Power Doppler Sonography in Tenosynovitis:

Significance of the Peritendinous Hypoechoic Rim

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The aim of this study was to evaluate the ability of power Doppler sonography to distinguish between hypoechoic fluid and synovium in patients with suspected tenosynovitis. Gray scale sonography and power Doppler sonography were performed on 26 tendons in 24 patients with tenosynovitis and 30 tendons in five asymptomatic volunteers. Peritendinous blood flow was graded on a scale of 0 to 3 and the percentage of the hypoechoic rim that contained blood flow was also noted. In the symptomatic group, flow was demonstrated in more than 50% of the peritendinous hypoechoic rim in 17 of 26 tendons. A positive correlation was found between the power Doppler sonographic grade and the percentage of the rim that had flow. These results suggest that a significant proportion of the hypoechoic rim probably represents vascularized synovium rather than complex fluid. KEY WORDS: Power Doppler sonography; Tenosynovitis.

Ultrasonography of tendons is a useful technique for the depiction of tendon tears, degeneration, and inflammatory changes.[1,2] Tendons within synovial sheaths may normally have a hypoechoic rim surrounding the tendon, which possibly represents either a small amount of fluid[3] or part or all of the synovial sheath.[4] The width of the hypoechoic rim considered normal varies with individual tendons.[5]

An increase in width of the peritendinous hypoechoic rim usually is considered to be secondary to the presence of fluid[5,6]; however, thickening of the synovial sheath may cause an identical appearance on gray scale imaging.[4] We evaluated the ability of PDS to distinguish between hypoechoic fluid and synovium in patients with suspected tenosynovitis.

ABBREVIATIONS

PDS, Power Doppler sonography

MATERIALS AND METHODS

A search of the sonography data base from January 1994 to March 1996 was made for patients in whom the clinical suspicion and sonographic features suggested a diagnosis of tenosynovitis. The gray scale sonographic and PDS images were then reviewed to

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ensure that corresponding transverse images of both techniques were available. Fourteen studies were excluded as the gray scale and PDS images were not entirely comparable. Twenty-six studies in 24 patients were considered appropriate for inclusion. Fifteen women and nine men, ranging in age from 34 to 71 years, composed the study group. The following tendons were evaluated: 18 long head of biceps brachii, four tibialis posterior, and one each of the common extensor tendons of the fingers, abductor pollicis longus, flexor carpi radialis, and peroneus longus tendons. Four patients had rheumatoid arthritis, one had ankylosing spondylitis, and one had infectious tenosynovitis. The remaining 18 patients had a clinical diagnosis of "idiopathic tenosynovitis."

Gray scale sonography and PDS were performed on a control group of five asymptomatic volunteers (age range, 25 to 35 years). Bilateral sets of tendons, including the long head of the biceps brachii tendons, tibialis posterior tendons, and peroneal tendons, were evaluated.

All sonographic examinations were performed by one of three radiologists experienced in musculoskeletal sonography with a Diasonics Spectra unit (Diasonics, Santa Clara, CA) and linear 5 and 10 MHz transducers. Transverse and sagittal representative images were recorded on film. The gray scale appearance of the tendon and peritendinous region was documented, including the presence of septations or debris. For PDS imaging, pulse repetition frequency was maintained at 1000 Hz in most cases. The color gain was adjusted so that no color signal was present deep to the cortical bone in the corresponding image. A color video printer (Sony UPS 200 MD, Sony, Tokyo, Japan) was used to record representative PDS images on color print film.

The gray scale and color images were reviewed independently in a retrospective manner by two radiologists. From gray scale images the tendon size and echogenicity and the appearance of the peritendinous region were documented. Corresponding PDS images were selected. The degree of peritendinous flow was graded on a scale of 0 to 3. Grade 0 represented normal flow; 1, mild peritendinous flow; 2, moderate peritendinous flow; 3, marked peritendinous flow with a confluent surrounding vascular blush.[7,8] A subjective assessment was then made regarding the percentage of the hypoechoic region surrounding the tendon on gray scale sonography, which demonstrated flow on PDS according to the following categories:0–25%, 25–50%, 50–75%, or > 75%. If disagreement occurred with any of the observations, a third radiologist reviewed the images and concordance between two of three radiologists determined the final grading.

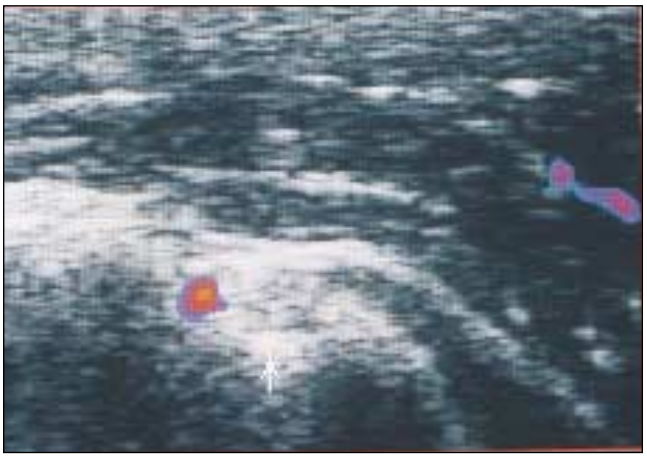
RESULTS

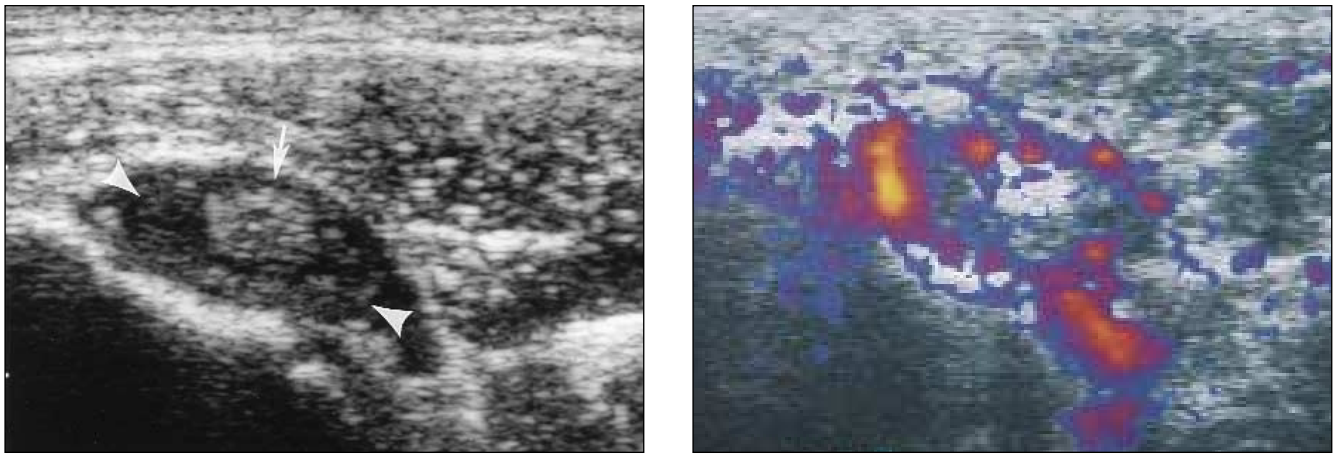
In the control group of 30 tendons, no ankle tendons had discernible peritendinous flow. Within the tendon sheath of the long head of biceps brachii, a single vessel could be identified in all of the ten shoulders examined. This was consistently located lateral to the tendon and presumably corresponds to the anterolateral branch of the anterior circumflex humeral artery (Fig. 1).

In the symptomatic group, all 26 tendons had hypoechoic areas of varying thickness; in four of these the material was complex, containing numerous echoes. The thickness of the peritendinous hypoechoic rim ranged from 0 to 1.2 mm in the control group and from 2.5 to 13 mm (mean, 5.9 mm) in the symptomatic group. Nine tendons had focal or diffuse intratendinous areas of hypoechogenicity, the remainder having normal gray scale appearances.

Thirteen of the tendons had surrounding grade 3 flow, nine had grade 2, three had grade 1, and one had grade 0 flow. In 12 of the 26 sites examined, greater than 75% of the peritendinous hypoechoic areas demonstrated flow on PDS; in five, 50 to 75% of the hypoechoic region had flow; in six 25 to 50% had flow; and in three 25% or less had flow (Figs. 2 to 4). Of the 13 that had grade 3 hyperemia, 11 had blood

Figure 1 Transverse PDS image of a 28 year old asymptomatic volunteer. The tendon of the long head of the biceps brachii muscle lies within the bicipital groove (*arrow*). A circumscribed focus of flow is seen lateral to the tendon, representing the anterolateral branch of the anterior circumflex humeral artery.





A **B**

Figure 2 A 53 year old woman with biceps tenosynovitis and rotator cuff tendon tear. **A**, Transverse sonogram of the long head of the biceps brachii tendon (*arrow*). Distention of the tendon sheath with complex hypoechoic material is observed (*arrowheads*). **B**, Corresponding PDS image shows marked hyperemia within the complex peritendious material. This case was graded PDS grade 3. Flow was present in 50 to 75% of the hypoechoic rim.

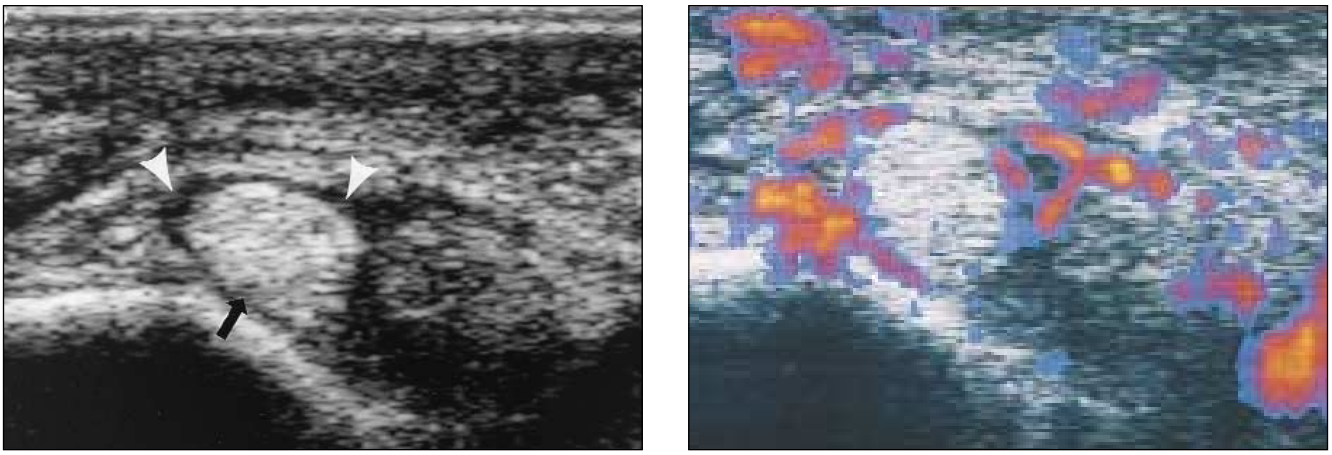
flow within more than 75% of the peritendinous hypoechoic region. Conversely, in all of those with grades 0 and 1 (normal or mildly increased blood flow) less than 50% of the hypoechoic region demonstrated blood flow (Table 1).

Of the four peritendinous hypoechoic areas that contained debris or septations, one had flow in 25–50%, two had flow in 50–75%, and one flow in >75%. Of the nine tendons with abnormal echotexture, one had flow in each of the 0–25%, 25–50%, and 50–75% groups, and six had flow in >75% of the peritendinous hypoechoic area.

Exact agreement for PDS grade occurred between two observers in 18 of the 26 sites (Cohen kappa statistic, 0.59). In the remaining eight cases a variance of one PDS grade was noted between the two observers. For percentage of the hypoechoic rim containing flow, exact agreement occurred between two observers in 20 of the 26 sites (Cohen kappa statistic, 0.69). At the remaining six sites, a variance of one percentage group was found between the two observers.

Figure 3 A 33 year old HIV positive man with tibialis posterior tenosynovitis. **A**, Transverse sonogram proximal to the medial malleolus shows enlarged tibialis posterior tendon (*arrow*) with surrounding hypoechoic rim (*arrowheads*). **B**, Corresponding PDS image, grade 2, with flow present in 50 to 75% of the hypoechoic rim.

A **B**



DISCUSSION

Gray scale sonography using high-resolution linear array transducers provides excellent structural detail of superficial tendons.[9] Tendinitis is demonstrated as regions of tendon thickening and diminished echogenicity.[1] Tenosynovitis appears as increased fluid within the synovial sheath of the tendon and thickening of the synovium. It can be difficult, using gray scale sonographic appearances alone, to distinguish between hyperplastic synovium and fluid.

In a correlative study between gray scale ultrasonography and histology in 50 patients with carpal tunnel syndrome, Nakamichi and Tachibana[10] demonstrated that the hypoechoic area around the tendons in 11 patients corresponded to hypertrophied synovium. These authors also showed that in the absence of synovitis, tendons may have a small hypoechoic rim that represents fluid. Futami and colleagues[11] used sonography to examine 36 children with transient synovitis of the hip and 12 children with early Perthes disease. They described distinct sonographic appearances between the two groups, those with transient synovitis having anechoic joint effusions with capsular distention and those with Perthes disease having "less capsular distention but more synovial thickening." It has, however, been our experience that edematous hypoechoic synovium and complex fluid may have identical gray scale appearances.

PDS is a recently described technique that provides an assessment of local vascularity or blood volume.[12] It has been shown to depict hyperemia in musculoskeletal inflammatory disease.[7,8,13] The presence of blood flow in the hypoechoic peritendinous tissue demonstrates that it must, at least in part, represent vascularized tissue (i.e., synovium) rather than fluid.

In our study, 17 of 26 cases demonstrated blood flow in greater than 50% of the peritendinous hypoechoic rim, including three of the four that had an appearance suggesting complex fluid, indicating that the majority of the hypoechoic rim in these cases largely represents hyperplastic synovium rather than fluid. In the other nine symptomatic patients, all had PDS findings that demonstrated greater blood flow than in the asymptomatic control group, although this was greater than 50%. Seven of the nine tendons with abnormal echotexture on gray scale sonography also had flow in more than 50% of the surrounding hypoechoic rim.

As would be expected, an association was found between PDS grade and the percentage of flow in the peritendinous rim. The only case with grade 0 surrounding perfusion had flow present in less than 25% of the hypoechoic rim. Of the 13 cases with grade 3 hyperemia, 11 had flow in more than 75% and two had flow in 50 to 75% of the peritendinous hypoechoic rims. It is possible that the portions of the hypoechoic rims that did not demonstrate flow may also have represented synovium rather than fluid. However, if there was relatively little inflammation (PDS grades 0 and 1), hyperemia may not be demonstrated.

A potential pitfall in PDS of the long head of biceps brachii tendon is the normal focal area of flow adjacent to the tendon within the synovial sheath, representing the anterolateral branch of the anterior

Figure 4 A 60 year old diabetic man with infectious tenosynovitis of the common extensor compartment of the wrist. **A**, Transverse sonogram of the common extensor tendons shows diffuse tendon enlargement and distention of the tendon sheath with complex material (*arrows*). **B**, Corresponding PDS image, grade 3, with flow present in more than 75% of the hypoechoic rim.

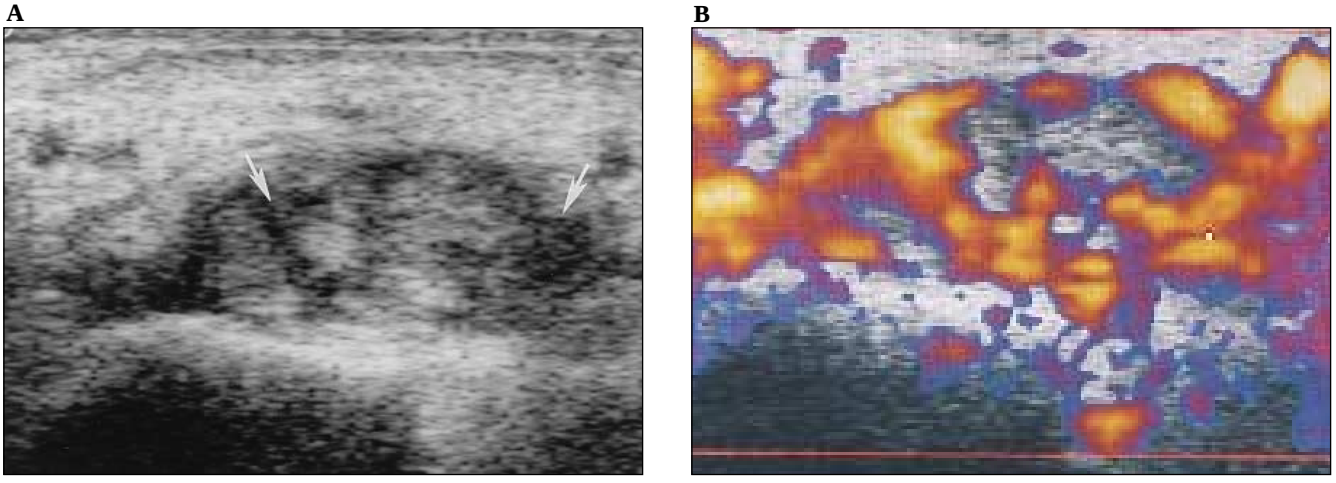


Table 1: Association of PDS Grade with Percentage of Peritendinous Hypoechoic Rim Containing Flow on PDS

	Percent Hypoechoic Peritendinous Rim with Flow			
PDS Grade	< 25	25–50	50–75	> 75
0	1			
1		3		
2	2	3	3	1
3			2	11

circumflex humeral artery. This is, however, easily recognizable and located in a very predictable location and therefore was easily identifiable in all of the control group. This has been described previously as a diagnostic pitfall in shoulder MR imaging.[14] There are a number of limitations to our study. The first of these is that we have no histopathologic correlation of our observations. The diagnosis of tenosynovitis is usually a clinical one, and patients are not subjected to a synovial biopsy or diagnostic aspiration unless there is another clinical concern (e.g., infection). Indeed, in this study only one patient underwent surgical biopsy, which confirmed the presence of inflammatory synovitis. This is a report of our initial experience, and we hope it will form the basis of further study that will include histopathologic correlation.

A second limitation is that the over two thirds of the tendons studied involved the long head of the biceps brachii. It is possible that PDS evaluation of other tendons may yield different observations to the ones reported in this study.

The ability to distinguish fluid from synovium has a number of potential advantages. If it is shown that a patient has synovitis rather than fluid around the tendon sheath, a clinical course of nonsteroidal antiinflammatory medication or tendon sheath injection may be considered. Patients may be saved from unnecessary tendon sheath aspiration. PDS also may give an indirect measure of disease activity in patients with conditions such as rheumatoid arthritis. Sequential PDS may potentially develop into a useful noninvasive means to evaluate response to treatment, especially in the setting of clinical trials. Similarly, PDS may be able guide potential sites for biopsy in cases of suspected infection or malignancy.

In summary, PDS frequently depicts flow in the hypoechoic rim of synovium-lined tendons in cases of suspected tenosynovitis. This suggests that the hypoechoic rim predominantly represents vascularized synovium rather than fluid. This information may guide diagnostic evaluation and therapy and further highlights the limitations of gray scale sonography alone in differentiating complex fluid from soft tissue.

REFERENCES

1. Bouffard JA, Eyler WR, Introcaso JH, et al: Sonography of tendons. Ultrasound Q11:259, 1993
2. Weiner SN, Seitz WH Jr: Sonography of the shoulder in patients with tears of the rotator cuff: Accuracy and value for selecting surgical options. AJR 160:103, 1993
3. van Holsbeeck M, Introcaso JH: Sonography of tendons. *In* Musculoskeletal Ultrasound. Chicago, Mosby–Year Book, 1990, p 57
4. Fornage BD: Soft-tissue changes in the hand in rheumatoid arthritis: Evaluation with US. Radiology 174:735, 1989
5. Nazarian LN, Rawool NM, Martin CE, et al: Synovial fluid in the hindfoot and ankle: Detection of amount and distribution with US. Radiology 197:275, 1995
6. Jeffrey RB Jr, Laing FC, Schechter WP, et al: Acute suppurative tenosynovitis of the hand: Diagnosis with US. Radiology 162:741, 1987
7. Newman JS, Laing TJ, McCarthy CJ, et al: Power Doppler sonography of synovitis: Assessment of therapeutic response—preliminary observations. Radiology 198:582, 1996
8. Breidahl WH, Newman JS, Taljanovic MS, et al: Power Doppler sonography in the assessment of musculoskeletal fluid collections. AJR 166:1443, 1996
9. Marinoli C, Derchi LE, Pastorino C, et al: Analysis of echotexture of tendons with US. Radiology 186:839, 1993
10. Nakamichi K, Tachibana S: The use of ultrasonography in detection of synovitis in carpal tunnel syndrome. J Hand Surg [Br] 18:176, 1993
11. Futami T, Kasahara Y, Suzuki S, et al: Ultrasonography in transient synovitis and early Perthes' disease. J Bone Joint Surg [Br] 73:635, 1991
12. Rubin JM, Bude RO, Carson PL, et al: Power Doppler: A potentially useful alternative to mean-frequency based color Doppler sonography. Radiology 190:853, 1994
13. Newman JS, Adler RS, Bude RO, et al: Detection of soft-tissue hyperemia: Value of power Doppler sonography. AJR 163:385, 1994
14. Kaplan PA, Bryans KC, Davick JP, et al: MR imaging of the normal shoulder: Variants and pitfalls. Radiology 184:519, 1992