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Validity of ultrasonography in surgically treated zone 2 flexor tendon injuries

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Objectives: The purpose of this study was to determine the validity of ultrasonography (USG) with surgical confirmation in surgically treated zone 2 flexor tendon injuries.

Methods: Between 2003 and 2008, zone 2 flexor tendon repairs of 30 patients were evaluated with real-time USG when there was a loss of motion and prediagnosis of rupture or adherence in follow-up. The mean duration between injury and USG evaluation was 81.5 days (range 10-240 days). USG demonstrated rupture in 15 patients, adherence in 14 patients, and tenosynovitis in one patient. After clinical examination, surgery was performed in 27 of the patients.

Results: Fifteen patients with diagnosis of rupture in USG were operated, and diagnosis was confirmed in 14 patients. Eleven patients in the adherence group were also surgically treated. Eight of them received only tenolysis, and three were repaired with tendon grafts—one for re-rupture and two for insufficiency after tenolysis. One patient who was diagnosed with tenosynovitis also had a re-ruptured tendon. Therefore, USG resulted in one false finding out of the 15 patients in the rupture group, one false finding out of 11 patients in the adherence group, and one false finding in tenosynovitis group. In total, validity of USG was confirmed in 24 of 27 patients.

Conclusion: USG is a dependable diagnostic aid in operated zone 2 flexor tendon injuries when there is uncertainty of rupture or adherence.

Key words: Flexor tendon; injury; rupture; surgery; ultrasonography.

As a diagnostic tool, ultrasonography (USG) has been used in different branches of medicine for sixty years. Its utility in flexor tendon injuries, the recently repaired tendons, and complications been demonstrated by many authors.[1-4] Diagnostic USG is non-invasive and cheap, and provides real-time imaging of tendons.

Zone 2 flexor tendon injuries occur in the region from the mid portion of the middle phalanx to the neck of the metacarpals where the superficialis tendons are inserted over the middle phalanx to the origin of the flexor tendon sheath. For the thumb, zone 2 flexor tendon injuries occur in the region from the neck of the proximal phalanx to the neck of the metacarpal where the flexor retinaculum exits. Despite the best possible repairs and physical therapy modalities, repairs in zone 2 carry the risk of tendon adhesions within the confined sheath and rupture. Bone pathologies increase the incidence of adhesion. Rupture of tendon repairs is a complication that requires re-exploration, and re-repair is the preferred method of treatment. Adhesions prevent

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tendons from gliding sufficiently to enable the normal range of motion of the digits. Surgical exploration to determine the condition of a flexor tendon is not an ideal method of diagnosis. Recognition of an adhesion or rupture is usually based on physical examination, but the use of magnetic resonance imaging (MRI) or USG has been shown to be diagnostically helpful.

The purpose of this study was to determine the validity of USG in diagnosing adherent or ruptured tendons in surgically treated zone 2 flexor tendon injuries.

Patients and methods

Between 2003 and 2008, zone 2 operated flexor tendon injuries of 30 patients (27 men and 3 women) were evaluated with USG when a tendon rupture or adherence was suspected during their physical therapy. The mean age of patients was 28.4 years (range 2-59 years). Four injuries involved the thumb, nine the index finger, five the long finger, five the ring finger, and seven the little finger. Revascularization was performed for eight fingers that did not have arterial circulation. Proximal phalanx fractures were repaired with Kirschner wires in eight fingers. Digital nerves were repaired for 17 fingers. Flexor pollicis longus (FPL) tendons of four involved thumbs, both flexor digitorum superficialis (FDS) and flexor digitorum profundus (FDP) tendons of 18 fingers, and FDP tendons alone in eight fingers were repaired during the initial surgery. Physiotherapy commenced under the supervision of an experienced hand therapist. After reaching a plateau in progress through exercise and splinting or upon the loss of a previously gained range of motion, possible clinical adhesions or ruptures were evaluated with USG. The mean time interval between USG and the first repair was 81.5 days (range 10-240 days) (Table 1).

Ultrasonography technique

Ultrasonographic examinations were performed with a Siemens Antares scanner (Siemens AG, Erlangen, Germany) and a 9 to 12 MHz linear array transducer used by the same radiologist. Each patient's injured hand was positioned on a table in a palm-up position while the patient was sitting. The fingers were examined at rest and during active-passive flexion and extension of the involved fingers. A normal finger of the same hand was also studied for comparison. The mean USG examination time was 15 min per patient. The operated flexor tendons were classified according to USG findings of a ruptured or adhered tendon.

The repaired/intact tendon criteria were fibrillar continuity in normal thickness and tendon gliding during active-passive flexion and extension of the involved fingers (Fig. 1).

A loss of the fibrillar pattern is the most important criterion to diagnose rupture. The gap between the two ends of the tendon that fills with fluid is helpful for diagnosis, especially in the case of a recent injury. Sometimes these gaps become filled with mixed echogenic material, which is interpreted as fibrinous tissue, in relatively late cases. This appearance may lead to the misdiagnosis of an intact tendon in these cases. The loss of the fibrillar pattern and the lack of tendon gliding during finger movement can be useful for achieving the correct diagnosis (Fig. 2).

Although some tendons retained their continuity with minimal loss of the fibrillar pattern, their thickness was thinner than normal. These tendons showed little or no gliding during active-passive flexion and extension. These findings may be explained by the increased tendon length and tendon stretching. Because these tendons became non-functional, they were evaluated in the rupture group.

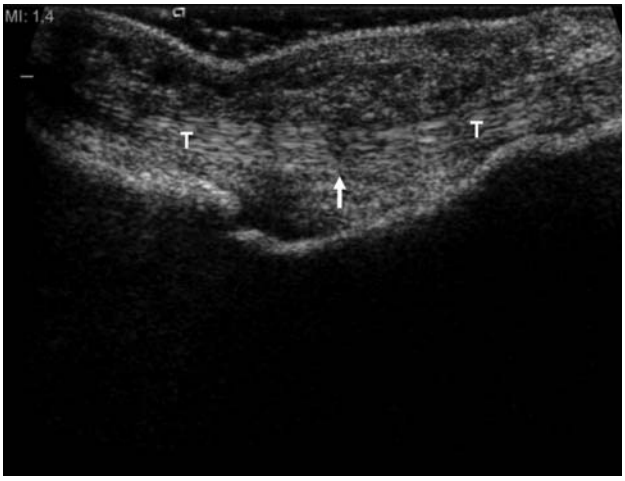

Fig. 1. Repaired-intact tendon, fibrillar continuity, and normal thickness of tendon are seen in ultrasonography. No gap or fibrotic tissue is seen at rupture site. Arrow shows repair site. T: Tendon.

Table 1

Summary of patients' data

Patient no.	Sex	Age	Finger	Tendons	Nerve repair	Arterial repair	Bone fixation	USG finding	Surgery	Time of USG (days)
1	M	15	5	FDP	No	No	No	Rupture	Rupture+secondary repair	30
2	M	59	2	FDS+FDP	Yes	Yes	No	Adhesion	Adhesion+tenolysis	90
3	M	4	4	FDS+FDP	No	No	No	Rupture	Rupture+secondary repair	20
4	M	23	5	FDS+FDP	No	No	Yes	Adhesion	Adhesion+tenolysis	52
5	M	18	2	FDS+FDP	Yes	Yes	Yes	Adhesion	Adhesion+tenolysis	240
6	M	21	2	FDS+FDP	Yes	Yes	Yes	Adhesion	Follow-up without operation	83
7	M	35	3	FDP	Yes	Yes	Yes	Rupture	Rupture+secondary repair	58
8	M	35	4	FDS+FDP	No	No	No	Adhesion	Adhesion+tenolysis+graft	90
9	M	42	1	FPL	Yes	No	No	Rupture	Rupture+secondary repair	45
10	M	34	5	FDS+FDP	Yes	No	Yes	Adhesion	Adhesion+tenolysis	60
11	M	11	3	FDS+FDP	No	No	No	Adhesion	Adhesion+tenolysis	160
12	F	16	5	FDS+FDP	Yes	No	No	Rupture	Rupture+secondary repair	42
13	M	29	4	FDS+FDP	Yes	No	No	Rupture	Rupture+secondary repair	49
14	M	25	2	FDP	No	Yes	Yes	Adhesion	Follow-up without operation	131
15	M	25	4	FDP	Yes	No	No	Rupture	Rupture+secondary repair+graft	90
16	M	47	1	FPL	No	No	No	Rupture	Rupture+secondary repair+graft	42
17	M	43	2	FDS+FDP	Yes	Yes	No	Adhesion	Adhesion+tenolysis	240
18	F	46	2	FDS+FDP	No	No	No	Adhesion	Adhesion+tenolysis+graft	180
19	M	17	2	FDS+FDP	Yes	Yes	Yes	Adhesion	Adhesion+tenolysis	210
20	M	44	3	FDS+FDP	No	No	No	Tenosinovitis	Rupture+secondary repair	20
21	M	25	3	FDP	Yes	No	No	Adhesion	Rupture+secondary repair+graft	42
22	M	24	2	FDS+FDP	Yes	No	No	Rupture	Adhesion+tenolysis	10
23	M	2	4	FDP	No	No	No	Rupture	Rupture+secondary repair	90
24	M	16	5	FDS+FDP	Yes	Yes	No	Rupture	Rupture+secondary repair	30
25	M	22	5	FDP	No	No	Yes	Adhesion	Follow-up without operation	45
26	M	29	5	FDS+FDP	No	No	No	Rupture	Rupture+secondary repair	30
27	M	29	2	FDP	Yes	No	No	Adhesion	Adhesion+tenolysis	42
28	M	34	1	FPL	No	No	No	Rupture	Rupture+secondary repair	120
29	F	50	3	FDS+FDP	Yes	No	No	Rupture	Rupture+secondary repair	60
30	M	31	1	FPL	Yes	No	No	Rupture	Rupture+secondary repair	44

USG: Ultrasonography, M: Male, F: Female, FDP: flexor digitorum profundus, FDS: flexor digitorum superficialis, FPL: Flexor pollicis longus.

As a result of an inactive flexor system and injuries to other soft tissues of the digits, the tendon can sometimes adhere to the surrounding scar tissue. An adhered flexor tendon appears to be continuous at the repair site with no evidence of a gap, but the tendon is thickened and enclosed by mixed echogenic tissue interpreted as fibrosis in these cases. There is some disorganization in the fibrillar pattern of tendon. Either the adhered tendon shows no gliding during flexion and extension of the finger, or both the tendon and soft tissues that surround the tendon show little coordinated movement (Fig. 3).

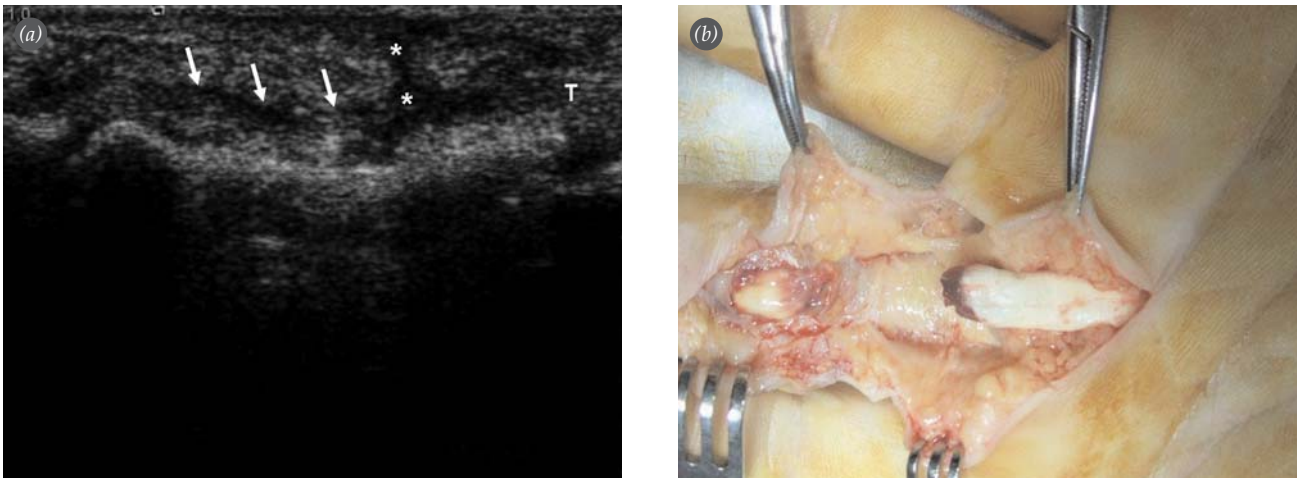

Fig. 2. **(a)** Late ruptured flexor tendon in ultrasonography. The thickness of the tendon is narrowed (arrows) with a loss of the fibrillar pattern. Asterisks show rupture site. T: Retracted proximal end of the tendon. **(b)** Surgical confirmation of tendon rupture.

USG was used to diagnose tendon rupture in 15 patients, adherence in 14 patients and tenosynovitis in one patient. After surgery, diagnoses were evaluated with statistical analyses. The chi-square test was performed using SPSS 13.0 software with a confidence interval of 95%.

Results

Following the US examinations that indicated the need for tendon rupture repairs and tenolysis, surgery was performed in 27 patients. Three patients did not receive surgery and were only applied physical therapy, which resulted in improved motion of the affected digit.

Fifteen patients were diagnosed with tendon rupture by USG and all received surgery. Of these 15 patients, surgery revealed 14 ruptures and one adhesion. Tenolysis was performed for the adherent tendon. Secondary tendon repairs were done without tendon grafts for 12 patients and with grafts for two patients. USG diagnosis was correct in 14 of the 15 patients.

Eleven patients received surgery in the adherence group of 14 patients after clinical examination. For

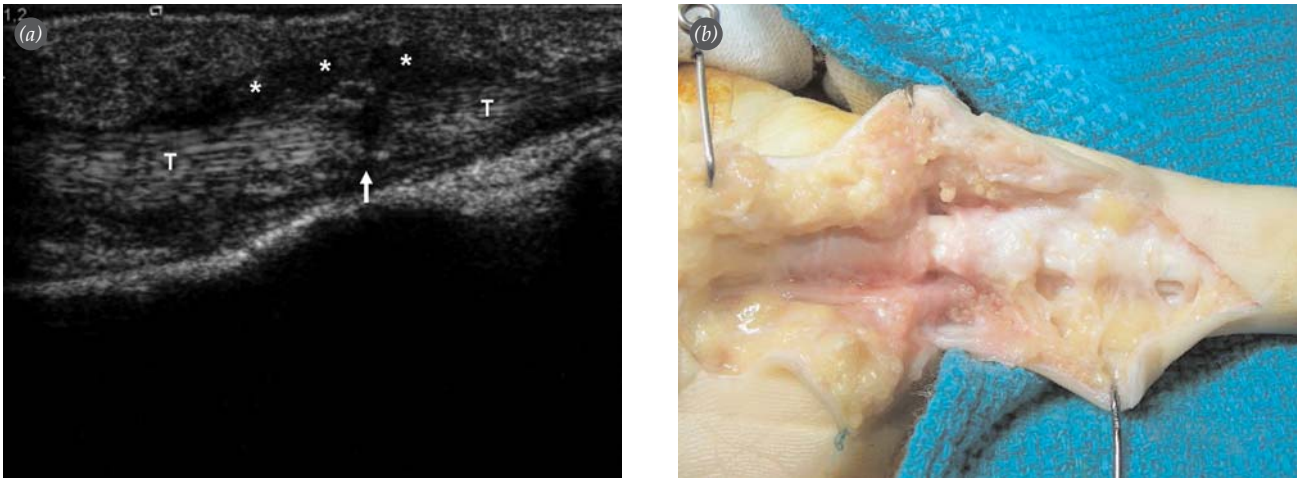

Fig. 3. **(a)** A thickened adherent tendon surrounded by mixed echogenic fibrotic tissue in ultrasonography (asterisks). Suture material is seen within the rupture site as hyperechoic foci (arrow). T: proximal and distal ends of the tendon. **(b)** Surgical confirmation of tendon adherence.

eight of them, tenolysis alone was performed. One of these cases was shown to be a tendon rupture. Two were secondarily repaired with tendon graft for insufficiency after tenolysis. USG diagnosis was correct in 10 of 11 patients.

The patient diagnosed with tenosynovitis was also found to have a tendon rupture that was then repaired.

In summary, USG was incorrect in three patients (one in the rupture group, one in the adhesion group, and one with the tenosynovitis diagnosis). Surgery verified the USG diagnosis in 24 of the 27 patients with USG reports. Statistically, the chi-square test showed significant concordance between surgical and USG diagnoses ($p<0.05$).

Discussion

The recognition of an adhesion or rupture is usually based on careful physical examination and history. An acute loss of motion, a patient's report of hearing a popping sound during the injury and the final position of the finger generally demonstrates a tendon rupture.[5]

However, differentiating between an adhesion in scar tissue and a late rupture can sometimes raise difficulties, especially after fracture repair of the fingers, revascularizations or diffused crush injuries. Insisting on unnecessary physical therapy can both waste time and affect the functional results.[5]

There is no doubt that the rupture of repaired tendons is a significant complication and that early recognition and secondary repair is mandatory. However, early surgical exploration of a tendon with limited function due to scar tissue adhesion, which can be overcome with physical therapy alone, is also unnecessary and could worsen the results.[5]

Zone 2 flexor tendon injuries are known to be susceptible to surgical complications.[5]

The advancement of high-frequency USG has enabled the clear identification of the anatomy and the pathology of the soft tissues in the hand with a high rate of accuracy.[1,6,7] The advantage of USG is that it provides real time images instead of the static images provided by the MRI.[8,9] This feature allows the moving of the tendons to be visualized. It is also widely available, noninvasive, involves no ionizing radiation, has good patient tolerance and is cost-effective. High operator dependence seems to be the most significant disadvantage to date.[1]

McGeorge and McGeorge[3] demonstrated that the repair site of the tendons and the ruptures of repairs can be identified with USG when studying finger anatomy. However, they did not perform clinical or surgical confirmation.

Höglung et al.[4] used USG for soft tissue pathologies of the hand to demonstrate a case of flexor tendon repair rupture with USG diagnosis. They reported a gap of 1 cm between the tendon ends and identified a rupture with USG that they confirmed with surgery. No details were given about the zone of the injury.

As far as zone-specific findings, Corduff et al.[6] assessed the results of zone 1 flexor tendon repairs using USG. They reviewed 22 flexor tendon repairs in zone 1 and showed that USG has an important role in assessing flexor tendon repairs as an objective method of evaluating repair results. They reported that USG was valuable in differentiating tendon rupture and adhesion.

Wang et al.[10] have used ultrasonic assistance in the diagnosis of flexor tendon injuries and showed that USG was used to make correct preoperative determinations in six of the eight patients they studied. They concluded that US was helpful in evaluating equivocal flexor tendon injuries. They used surgical confirmation, but the paper was not zone-specific.

Lee et al.[1] preoperatively used real-time USG for potentially injured flexor tendons and showed that USG accurately identified the status of flexor tendons in 11 of 13 digits and in 18 of 20 flexor tendons. Tendon lacerations and proximal stump positions were surgically confirmed, and the authors reported USG as a viable diagnostic tool in the preoperative evaluation of flexor tendon injuries with a reasonable accuracy.

Jeyapalan et al.[7] used USG to establish tendon pathologies in 17 patients in 18 digits. Surgery was undertaken in only three cases; two of these surgical cases confirmed USG findings. USG imaging helped to avoid surgery in 14 cases by excluding flexor tendon re-ruptures. Six of the investigated tendons were zone 2 injuries following repair.

Although the use of USG for the assessment of flexor tendons has been described in a number of previous studies, zone-specific cases with surgical

confirmation have not been widely studied. A zone-specific study was only reported by Corduff et al.[6] They have also emphasized the necessity of demonstrating USG applications in other zones.

The study's retrospective design, including a small number of patients and a lack of details regarding flexor digitorum superficialis tendons, seems to be the main limitation. However, the zone specificity, especially for a region that is usually described as problematic by hand surgeons, and surgical confirmation of the USG diagnosis are this study's advantages.

We have been using USG as a diagnostic tool for flexor tendon injuries since 2003, and have seen that it may also be useful in evaluating of zone 2 repaired flexor tendon injuries. The technique seems to be accurate in determining the status of tendon rupture and adherence. Cooperation between the radiologist, physical therapist, and surgeon should aid in the early decision of pursuing re-repair or insisting on therapy.

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