This procedure was then repeated for the T_2-weighted fast spin echo sequences. The MRI rankings were compared with the clinical ranking (VISA score).

Statistical Methods

Statistical analyses were performed using StatViewSE+ (Abacus Computing, Berkeley, CA). Preoperative and postoperative numerical data were compared using the paired t test. The mean areas of imaging abnormality in the excellent, good, and poor outcome groups were compared using one-way analysis of variance. Test-retest and interobserver reliability for categorical data were calculated using Cohen's κ.[27] All correlations were performed using Spearman's rank correlation (r_s).

RESULTS

Patients

At the time of surgery, the 13 patients in Part A (all men) ranged in age from 20 to 42 years (mean 31 years, SD 9 years) and had had symptoms for between 9 and 96 months (mean 36 months, SD 31 months). The sport that each patient considered the main cause of symptoms was basketball (six cases), running (five), karate (one), and cricket (one).

At the time of surgery, the 17 patients in Part B (1 woman, 1 female tendon) ranged in age from 18 to 41 years (mean 27 years, SD 8 years). Before surgery, symptoms had been present for 6 to 48 months (mean 18 months, SD 15 months). Sports played were basketball (n = 6), football codes (n = 5), cricket (n = 5), and track (n = 1).

Clinical Features and Functional Assessment

For patients in Part A, the postoperative outcome at 12 months was excellent in seven tendons (46%), good in four (27%), and poor in four (27%). This measure of clinical improvement was mirrored by the VISA score. The median (range) VISA score was 22 (4–60) before surgery, and it improved after surgery to 51 (22–77) at 6 months and 69 (55–100) at 12 months (Table 1). Twenty-four-month surgical outcome paralleled 12-month outcome (seven excellent, five good, three poor).

In the retrospective study, at a mean of 3.9 years (range 2.0–5.7 years) after surgery the median VISA score was 90 (range 55–100), which represents high-level pain-free function. By categorical clinical rating, 16 tendons were reported as either excellent (6 cases) or good (10) and 2 were reported as poor.

Ultrasound Results

Qualitative Analysis: Prospective Study (Part A)

In every case, preoperative sonography revealed a focal hypoechoic area combined with various degrees of increase in diameter of the surrounding tendon, particularly on the deep surface (Fig. 1A). All postoperative ultrasound scans (Fig. 1B) contained a hypoechoic region; that is, none could be reported as "normal" (Table 1).

Postoperative ultrasound images all revealed areas of relative hypoechogenicity compared with normal tendon (Fig. 1B). Comparison of cases with excellent (Fig. 2A) and poor (Fig. 2B) postoperative outcome failed to reveal consistent differences in the size or echogenicity of hypoechoic regions within these surgical outcome categories (Fig. 2). This impression was confirmed by the poor correlation between the radiologists' qualitative ranking of 12-month ultrasound images and the clinical ranking (r_s = −0.11). Calcium was present in the ultrasound scans of patients with excellent (present in three of seven), good (two of four), and poor (two of four) clinical outcomes.

Quantitative Analysis: Prospective Study (Part A)

When all 15 tendons were analyzed, there was no difference between cross-sectional area of the hypoechoic region before surgery and that 12 months after surgery (Table 1). After surgery, the mean cross-sectional areas of hypoechogenicity in the excellent (88 mm^2), good (98 mm^2), and poor (89 mm^2) categories did not differ from each other. There was no consistent trend in percent change in area of hypoechogenicity from baseline in the three outcome categories. For example, the seven patients with excellent outcomes included two with substantial decreases in area, one with a small decrease, and four in whom the area of hypoechogenicity increased substantially after surgery. There was no correlation between size of hypoechoic area on ultrasound and clinical outcome as measured by VISA score (r_s = −0.12).

The test–retest reliability, κ, of the radiologist in categorizing the ultrasound images as either preoperative or postoperative was 0.51 ($p < 0.05$). Thirty-four of 42 (81%) tendon cases were correctly labeled as pre- or postoperative. When the 15 ultrasound images were ranked twice according to severity of abnormal echogenicity, correlation was good (r_s = 0.76). When the first sonographic ranking was compared with the clinical ranking, the correlation was poor (r_s = −0.11).

Retrospective Study (Part B)

In the retrospective study, 3 of the 18 tendons (17%) were sonographically normal. The remainder contained hypoechoic regions measuring a mean of 53 mm^2 (range 9–89 mm^2). Nine tendons also contained hyperechoic

TABLE 1. *Prospective study (Part A): clinical and imaging features before and 12 months after surgery in athletes who underwent patellar tenotomy for proven patellar tendinosis*

Clinical and imaging characteristics	Before surgery	12 Months after surgery
Clinical (n = 15)		
median VISA score (0–100)	22 (4–60)	69 (55–100)*
Ultrasound (n = 15)		
normal appearance of tendon (n)	0	0
mean cross-sectional area of abnormality (axial image · mm^2)	95 (16–236)	91 (11–151)
Magnetic resonance imaging (n = 8)		
normal appearance on T_2* GRE	0	0
area of the largest abnormal signal region (mm^2)		
on T_2* GRE	390 (120–800)	540 (220–890)
on T_2 FSE	180 (40–500)	170 (45–310)†

* $p < 0.001$, before surgery versus after surgery (paired t test).
† $p < 0.01$ for FSE versus GRE sequences.
Values are presented as mean (range) unless indicated.
VISA = Victorian Institute of Sport Assessment; GRE = gradient-recalled echo; FSE = fast spin echo.

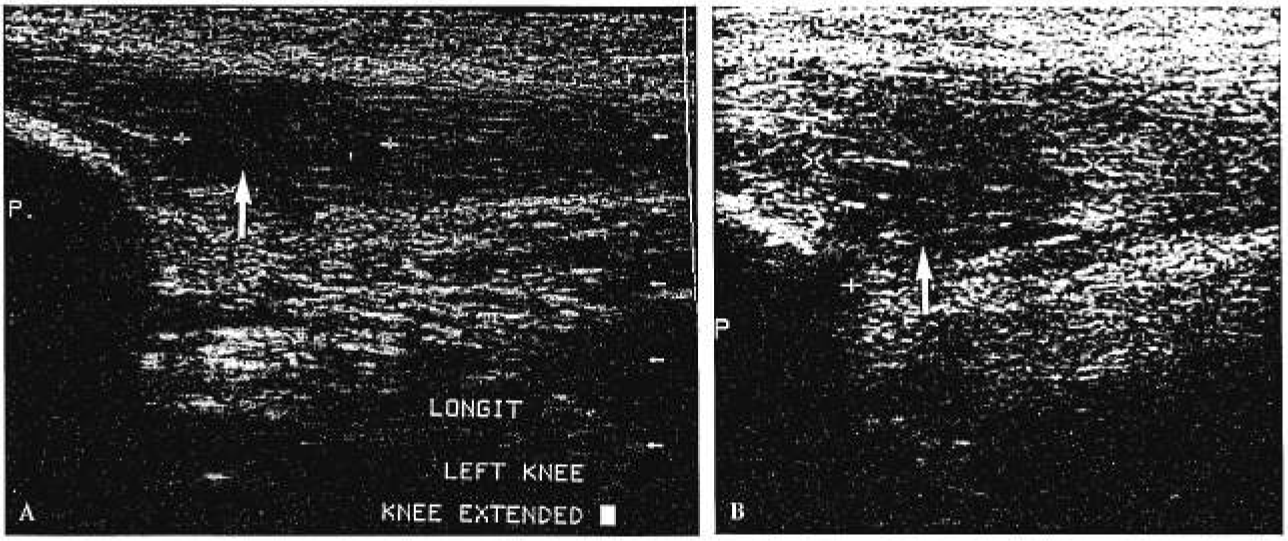

FIG. 1. Patellar tendon ultrasound appearances before and after open patellar tenotomy in a 33-year-old patient, as shown on longitudinal scans obtained before **(A)** and 12 months after **(B)** surgery. Although this patient had an excellent surgical outcome and had returned pain-free to running at 12 months, ultrasound findings were clearly abnormal, with large hypoechoic areas **(arrows)**.

regions, consistent with calcification. There was no correlation between size of hypoechoic region and patients' clinical status as measured by VISA score ($r_s = 0.17$). Further, there was no correlation between time since surgery and size of hypoechoic area ($r_s = 0.23$).

Magnetic Resonance Imaging Results (Part A Only)

Qualitative Analysis

Before surgery, each tendon studied contained a region of increased signal intensity relative to the tendon on the sagittal T_1-weighted images and the sagittal T_2*-weighted GRE (Fig. 3A) and fast spin echo images. All postoperative MRI scans were abnormal. In three cases, high-signal regions were less obvious than before surgery, and in seven cases, high signal remained over a substantial area (Fig. 3B). The appearances of patients whose surgical outcome was excellent (Fig. 4A) did not differ qualitatively from those whose surgical outcome was poor (Fig. 4B).

Quantitative Analysis

Mean cross-sectional area of the high-intensity abnormal signal region on the T_2*-weighted GRE and the T_2-weighted fast spin echo sequences did not change significantly between the preoperative and postoperative MRI scans (Table 1). Twelve months after surgery, there were no differences between the area of abnormal signal in the excellent (460 mm^2), good (570 mm^2), and poor (590 mm^2) surgical outcome categories on either of the T_2-weighted sequences. The mean area of the largest abnormal signal region on the T_2* GRE sequence was significantly larger than on the T_2 fast spin echo sequence ($p < 0.01$). Percentage change in high signal intensity area between tendons before surgery and 12

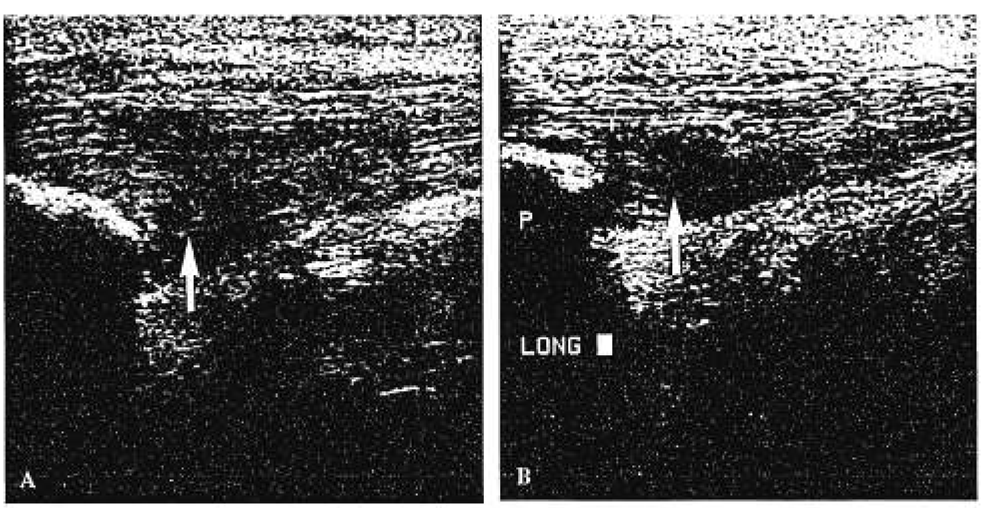

FIG. 2. Patellar tendon ultrasound appearances in two patients with vastly different clinical outcomes 12 months after surgery. **(A)** Longitudinal ultrasound image of a 39-year-old patient with an excellent clinical outcome. **(B)** Ultrasound image obtained in a 27-year-old patient with a poor clinical outcome. Despite the difference in clinical outcomes, both scans reveal large hypoechoic areas in the patellar tendon **(arrows)**.

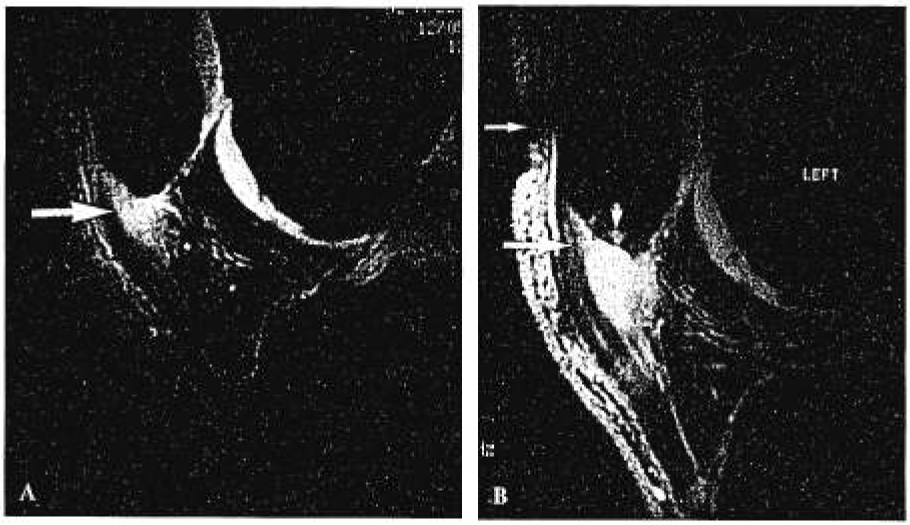

FIG. 3. T_2*-weighted gradient echo images of the patellar tendon in a 42-year-old patient before **(A)** and 12 months after **(B)** surgery. This patient had a good surgical outcome at 12 months despite the persistence of a large area of increased signal within the patellar tendon **(large arrows)**. In the postoperative image **(B)**, note the region of decreased signal in the subcutaneous tissue **(medium arrow)** and the bone edema present in the inferior pole of the patella **(small arrow)**.

months after surgery varied greatly within each outcome category.

There was good agreement between the two radiologists in ranking patients' MRI sequences in order of decreasing abnormality (intertester agreement r_s = 0.72 for T_2*-weighted GRE MRI, r_s = 0.93 for fast spin echo MRI). However, these rankings of imaging abnormality did not correlate with clinical ranking (r_s = 0.38 and −0.05). Similarly for T_2-weighted fast spin echo image ranking, the radiologists' correlations with the clinical ranking were −0.05 and 0.07.

DISCUSSION

This is, to our knowledge, the first study designed to critically evaluate the utility of postoperative imaging after surgery for tendinopathy—the clinical syndrome previously known as "tendinitis." [19] We used a prospective study design (Part A) to test clinicoradiologic correlation at 12 months and to determine whether imaging appearance predicted subsequent clinical outcome up to 2 years. We used a retrospective study design (Part B) to obtain corroborative evidence from a longer-term perspective and in a larger cohort than would have otherwise been possible. This study is the first to report reliability of interpretation of tendon imaging in the postoperative setting.

The proportion of successful outcomes after open patellar tenotomy at 12 and 24 months in our study was almost identical with those found in large surgical outcome studies of 138[9] and 48[4] cases. This suggests that our sample is representative of the larger population of patients undergoing patellar tenotomy.

Correlation Between Ultrasound and Clinical Findings

We found, both qualitatively and quantitatively, that ultrasound images remained clearly abnormal 12 months

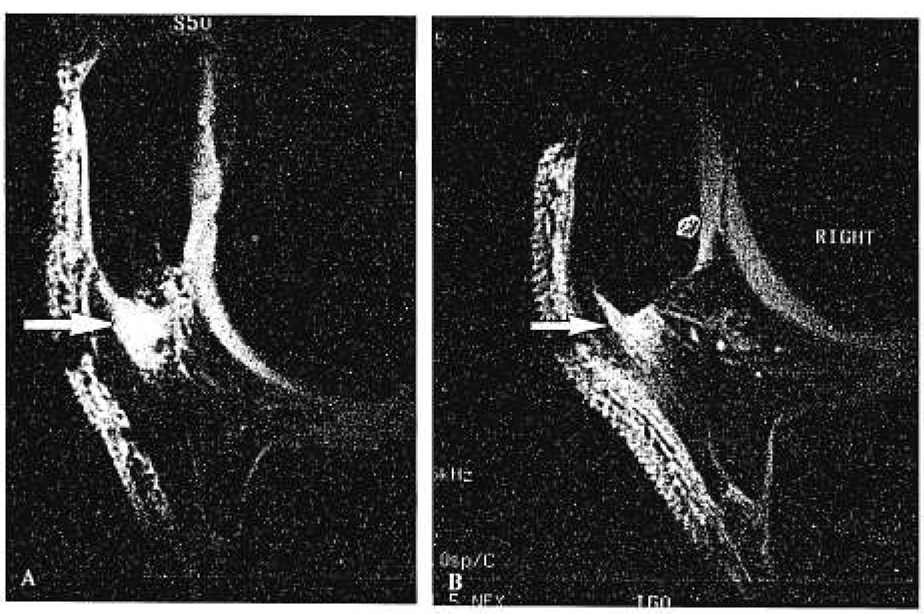

FIG. 4. T_2*-weighted gradient echo images of the patellar tendon from two patients with vastly different clinical outcomes 12 months after surgery. **(A)** Magnetic resonance image of a 39-year-old man with an excellent clinical outcome. **(B)** Magnetic resonance image obtained in a 27-year-old man with a poor clinical outcome. Despite the difference in clinical outcomes, both images demonstrate residual marked increased signal of the patellar tendon **(arrows)**.

after surgery, even in athletes who had returned pain-free to full competition (Fig. 2A). A small number of case reports (using retrospective design) have suggested that ultrasound images may remain abnormal after clinical recovery from surgery,[18,28,29] but these findings appear to have been ignored in clinical practice. The prospective nature of this study provides the most convincing evidence to date that ultrasound ought not be used routinely to monitor postoperative tendon healing. The cross-sectionally acquired data of patients 24 to 67 months after patellar tenotomy provided further evidence that ultrasound appearance is not correlated with clinical outcome (Fig. 2).

In both the prospective and the retrospective study, hyperechoic signal consistent with calcium deposition was present in patients with excellent, good, and poor outcomes. The lack of correlation between tendon calcification and symptoms of patellar tendinopathy has been noted previously in asymptomatic elite athletes.[30]

Radiologic ultrasound interpretation itself was reproducible: The sonologist was able to correctly label pre- and postoperative films and reproducibly rank films in order of sonographic abnormality. However, the qualitative ultrasound ranking of abnormality did not mirror clinical outcome. The lack of correlation between ultrasound findings and clinical outcome is consistent with the finding that asymptomatic athletes can have sonographically abnormal tendons[25,26,30–32] and that patients who have recovered successfully from patellar tendon surgery often have persisting sonographic abnormalities.[5]

Correlation Between MRI and Clinical Findings

We found that T_1- and T_2-weighted images did not regain their normal appearance for in excess of 12 months after successful patellar tenotomy. This finding is consistent with findings from a 12-month longitudinal study of the patellar tendon anterior cruciate ligament donor graft site.[33] At 3 years after tenotomy, however, tendon appearance may return to normal.[34]

In this study, the area of abnormal signal persisted longer in T_2*-weighted GRE images than in T_2-weighted fast spin echo images. McLoughlin et al.[35] reported appearances of tendons using these two imaging sequences (with gadolinium) in unoperated cases of patellar tendinopathy. In our cases, after surgery neither MRI sequence alone nor both sequences viewed together helped differentiate between patients with successful recovery and those with a poor outcome.

Although abnormal signal in the T_2-weighted fast spin echo images diminished more consistently than in the T_2*-weighted GRE images, both sequences remained abnormal in patients with successful outcomes. Further, practitioners working in the clinical setting (as opposed to a research setting) would generally not have the benefit of serial MRI scans and would therefore not know whether signal intensity was diminished relative to previous (e.g., 6-month) images.

Increased tendon high signal intensity on T_2*-weighted GRE images can arise from the "magic angle" phenomenon.[36] However, this does not appear to underlie our finding for several reasons. First, in our MRI coil arrangement, the proximal patellar tendon coursed at <30° to the constant magnetic induction field (Figs. 3 and 4). Second, the region of increased signal intensity affected only the posterior part of the tendon despite both anterior and posterior portions of the tendon running parallel. Third, abnormal signal extended into the paratendinous fat deep to the tendon. Fat does not possess the properties of collagen that permit the magic angle phenomenon.[37] Finally, and significantly, areas of abnormal T_2*-weighted GRE signal corresponded with areas of abnormal signal on T_1-weighted and T_2 fast spin echo MRI and hypoechogenicity on ultrasound. We do, however, note the presence of the magic angle phenomenon at the tibial insertion of the patellar tendon where the tendon coursed at 55° to the magnetic field in some patients.

The MRI reliability study revealed that experienced radiologists intimately familiar with the condition of patellar tendinopathy were in agreement about the ranking of severity of abnormality on MRI. However, the MRI ranking did not correlate with clinical ranking. As was the case with ultrasound discussed above, this suggests that the abnormal signal detected on MRI does not necessarily underlie the symptoms reported by patients after surgery. Abnormal MRI signal has previously been shown in tendons of asymptomatic subjects.[38,39] MRI may, however, reveal other pathologies that may contribute to pain, such as chondral damage in nearby joint surfaces and rare conditions such as a patellar tumor.

Study Limitations

Although the strengths of study design have been outlined above, limitations were also present. All patients who underwent surgery were competitive sportspeople, so the results may not be generalizable to individuals who develop patellar tendinopathy due to work-related activities or to those who develop symptoms while being inactive (an uncommon phenomenon). Also, the prospective study was restricted to those patients who lived within 200 km of a major city center. Although this is unlikely to confound our result that imaging appearances did not correlate with clinical findings, it does make our overall clinical outcome data (73% good or excellent results) prone to ascertainment bias. However, these results fit well within the range reported in a recent review of 22 studies concerned with surgery in patellar tendinopathy.[6]

We note that Parts A and B of the investigation were performed on different instruments. Each instrument, however, has been shown to be reliable for detecting the presence or absence of hypoechoic lesions on ultrasound. Further, as all of Part A was undertaken using one ultrasound scanner and all of Part B was undertaken using the other, there was no comparison of results across scanners.

Conclusion

Both ultrasound and MRI are very sensitive to abnormal tendon morphology, so imaging abnormalities can occur without the patient having symptoms.[30,39,40] The fact that abnormal imaging results do not necessarily reflect clinically significant pathologic involvement is a fundamental axiom of radiology, but one that bears reemphasis at a time when clinicians are relying increasingly on imaging results for diagnosis.[40]

Our finding that after patellar tenotomy, even in asymptomatic patients, imaging abnormalities persist at least 12 months (MRI) and up to 6 years (ultrasound) contradicts numerous assertions in the literature[11,14,29] and provides two clinical corollaries. First, it reinforces that, in general, clinicians ought to base post-patellar tenotomy management on clinical grounds rather than imaging findings. Second, it suggests that, at present, there is no role for routine postoperative imaging to monitor the progress of patients recovering slowly after tendon surgery.

However, this is not to suggest that imaging cannot play a role in certain circumstances. If, for example, imaging revealed that the tendon was morphologically normal (which would generally occur only ≥12 months after surgery), this would direct attention to other possible sources of the patient's symptoms. If dehiscence of the tendon was suspected, imaging could prove confirmatory and thus aid in the decision to reoperate. Also, the surgeon may wish to image the tendon to plan the site of repeat surgery.[22] Our findings should not be generalized to postoperative appearance of other tendons.

We hope that future innovations in MRI sequence development or in ultrasound technology (e.g., color Doppler ultrasound)[32] will provide clinicians with the information they need when faced with a patient with difficult tendinopathy after surgery. In the meantime, however, evidence-based radiology dictates that negative results be aired[41] to prevent inappropriate use of imaging.

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