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# Color Doppler Ultrasound Findings in Patellar Tendinopathy (Jumper's Knee)

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**Background:** Recent studies have revealed structural changes with neovessels in patients with jumper's knee and Achilles tendinopathy, and treatment with sclerosing injections has shown promising clinical results.

**Purpose:** To study the prevalence of neovascularization and structural tendon changes on color Doppler ultrasound examination in elite athletes with clinical symptoms of jumper's knee and to examine the ultrasound characteristics of the tendon after sclerosing injection treatment with polidocanol.

**Study Design:** Cohort study; Level of evidence, 3.

**Methods:** The authors recruited patients among elite athletes with a clinical diagnosis of jumper's knee who participated in a previous randomized clinical trial. The patients recorded knee function using the Victorian Institute of Sport Assessment score. Patients were examined by color Doppler ultrasound at baseline and, for patients with structural changes and neovascularization who received sclerosing treatment, after treatment.

**Results:** Sixty-three patients (11 women and 52 men) with 79 symptomatic tendons were studied. The ultrasound examination revealed that neovascularization was present in 48 of the 79 tendons (60%). Of 33 patients (43 tendons) who received sclerosing injections, 29 patients (37 tendons, 86%) were examined 37 (19 to 53) weeks after their final sclerosing injections. Of these, 7 tendons (18.9%) had no change in neovascularization after treatment, 21 tendons (56.8%) had less neovascularization, and 9 tendons (24.3%) had more visible neovascularization. There were no significant differences in the change in Victorian Institute of Sport Assessment score between patients who had less, more, or unchanged neovascularization after treatment (analysis of variance,  $P = .9$ ).

**Conclusion:** About two thirds of patients with jumper's knee can be expected to have structural tendon changes with neovascularization. There was no relationship between changes in ultrasound characteristic and knee function after sclerosing treatment.

**Keywords:** patellar tendinopathy; color Doppler ultrasound; neovascularization; sclerosing therapy; tendon changes

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In 2 early studies, Weinberg et al<sup>20</sup> and Terslev et al,<sup>18</sup> using color Doppler ultrasound examination, showed that

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neovessels can be demonstrated in some patients with jumper's knee. In a study on the midportion Achilles tendon, color Doppler ultrasound revealed neovascularization in the painful area with structural changes in tendons with chronic tendinosis but not in pain-free normal tendons.<sup>15</sup> We later showed that an eccentric exercise program stopped the flow in these vessels and that the patients became symptom free.<sup>11,14</sup> In another study on active jumping athletes, the presence of neovascularization in abnormal patellar tendons was associated with more tendon pain than in abnormal tendons without neovascularization.<sup>5</sup>

Taken together, these findings led to the hypothesis that the vessels, and possibly the nerves accompanying the vessels, were involved in the pain mechanism in chronic painful Achilles tendinosis. This hypothesis led to a pilot study of a new treatment method with sclerosing of these vessels,<sup>12,13</sup> which showed promising results in patients with midportion Achilles tendinosis. In a recent randomized controlled trial of 42 patellar tendons with tendinopathy, injection treatment with the sclerosing agent polidocanol showed convincing clinical results in this group as well.<sup>6</sup> The area with neovascularization/increased blood flow is the target area for sclerosing injection treatment. However, in tendons clinically diagnosed with jumper's knee, it is not known how many display neovascularization and could be suitable for treatment. Also, it is of interest to follow the ultrasound characteristics of the patellar tendon after sclerosing treatment with polidocanol because it is not known how such treatment affects tendon structure and vessels.

Therefore, we wanted to study a number of elite athletes with clinical symptoms of jumper's knee to see how many displayed neovascularization and to study the posttreatment color Doppler ultrasound characteristics of the tendons included in the randomized trial<sup>6</sup> after sclerosing treatment.

## MATERIALS AND METHODS

### Patient Recruitment

We recruited patients by contacting clubs and players in the elite division in basketball, team handball, and volleyball for both male and female players in the southern part of Norway with an invitation to take part in a clinical examination. The coach and the club were informed of the purposes and procedures of the study by letter (mid-March 2004), and we visited each of the clubs to inform the players of the purposes and procedures of the study toward the end of the competitive season at a time convenient to them. After an oral presentation, the players were asked to take part in a clinical screening examination, in which they were required to complete a questionnaire detailing their anthropometric details, history of their knee pain, any treatment received, sporting profile, and activity level. Patients who fulfilled the inclusion criteria were invited to the ultrasound screening. In addition, a press release about the study led to coverage in a major newspaper, in which elite athletes from all sports were asked to contact the investigators for a clinical and ultrasound examination in the same way as for the team sports.

The study was approved by the regional committee for medical research ethics, and written consent was obtained from each participant.

### Inclusion Criteria

The inclusion of patients to the baseline ultrasound examination was based on the clinical examination alone. The following diagnostic criteria were used to identify patients with jumper's knee<sup>9</sup>:

- History of pain in the patellar tendon or the patellar tendon insertion into the tip of the patella in connection with training or competition
- Tenderness to palpation corresponding to the painful tendon area
- Symptoms from the patellar tendon for a minimum of 3 months
- Victorian Institute of Sport Assessment (VISA) score (0-100 points) of less than 75 points
- Both knees were included if the patient had bilateral problems

Athletes were excluded if they had a history of knee problems caused by patellofemoral pain syndrome, inflammatory joint conditions, or degenerative conditions. Athletes had to be between the ages of 18 and 40 years. These age limits exclude the diagnoses of Osgood-Schlatter and Sinding-Larsen-Johansson disease in the adolescent athlete and significant osteoarthritis in the older athlete. Participants also had to be residents of Norway and understand oral and written Norwegian.

### Sclerosing Treatment and Follow-Up

The baseline ultrasound examinations were performed in May to June 2005, 1 to 6 weeks after the clinical screening examination. All patients with neovascularization/increased blood flow corresponding to the painful area were invited to be included in a randomized clinical trial to test the effect of sclerosing treatment with polidocanol. Patients without neovascularization were not offered further treatment or follow-up. The design, methods, and clinical results of the clinical trial have been described in detail in a separate article.<sup>6</sup> Polidocanol (Aethoxysklerol, 10 mg/mL, Inverdia AB, Stockholm, Sweden) was used as the sclerosing agent. Patients were randomized to a treatment group, which received polidocanol injections against the area with vessels entering the patellar tendon from the dorsal side of the tendon, or a control group, which initially received similar injections with lidocaine and epinephrine (Xylocaine-adrenalin, 5 mg/mL + 5 µg/mL, AstraZeneca, Oslo, Norway). After 4 months of treatment, the control group was also given active treatment with polidocanol. The patients in both groups received from 1 up to a maximum of 5 injections at 4- to 6-week intervals depending on their pain level and whether there was visible neovascularization after last treatment session. In other words, patients in both groups received polidocanol injections until they had an acceptable clinical result. The posttreatment ultrasound examinations were performed in June through August 2006, that is, 12 to 15 months after the baseline ultrasound examination.

### Ultrasound Examination and Evaluation

Both examinations were performed by the same experienced ultrasonographer (L. Ö.), using high-resolution grey-scale ultrasound with the aid of color Doppler (Philips EnVisor HD, Vingmed AS, Oslo, Norway). A linear, multifrequency

(8-13 MHz) probe (type L12-3) was used, and the pathologic changes in the painful, thickened patellar tendon were registered on a standard form. Color Doppler was used to diagnose vascularity/increased blood flow.

We classified the main ultrasound findings into 3 categories:

- Normal tendons: tendons with a regular and smooth fiber structure without hypoechoic areas or vascular flow (Figure 1A)
- Abnormal tendons with structural changes: tendons with a localized widening, including irregular structure and hypoechoic areas (Figure 1B)
- Abnormal tendons with neovascularization/increased blood flow: tendons with a localized widening, including irregular structure, hypoechoic areas, and vascular flow (1 or several vessels inside the area with structural changes) (Figure 1C)

We also measured the thickness of the tendon before and after sclerosing treatment at the apex, as well as 0.5 cm and 1.0 cm from the apex.

We classified the neovascularization before and after treatment in 4 categories ranked according to the degree of visible neovascularization, in which 0 represents no visible blood vessels, 1 represents 1 to 2 blood vessels (low blood flow), 2 represents some blood vessels (some blood flow), and 3 represents many blood vessels (strong blood flow).

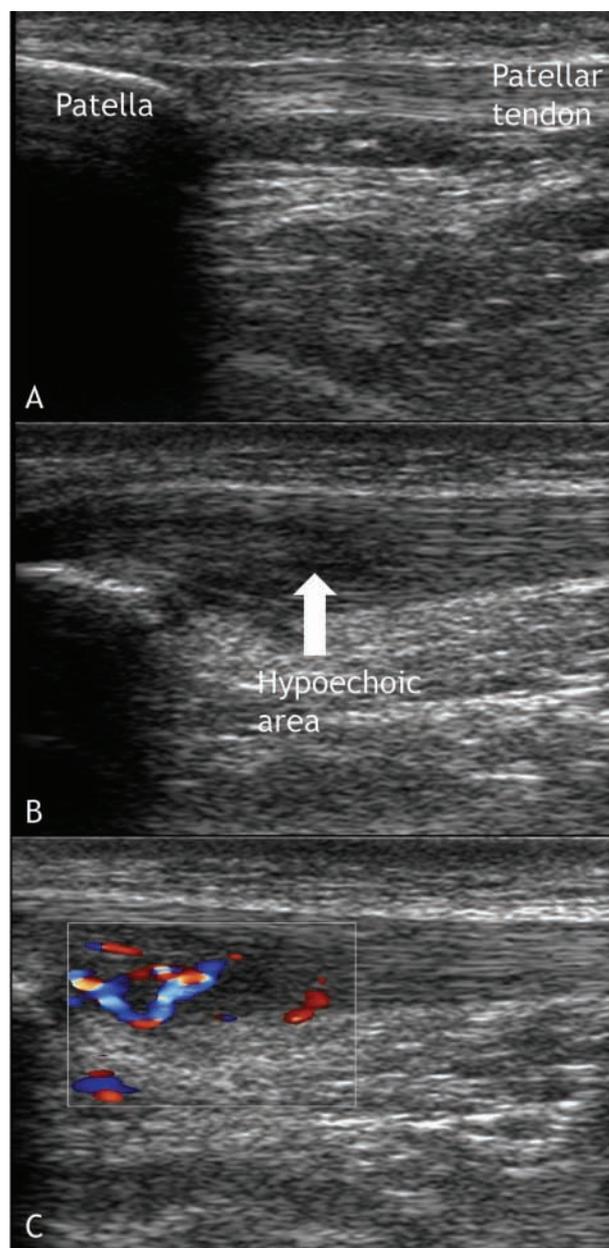
### Symptom Evaluation

Knee function was assessed using the VISA score and a visual analog scale for pain. The VISA score was designed specifically to quantify knee function in persons with patellar tendinopathy and has been shown to be a reliable and valid measure.<sup>4,7,19</sup> The patients self-recorded VISA score separately for each knee during the clinical screening examination and before the ultrasound examinations. At the time of the ultrasound examinations, the patients also self-recorded their knee pain during training the previous 2 weeks on a 10-cm continuous line marked "no pain" on one end and "worst pain" on the other. The 10-cm visual analog scale has been shown to be a reliable and sensitive scale for pain and has been used extensively in orthopaedic investigations.<sup>8,16</sup>

Before the ultrasound examinations, the patients were asked to perform 15 squats on a 25° decline board on the affected leg at a frequency of 15 squats per minute. They were instructed to use 5 seconds for the eccentric part of the squat, to use 3 seconds for the concentric part, and to stop if it was too painful to continue. These squats were done to evaluate their level of patellar tendon pain during the exercises, and this pain level was also self-recorded on a visual analog scale.

### Statistics

Patient characteristics were compared for differences in baseline anthropometry and injury severity. To test the



**Figure 1.** Typical ultrasound appearance. A, normal tendon with regular and smooth fiber structure, no hypoechoic areas or vascular flow. B, abnormal tendon with localized widening, including irregular structure and hypoechoic areas. C, abnormal tendon with localized widening, including irregular structure, hypoechoic areas, and vascular flow (several vessels inside the area with structural changes).

principal null hypothesis, that there was no group difference in VISA scores and pain score in relation to the ultrasound findings, these were compared using analysis of variance (ANOVA) and paired *t* tests.

We used a significance level of 5%, and unless otherwise noted, the results are presented as mean  $\pm$  SD.

## RESULTS

## Patient Characteristics

We examined 63 patients (11 women and 52 men) with 79 tendons having a clinical diagnosis of jumper's knee, that is, 16 patients with bilateral problems (Table 1). The patients primarily represented handball ( $n = 24$ ), basketball ( $n = 10$ ), volleyball ( $n = 9$ ), and football ( $n = 8$ ), but some were also included from ice hockey ( $n = 1$ ), orienteering ( $n = 2$ ), tae kwon do ( $n = 1$ ), boxing ( $n = 1$ ), aerobic fitness ( $n = 1$ ), tennis ( $n = 1$ ), and athletics ( $n = 4$ ). The self-reported VISA score at the time of the clinical screening examination for the 79 symptomatic tendons was  $57 \pm 15$  (range, 15-89).

## Baseline Ultrasound Characteristics

The ultrasound examination revealed that structural tendon changes (thickening with hypochoic areas) and neovascularization were present in 48 of the 79 tendons (60%), whereas 20 of the tendons had structural changes without neovascularization, and 11 were without structural changes. Of the 20 tendons with structural changes without neovascularization, 14 displayed thickening and hypochoic areas, 5 had hypochoic areas only, and 1 was classified as thicker than normal.

There were no differences in age, height, body mass, or training history between players with normal tendons, those with tendons with structural changes, and those with tendons with neovascularization (Table 1). In addition, there was no significant difference in the duration of symptoms between the groups (tendons with neovascularization,  $34 \pm 45$  months; structural changes,  $43 \pm 39$  months; normal tendons,  $27 \pm 23$  months; ANOVA,  $P = .5$ ).

However, the self-reported VISA score at the time of the ultrasound examination was lower for tendons with neovascularization than for tendons with structural changes without neovascularization or tendons with normal ultrasound findings (ANOVA,  $P = .001$ ) (Figure 2).

For the athletes who had the clinical screening examination during the competitive season and the ultrasound examination after the end of the season, with an interval of more than 3 weeks between the 2 examinations ( $n = 50$  tendons), the change in VISA score was significantly greater for tendons with structural changes only compared with tendons with structural changes and neovascularization (ANOVA,  $P = .001$ ). For tendons with structural changes only ( $n = 17$ ), VISA score improved by  $15 \pm 3$  (SE) points from the clinical screening examination until the ultrasound examination, whereas there was no change for tendons with structural changes and neovascularization ( $-2 \pm 2$ ,  $n = 27$ ) or normal tendons ( $4 \pm 4$ ,  $n = 6$ ).

The self-reported pain level at the time of the baseline ultrasound examination was also higher for tendons with structural changes and neovascularization than for tendons with structural changes alone or normal tendons (ANOVA,  $P = .001$ ) (Figure 3). The self-recorded pain level during the squat test showed the same trend as that of the recorded pain during activity—higher for tendons with structural changes and neovascularization than for tendons with structural changes alone or normal tendons (ANOVA,  $P = .001$ ) (Figure 3).

## Posttreatment Ultrasound Characteristics

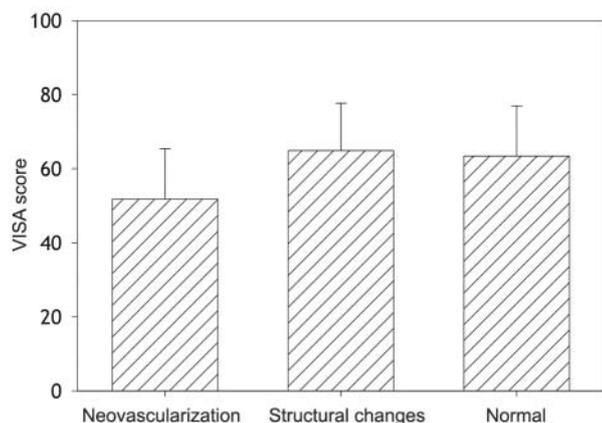
A total of 39 patients (5 women and 34 men) had structural changes and neovascularization at the ultrasound examination and therefore were eligible for inclusion in the randomized clinical trial to receive sclerosing treatment. Of these, 33 (5 women and 28 men; 43 tendons) elected to go through sclerosing treatment. Four of the patients (6 tendons) who received sclerosing treatment were not able to attend the second ultrasound examination for practical reasons; thus a total of 29 patients (37 tendons) participated in the posttreatment ultrasound examinations. The follow-up ultrasound examination was done 37 weeks (range, 19-53 weeks) after their final sclerosing injections.

As shown in Table 2, in 7 tendons (18.9%), there was no change in neovascularization after sclerosing treatment

TABLE 1  
Patient Characteristics (N = 63) in 3 Different Groups, Categorized According to the Baseline Examination<sup>a</sup>

	Normal Tendon, n = 10		Structural Changes, n = 16		Neovascularization, n = 37	
	Mean $\pm$ SD	Range	Mean $\pm$ SD	Range	Mean $\pm$ SD	Range
Age, y	23.8 $\pm$ 5.6	17-42	25.9 $\pm$ 5.2	19-36	24.6 $\pm$ 6.0	17-42
Height, cm	172.8 $\pm$ 5.6	165-185	186.9 $\pm$ 7.1	172-202	182.5 $\pm$ 8.7	168-201
Body mass, kg	72.6 $\pm$ 11.3	55-95	86.1 $\pm$ 10.2	62-102	81.1 $\pm$ 9.7	62-96
Sport-specific training, h/wk	7.1 $\pm$ 3.1	2.0-12.0	11.2 $\pm$ 2.7	6.0-15.0	10.1 $\pm$ 3.2	3.0-15.0
Weight training, h/wk	2.7 $\pm$ 2.4	1.0-8.0	3.9 $\pm$ 1.3	1.0-6.0	3.5 $\pm$ 2.1	1.0-8.0
Jump training, h/wk	1.0 $\pm$ 0.0	1.0-3.0	1.3 $\pm$ 0.5	1.0-2.0	1.6 $\pm$ 2.4	0.0-9.0
Total amount of training, h/wk	11.2 $\pm$ 4.8	2.0-18.0	14.4 $\pm$ 5.2	5.0-22.0	14.5 $\pm$ 5.2	5.0-28.5
Duration of symptoms, mo	27.3 $\pm$ 23.9	5.0-72.0	43.1 $\pm$ 39.9	5.0-120.0	34.0 $\pm$ 44.7	4.0-240.0

<sup>a</sup>Patients with 2 normal tendons were categorized in the normal tendon group, patients with neovascularization on at least 1 side in the neovascularization group, and patients with structural changes on at least 1 side in the structural changes group.



**Figure 2.** The Victorian Institute of Sport Assessment (VISA) score. The self-reported VISA score before the ultrasound examination for tendons with neovascularization, tendons with structural changes without neovascularization, and tendons with normal ultrasound findings.

compared with before treatment, 9 tendons (24.3%) had more neovascularization, and 21 tendons (56.8%) had less neovascularization than before treatment.

All patients had hypochoic areas before treatment ( $n = 37$ ). After treatment, 3 tendons (5.4%) no longer had hypochoic areas, and 34 tendons (94.6%) still revealed hypochoic areas. Furthermore, in 16 tendons (43.2%), there was no change in hypochoic status, 1 tendon (2.7%) had greater hypochoic areas, and 20 tendons (54.1%) had less hypochoic areas after sclerosing treatment compared to before treatment.

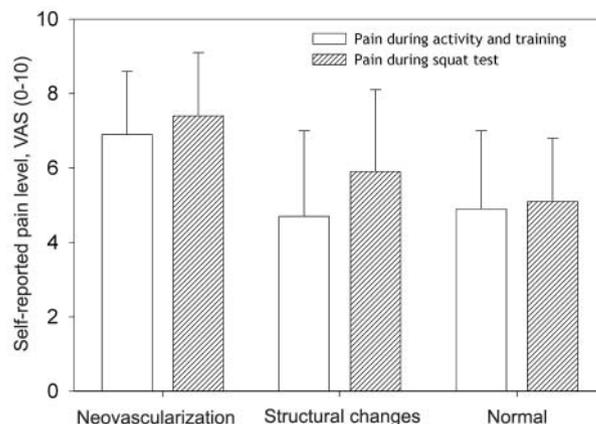
The mean tendon thickness at the apex was not different after treatment compared with before treatment. However, the tendon thickness was significantly greater 0.5 cm ( $0.73 \pm 0.03$  cm vs  $0.87 \pm 0.03$  cm [SE]) and 1 cm ( $0.62 \pm 0.05$  cm vs  $0.74 \pm 0.05$  cm) distal to the apex after treatment compared with before treatment.

#### Relationship Between Ultrasound Findings and Clinical Function

There was a significant improvement in VISA score from  $52 \pm 13$  at baseline to  $80 \pm 18$  at the time of the posttreatment examination ( $P = .001$ ,  $n = 37$ ). There was no difference in VISA scores at follow-up between the 37 tendons that were available for ultrasound examination and the 6 tendons we were not able to examine ( $87.0 \pm 14.6$ ,  $P = .23$ ).

Furthermore, at the time of the follow-up investigation, there was no difference in the change in VISA score between subjects in the control group, who received polidocanol injections after 4 months of placebo treatment, and the treatment group, who received polidocanol injections without delay ( $P = .72$ ).

The improvement in self-reported VISA score after treatment compared with before treatment was  $30 \pm 17$



**Figure 3.** Pain level during training for the previous 2 weeks and self-recorded pain level during the squat test showed for tendons with neovascularization, tendons with structural changes without neovascularization, and tendons with normal ultrasound findings. VAS, visual analog scale.

for tendons with unchanged neovascularization status ( $n = 7$ ),  $29 \pm 21$  for tendons with less neovascularization ( $n = 21$ ), and  $25 \pm 30$  for tendons with more neovascularization ( $n = 9$ ). There were no significant differences in the change in VISA score between tendons with less, more, or unchanged neovascularization after treatment (ANOVA,  $P = .9$ ). The relationship between change in neovascularization status and change in VISA score is also shown in Table 2.

The increase in self-reported VISA after treatment compared with before treatment was  $28 \pm 18$  for tendons with no change in hypochoic areas ( $n = 16$ ),  $29 \pm 24$  for tendons with less hypochoic areas ( $n = 20$ ), and 1.0 for 1 tendon with greater hypochoic areas. The increase in VISA score for patients who no longer had visible hypochoic areas after treatment was  $21 \pm 21$  (range,  $-4$  to  $34$ ) and was  $30 \pm 23$  (range,  $-15$  to  $80$ ) for patients who still had hypochoic areas after sclerosing treatment. There were no significant differences in the change in VISA score between tendons with or without hypochoic areas after treatment ( $P = .54$ ).

#### DISCUSSION

This study showed that in competitive athletes with clinical symptoms of jumper's knee, 60% of the examined tendons displayed structural tendon changes together with neovascularization/increased blood flow, whereas 26% had structural changes alone, and 14% were normal. For patients with neovascularization who went through sclerosing injection treatment with polidocanol, knee function had improved, but tendon structure was abnormal in most cases, and there was no correlation between clinical improvement and structural changes as seen on the follow-up ultrasound examination 13 to 53 weeks after the final injection.

TABLE 2  
Change in Victorian Institute of Sport Assessment Score in Relation to Change  
in Neovascularization Status From Before to 12 to 15 Months After Sclerosing Treatment (n = 37)

Neovascularization Grading Before Treatment	Neovascularization Grading After Treatment											
	0			1			2			3		
	Score Change	Range	n	Score Change	Range	n	Score Change	Range	n	Score Change	Range	n
1	35	25 to 44	6	22	10 to 33	2	30	-4 to 59	4	62		1
2	21	-15 to 35	4	26	8 to 45	5	33	7 to 58	5	11	-14 to 43	4
3	53	31 to 80	3	22	1 to 42	2	-9		1			0

### Prevalence of Neovascularization in Patients With Jumper's Knee

Weinberg et al<sup>20</sup> were the first to describe their experience with color Doppler sonography in the evaluation of patellar tendinosis. They found that in 20 symptomatic tendons from 14 patients, 11 had a proximal hypoechoic area, 12 had a thickened proximal patellar tendon, and all but 1 of these had increased blood flow on color Doppler sonography. The level of sports participation, symptom intensity, and duration of symptoms for these patients are not known. Next, Terslev et al<sup>18</sup> examined a group of 18 elite basketball players after a match. Among these, 4 players reported symptoms of jumper's knee, which were confirmed on tendon palpation, and 3 of these had both hypoechoic areas and increased blood flow. The remaining results are difficult to interpret because data were not reported separately for each knee.

In a recent cross-sectional study, Cook et al<sup>5</sup> examined 111 volleyball players representing elite to domestic competition levels with ultrasound and related the ultrasound findings to different measures of pain and knee function. The ultrasound examination revealed that of the 222 tendons examined, 124 were normal, 72 were abnormal with no vascularity, and 26 were abnormal with vascularity. However, because the clinical status was not reported separately for each knee, it is not possible to estimate the prevalence of neovascularization among athletes with clinical symptoms of jumper's knee. In a recent study, 15 elite or recreational athletes with long-standing symptoms (mean, 23 months) of jumper's knee were treated with sclerosing polidocanol injections.<sup>1</sup> In all of these patients, ultrasound and color Doppler examination showed structural changes with hypoechoic areas and neovascularization corresponding to the painful area. From the above studies, it appears that neovascularization is not a constant finding in patients with a clinical diagnosis of jumper's knee. This hypothesis is confirmed by the present study, which is the first to correlate the color Doppler ultrasound characteristics with clinical findings in a multisport patient group of competitive athletes having significant symptoms of jumper's knee. Our results suggest that about two thirds of patients display neovascularization and, as such, may be

candidates for sclerosing therapy with polidocanol injections targeting the area with neovessels.

However, the current findings also show that patellar tendon pain is not easy to diagnose and that the value of ultrasound examination in this group of patients may be questioned. It is possible that the 14% of patients who had normal tendon ultrasound appearance may have had other causes of pain, and patellofemoral cartilage lesions and synovial plicae can give rise to clinical symptoms similar to those of jumper's knee. Nevertheless, as discussed above, it is well documented that a number of symptomatic tendons do not reveal any ultrasound changes. Also, studies have shown that a number of athletes have tendon ultrasound changes without ever having experienced symptoms of jumper's knee.<sup>7,9</sup> The reasons for this apparent discrepancy are not known, and the current article provides additional evidence that the link between structural tendon changes, neovascularization, and symptoms is not clear. Other factors, for example neuromediators, have been implicated in tendon pain. Neuropeptides, such as substance P, modulate important aspects of tendinopathy including not just vascular flow but also pain and tissue remodeling.<sup>17</sup>

### Relationship Between Neovascularization and Symptoms

Cook et al,<sup>5</sup> in their cohort of symptomatic and asymptomatic volleyball players, reported significantly lower VISA scores in patients with abnormal tendons with neovascularization than in patients with abnormal tendons without neovascularization. The present study also shows that there is more pain and lower function scores in patients with abnormal tendons and neovascularization than in patients with abnormal tendons without neovascularization and patients with normal tendons.

Thus, it is possible that the percentage of patients with neovascularization would have been even higher if they had been examined with ultrasound during the peak competitive season (when the initial screening examination was done for the team sport athletes). For the baseline ultrasound examination, most of the athletes were examined several weeks after the end of the competitive season, when training and competition load were lower, and athletes

without neovascularization reported significantly improved function and less pain than during the in-season clinical screening examination. Consequently, the apparent relationship between neovascularization, VISA score, and pain leads to the hypothesis that the degree of neovascularization varies with activity load and that patients in periods with less pain and load may have no visible neovascularity. Whether this means that the vessels are absent or that blood flow is too low to be detectable on color Doppler ultrasound is open to speculation.

Other studies have demonstrated findings that support neovessels and accompanying nerves as a possible source of pain in chronic midportion Achilles tendinosis.<sup>3</sup> The data in our study reveal that thickening does not occur without hypochoic areas and that neovascularization does not occur without structural changes. The same pattern seems to have been observed in all of the previous studies combining grayscale and color Doppler ultrasonography.<sup>2,5,18,20</sup> This suggests that structural changes (thickening, irregular collagen fiber arrangement, and hypochoic areas) occur in the early stages of tendon injury, before blood vessels appear and pain symptoms worsen significantly. However, this hypothesis needs to be tested in a longitudinal study with serial ultrasound examinations and careful prospective registration of symptoms in a large cohort of jumping athletes.

### Ultrasound Changes After Sclerosing Therapy

Of 33 patients (43 tendons) who received sclerosing treatment in this study, 4 patients could not make their appointments and did not attend the follow-up ultrasound examinations. A total of 29 patients (37 tendons, 86%) participated in the posttreatment ultrasound examinations. We are not aware of any follow-up bias, as this seemed to be more related to geographical and practical issues than to clinical symptoms, as was documented by their VISA scores.

At the follow-up ultrasound examination, we saw improvements in neovascularization and hypochoic areas but only in some cases. All taken together, 13 of 37 tendons (35%) no longer revealed visible neovascularization, and 3 of 37 (5%) did not display hypochoic areas. This is in contrast to results of the study by Lind et al<sup>10</sup> on 42 tendons from middle-aged (mean age, 53 years) runners 2 years after sclerosing therapy for Achilles tendinosis. In this study, we found a considerable reduction in remaining neovessels. Color Doppler ultrasound showed no, or a few, remaining neovessels in the majority of the successfully treated tendons. There was also a significant reduction in tendon thickness at the 24-month follow-up. In the present study, the tendon thickness was not different at the apex and had increased 0.5 cm and 1.0 cm distal to the apex.

Furthermore, we could not find any relationship between the ultrasound findings and clinical function after sclerosing treatment. All patients reported improved function scores after treatment to the degree to which they were playing elite sports with no or minimal symptoms, but there was no difference in VISA scores between tendons with less, unchanged, or more neovascularization and hypochoic areas. This is in contrast to the results from the

previous study on Achilles tendinopathy,<sup>10</sup> in which patients with a good result of sclerosing treatment had no or few remaining neovessels, whereas all patients with a poor result had multiple remaining neovessels. One obvious potential explanation for the conflicting results between the present study and the study on Achilles tendinopathy is the time to follow-up. We did the follow-up 12 months after the first injection, and for patients who received placebo injections in the first 4 months, the follow-up was actually performed only 3 to 6 months after the last sclerosing injection. This may be too early to detect significant tendon remodeling with a reduction in tendon thickness and neovascularization corresponding to the effect of sclerosing injections. Nevertheless, the present data clearly suggest that clinical improvement after sclerosing therapy is not related to the presence or absence of neovessels or hypochoic areas within the tendon. Consequently, treatment should be based on the combination of tendon pain, structural changes, and neovascularization and not on tendon changes and neovascularization alone.<sup>1</sup>

It should also be kept in mind that the Achilles tendinopathy study examined a mixed patient group consisting mainly of middle-aged, recreational athletes. In the present study, we examined only elite athletes with a high activity level between the sclerosing injections and after the last treatment session. This high strain may influence the tendon's potential to recover. Another explanation may be that sclerosing treatment does not result in the same ultrasound changes for insertional tendinopathies (patellar or quadriceps tendinopathy) as for midportion tendinopathy (Achilles tendon). These issues need to be examined in a larger study on patients with different tendinopathies and with longer follow-up.

The explanation for the apparent discrepancy between clinical changes and posttreatment ultrasound appearance is not known. However, the speed with which the tendon pain is reduced suggests that the injections may be interfering with the local nerve supply, essentially creating a partial denervation of the tendon. The treatment also results in an acute increase in tendon blood flow, possibly from collateral circulation.<sup>1</sup> Thus, the effect of this treatment on neuropeptide distribution and neurovascular regulation warrants further investigation.

### CONCLUSION

Among elite athletes with a clinical diagnosis of jumper's knee, 60% had tendon changes together with neovascularization, making them candidates for sclerosing therapy. Athletes with neovascularization reported more pain than patients without neovascularization. Although sclerosing treatment leads to significant improvements in function, to the degree that all patients were competing with no or minimal pain, the majority of tendons still revealed significant neovascularization and hypochoic areas 3 to 12 months after the final injection. Also, there was no relationship between changes in function scores and changes in ultrasound status.

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