ORIGINAL ARTICLE

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Correlations between ultrasonography findings and surgical findings in patients with refractory symptoms after primary surgical release for carpal tunnel syndrome

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Objective: Surgical carpal tunnel release is very effective for symptom relief in carpal tunnel syndrome, and it remains the preferred choice of treatment. However, refractory symptoms following surgical release are not uncommon. We aimed to assess the usefulness of ultrasonography for determining the potential causes of ongoing symptoms following surgical release.

Methods: This retrospective study included 34 patients (32 women; mean age, 54.7±16.65 years; range: 30 to 81 years) with carpal tunnel syndrome who underwent surgical carpal tunnel release.

Results: A pathology related to the cause of the ongoing symptoms was detected by ultrasonography in 25 (74.5%) patients. The most common pathological findings were median nerve swelling (70.6%), incomplete transection of the transverse carpal ligament (23.5%) and perineural fibrosis (17.6%).

Conclusion: In the majority of the patients the pathology related to the ongoing symptoms was detected by ultrasonography, suggesting that ultrasonography could be used as a complementary imaging method for identifying the causes of failure following surgical carpal tunnel release. Detection of an ongoing pathology might help clinicians in managing persistent disease cases and aid in planning an exploration.

Keywords: Carpal tunnel release surgery; carpal tunnel syndrome; refractory symptoms; ultrasonography.

Carpal tunnel syndrome (CTS), characterized by pain and paraesthesia in the median nerve (MN) territory of the hand, is the most frequent compressive neuropathy of the upper limb and affects 1%–4% of the population.[1,2] Surgical carpal tunnel release is effective in relieving symptoms and is the preferred treatment after failure of conservative protocols.[1,3] Although 70%–90% of patients have good to excellent term outcomes after surgical release,[4] a substantial portion of patients have ongoing symptoms postoperatively. The reported symptom rate

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of these patients is 3%–19%, and carpal tunnel exploration has been reported in 0.5%–12% of all operated CTS cases.[2,5,6]

The course of refractory symptoms related to failed carpal tunnel surgery can be used to classify the disease into two main groups: persistent disease and recurrent disease. Persistent symptoms are characterized by failure of relief after surgery; the most common cause of persistent disease is considered to be incomplete transection of the transverse carpal ligament (TCL).[7] Recurrent disease, characterized by recurrence of symptoms following an asymptomatic period following surgery, is usually associated with fibrous proliferation within the carpal tunnel.[7] Other less common reported causes of relapse include tenosynovitis of the flexor tendons, pillar pain, surgical-site infection, postoperative necrosis of the skin or palmar fascia, entrapment of the palmar cutaneous branch of the median nerve and iatrogenic nerve laceration.[8,9] Although history and physical examination provide valuable information for diagnosis, they may not be adequate for determining the cause; hence, various diagnostic modalities, including ultrasonography (US), electrophysiological tests (e.g. electromyography) and magnetic resonance imaging (MRI), may be required.[7] The value of electrophysiological examinations alone is limited because the abnormal findings may persist for months after a successful surgery, and electrophysiological improvement never appears in some patients, despite the absence of postoperative symptoms.[2,10] This fact greatly limits the effectiveness of electrophysiological tests in failed carpal tunnel surgery. Recently, US examination has gained wide acceptance in CTS diagnosis. The main advantages of US are that it is simple, quick, cheap, non-invasive and easily accessible. MRI is helpful in evaluating carpal tunnel narrowing, assessing the median nerve swelling and identifying the ongoing pathology after a failed carpal tunnel surgery.[7] However, it has several disadvantages, such as increased cost, long examination time and limited availability, resulting in US being a more preferred modality.

The purpose of this study was to assess the usefulness of US for determining the potential causes of ongoing symptoms following surgical carpal tunnel release in carpal tunnel syndrome.

Patients and methods

This study was approved by our institutional review board.

Thirty-four patients (32 women; mean age, 54.7±16.65 years; range 30–81 years) who had ongoing symptoms following primary surgical release for CTS performed between 2009 and 2013 were enrolled in this study. The diagnosis was idiopathic CTS in all patients and was clinically confirmed by electrophysiological studies. The carpal tunnel was released using the standard technique or mini-incision open technique in all patients. Patients who had had previous hand surgery, wrist fractures, occupying lesions within the carpal tunnel and anatomical variations, such as a bifid MN and persistent median artery, were excluded. Following the initial surgical intervention, no patient received any additional treatment, such as steroid injections, for the relief of persistent symptoms.

All US examinations were performed using a 9–12-

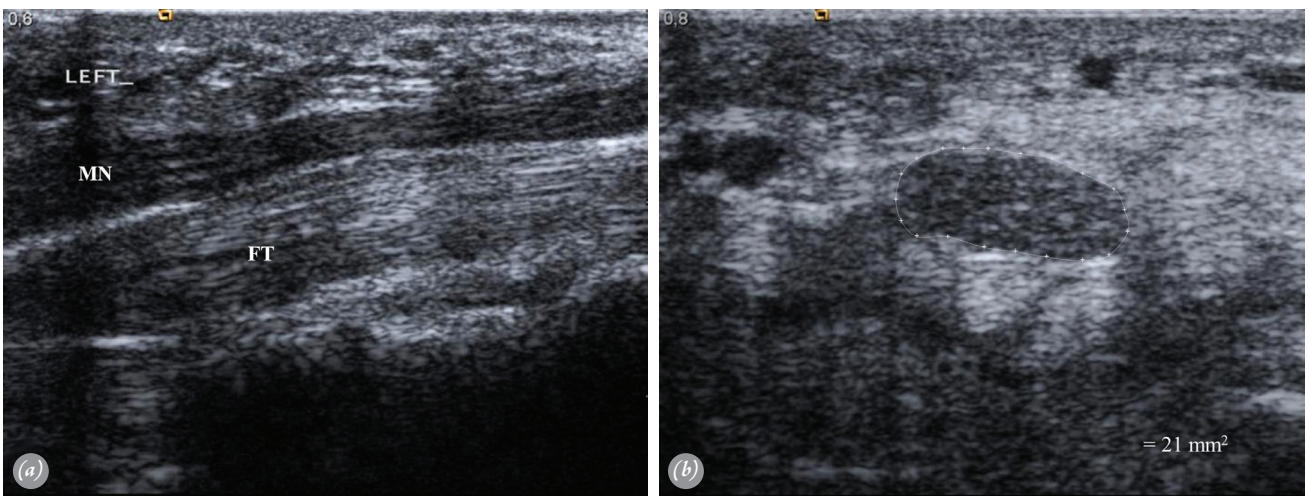

Fig. 1. An elderly woman with persistent symptoms of carpal tunnel syndrome. Longitudinal **(a)** and transverse **(b)** ultrasonography images clearly demonstrate median nerve thickening. The sectional area of the nerve was measured to be 21 mm^2 in this patient (MN: Median nerve; FT: Flexor tendon). [Color figure can be viewed in the online issue, which is available at www.aott.org.tr]

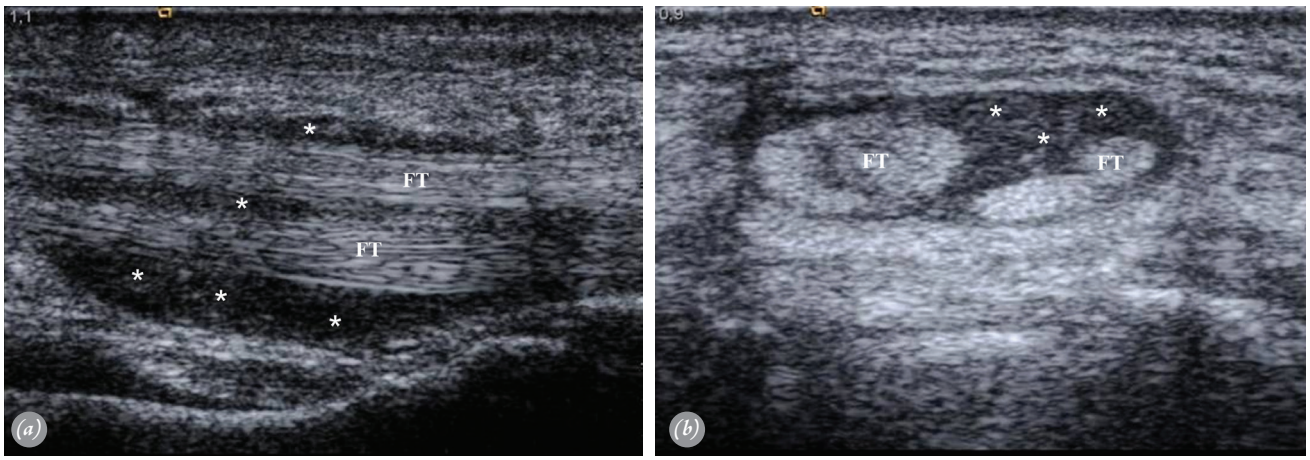

Fig. 2. A old woman with persistent symptoms of CTS. Longitudinal **(a)** and transverse **(b)** ultrasonography images demonstrating flexor tenosynovitis (indicated by asterisks) at the carpal tunnel level. Note that normal fibrillar echotexture of the flexor tendons was preserved (FT: Flexor tendon). [Color figure can be viewed in the online issue, which is available at www.aott.org.tr]

MHz linear array transducer mounted to a Siemens Antares scanner (Siemens AG, Erlangen, Germany). All wrists were examined in the neutral position with the palm facing up and fingers extended. The examination included both longitudinal and transverse sonograms of the carpal tunnel.

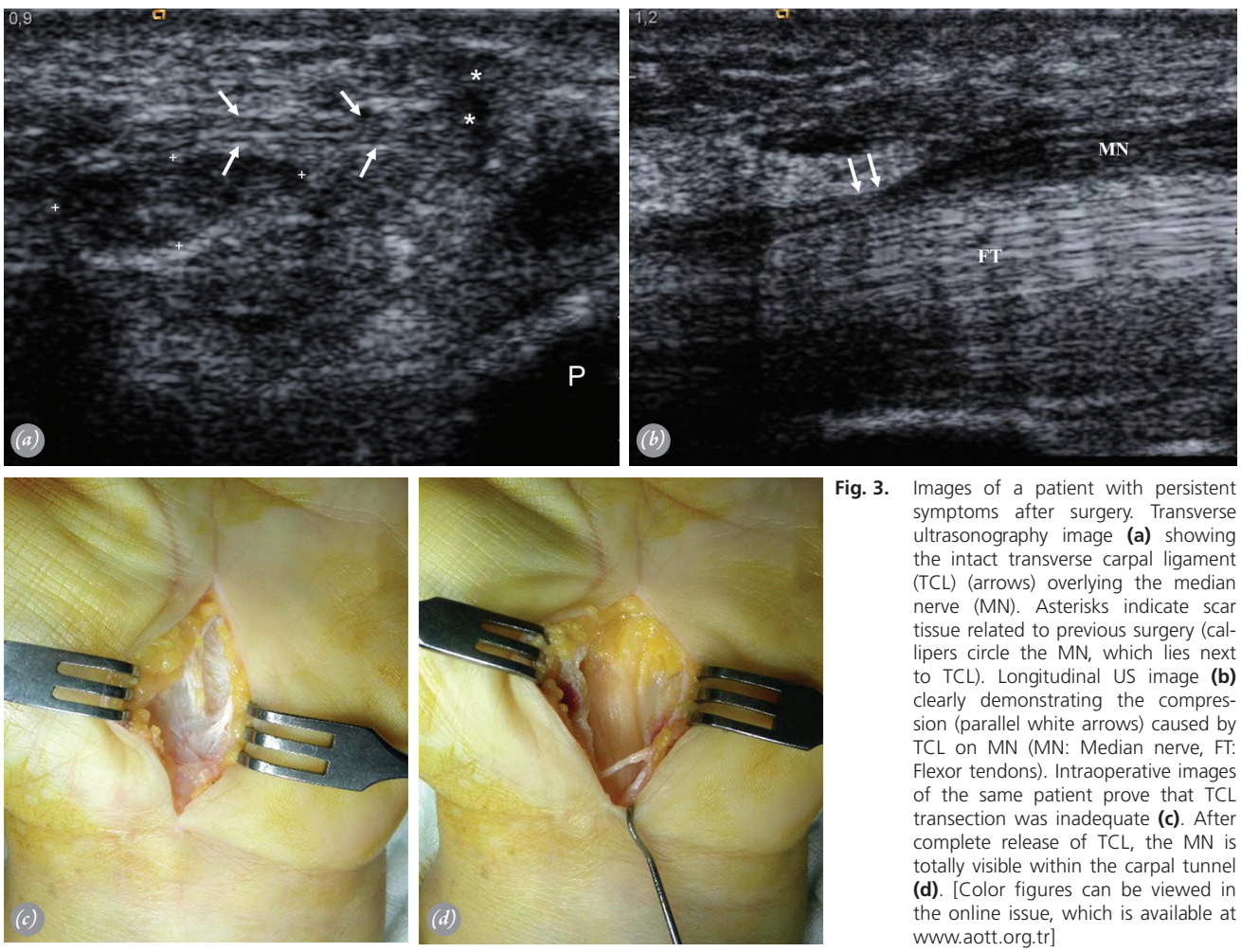

Fig. 3. Images of a patient with persistent symptoms after surgery. Transverse ultrasonography image **(a)** showing the intact transverse carpal ligament (TCL) (arrows) overlying the median nerve (MN). Asterisks indicate scar tissue related to previous surgery (callipers circle the MN, which lies next to TCL). Longitudinal US image **(b)** clearly demonstrating the compression (parallel white arrows) caused by TCL on MN (MN: Median nerve, FT: Flexor tendons). Intraoperative images of the same patient prove that TCL transection was inadequate **(c)**. After complete release of TCL, the MN is totally visible within the carpal tunnel **(d)**. [Color figures can be viewed in the online issue, which is available at www.aott.org.tr]

MN integrity was examined in both the longitudinal and transverse planes, and the sectional area (CSA) of MN was measured to assess nerve thickening (Fig. 1).[11] CSA was measured using an electronic cursor at the level of the pisiform, and the area demarcated by the hyperechogenic line (epineurium) was calculated (Fig. 1b). CSA values of >12 mm^2 were considered to indicate MN thickening.

The flexor tendons within the carpal tunnel were examined for the presence of tenosynovitis. US findings of tenosynovitis included the presence of fluid and/or hypertrophic synovia located within the tendon sheath, nodularity and sheath thickening (Fig. 2).

TCL was evaluated for inadequate or incomplete transection. Complete TCL transection was considered if TCL thickness was ≥1.32 mm and if its smooth outline was lost on postoperative US examination.[12] Persistent visualization of the integrity of TCL after surgery, with or without MN flattening, was considered to indicate incomplete transection (Fig. 3).

US findings of perineural fibrosis were defined as an defined occupying hypoechogenic area between MN and tendons or surrounding soft tissue and an irregular volar margin of MN (Fig. 4).

Fisher's exact test was used for statistical analysis and comparison of variables between the groups, and p values of <0.05 were considered to indicate statistical significance. Independent variables were compared using the Mann–Whitney U test.

Results

The average duration after which the patients presented for re-evaluation after the index surgery was 16.4±18.7 months. The most common pathological US finding detected in our study was MN swelling (n=24, 70.6%); followed by incomplete transection of TCL (n=8, 23.5%). Perineural fibrosis was the third most common US finding (n=6, 17.6%). In nine (26.5%) patients, however, any pathology that could explain the ongoing symptoms was not detected by US. More than one pathological find-

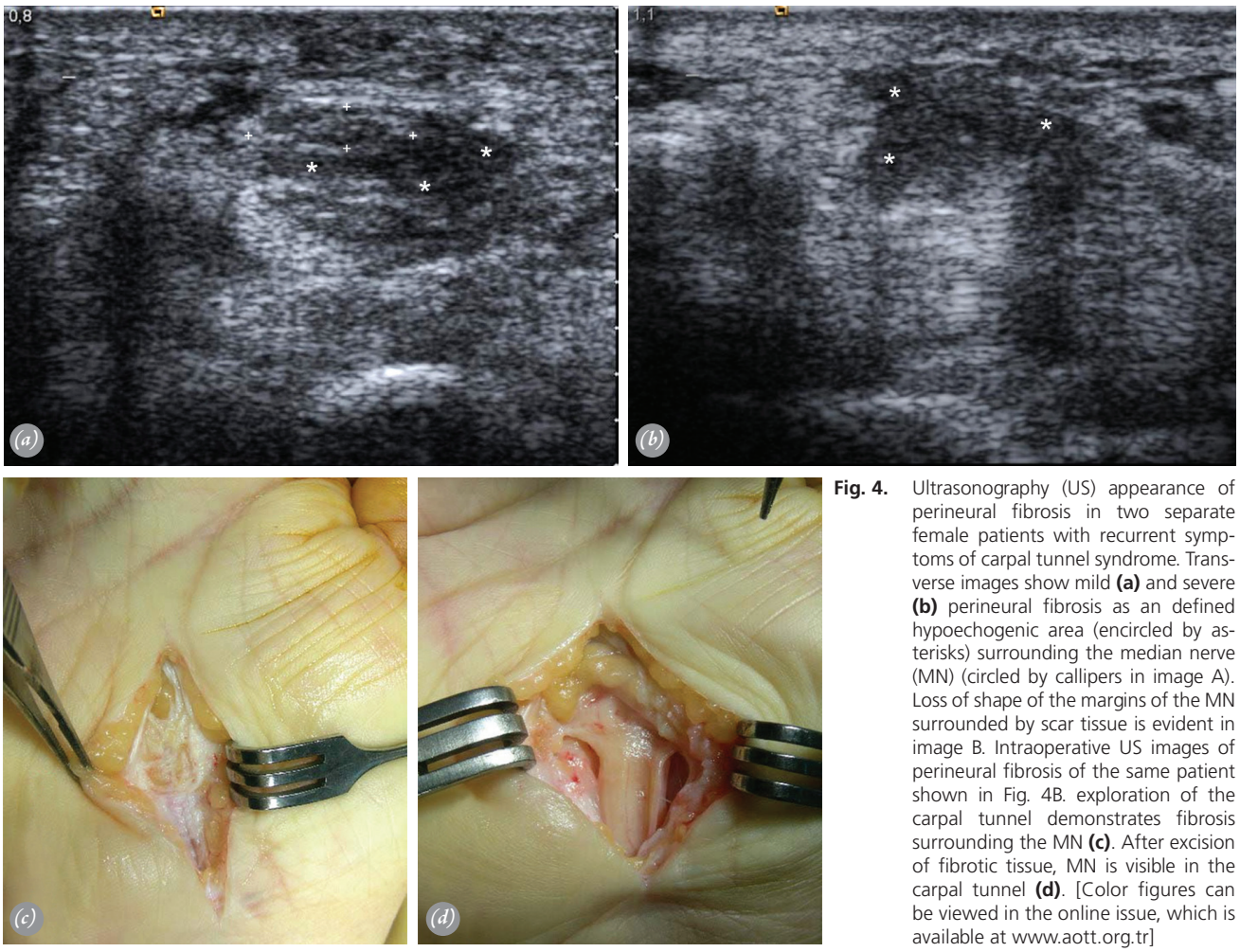

Fig. 4. Ultrasonography (US) appearance of perineural fibrosis in two separate female patients with recurrent symptoms of carpal tunnel syndrome. Transverse images show mild **(a)** and severe **(b)** perineural fibrosis as an defined hypoechogenic area (encircled by asterisks) surrounding the median nerve (MN) (circled by callipers in image A). Loss of shape of the margins of the MN surrounded by scar tissue is evident in image B. Intraoperative US images of perineural fibrosis of the same patient shown in Fig. 4B. exploration of the carpal tunnel demonstrates fibrosis surrounding the MN **(c)**. After excision of fibrotic tissue, MN is visible in the carpal tunnel **(d)**. [Color figures can be viewed in the online issue, which is available at www.aott.org.tr]

Table 1. Demographic and ultrasonography findings of the patients.

No	Age	Sex	Time interval* (months)	Symptoms	US findings				
					Incomplete transection of TCL	MN swelling	Perineural fibrosis	Flexor tenosynovitis	Other
1	65	Female	18	Persistent	+	+			
2	56	Female	12	Persistent		+			
3	61	Female	4	Persistent					Normal
4	50	Female	8	Persistent		+	+		
5	39	Female	8	Persistent	+	+		+	
6	55	Female	5	Persistent	+	+			
7	42	Female	7	Persistent	+	+			
8	55	Female	1	Persistent				+	
9	67	Female	4	Persistent	+	+			Ganglion cyst
10	61	Female	8	Persistent		+	+		
11	69	Female	7	Persistent		+	+		
12	73	Male	2	Persistent		+			
13	60	Female	5	Persistent					Normal
14	36	Female	12	Persistent	+	+			
15	30	Male	7	Persistent					Normal
16	49	Female	3	Persistent		+			
17	59	Female	1	Persistent	+	+			
18	48	Female	6	Persistent	+	+			
19	39	Female	2	Persistent					Normal
20	47	Female	9	Persistent		+			
21	47	Female	48	Recurrent		+			
22	55	Female	48	Recurrent		+	+		
23	51	Female	56	Recurrent		+			
24	74	Female	72	Recurrent					Normal
25	65	Female	60	Recurrent		+	+		
26	81	Female	12	Recurrent					Normal
27	59	Female	12	Recurrent		+			
28	45	Female	8	Recurrent		+	+		
29	51	Female	12	Recurrent					Normal
30	60	Female	36	Recurrent		+			
31	68	Female	12	Recurrent					Normal
32	42	Female	23	Recurrent					Normal
33	50	Female	23	Recurrent		+			
34	50	Female	8	Recurrent		+			

*Between surgery and admission to hospital. US: Ultrasonography; MN: Median nerve.

ing was observed in some patients. Demographic characteristics and US findings of the patients are provided in Table 1.

Twenty patients who did not show a period of symptom relief were evaluated as having persistent disease. The mean duration between surgery and admission to the hospital was 6.45±4.21 months (1–18 months). The most common US findings in this group were incomplete transection of TCL combined with MN swelling in eight (40.0%) patients, MN thickening in seven (35.0%) patients and tenosynovitis in one patient. No pathology was detected by US in the remaining four (20.0%) patients. Carpal tunnel exploration was planned for all patients with incomplete transection of TCL, but only six of the eight patients accepted a second surgery and were operated in our clinic. In two of these six patients, the ongoing pathology (surgical exploration revealed perineural fibrosis in one patient and tenosynovitis in the other) was not detected by US. The demographic characteristics, US findings and surgical findings of these patients are presented in Table 2.

Fourteen patients who had a brief period of improve-

Table 2. Demographic, ultrasonography and surgical findings of patients who underwent exploration of carpal tunnel in the persistent disease group.

Age	Sex	Time interval* (month)	US findings	Second carpal tunnel surgery findings
50	Female	8	MN swelling + perineural fibrosis	MN swelling + mild perineural fibrosis
65	Female	18	Incomplete transection of TCL + MN swelling	MN swelling + perineural fibrosis
36	Female	12	Incomplete transection of TCL + MN swelling	Incomplete transection of TCL + MN swelling
39	Female	8	Incomplete transection of TCL + MN swelling + synovitis	Incomplete transection of TCL + MN swelling + synovitis
61	Female	8	MN swelling + perineural fibrosis	MN swelling + perineural fibrosis
48	Female	6	Incomplete transection of TCL + MN swelling	Incomplete transection of TCL

*Between surgery and admission to hospital. US: Ultrasonography; MN: Median nerve; TCL: Transverse carpal ligament.

ment followed by symptom relapse were evaluated as having recurrent disease. The mean time between surgery and admission to the hospital was 30.71±22.15 months (8–72 months) in this group. The most common US findings in this group were MN swelling in six (42.9%) patients and perineural fibrosis accompanying MN thickening in three (21.4%) patients. No pathology was demonstrated by US in the remaining five (35.7%) patients. exploration of the carpal tunnel was planned for the patients with perineural fibrosis, all patients in this group rejected a second operation.

The patients in both groups who underwent a second operation achieved permanent relief of their symptoms.

No significant correlation was found between symptoms and sex. Incomplete transection of TCL was observed in the persistent group (n=8) but not in the recurrent disease group, and a significant difference was detected between the two groups ($p<0.0.5$). No statistically significant differences in MN thickness and frequency of perineural fibrosis were observed between the persistent and recurrent groups ($p\geq0.05$). No statistically important differences were observed between the symptoms and age. When the duration from the index operation and application to the hospital was evaluated, a statistically significant difference was observed between the groups ($p<0.001$).

Discussion

Identifying the cause of persistent symptoms following carpal tunnel release is an arduous task. Physical examination alone is not reliable for proper evaluation and accurate diagnosis and complementary diagnostic modalities are usually needed. US is a promising modality for evaluating the exact cause in such complicated cases. We observed that patients were able to tolerate US examinations despite ongoing pain and discomfort at the operative site, even in the early postoperative period. The use of an abundant amount of US transmission gel, which diminishes the pressure applied by the probe on the painful tissues, is effective in alleviating patient discomfort.

This study showed that US was a potent imaging modality for defining the pathology of failed carpal tunnel surgery in almost three fourths of the patients in the study, although in 26.5% of all patients, US failed to detect any pathology. Although the failure rate of US was low (20.0%) in the persistent disease group, it was much greater (35.7%) in the recurrent disease group.

The most important US finding considered as an indicator of the need for operation was incomplete transection of TCL, which was diagnosed in eight patients with persistent symptoms. Among these eight patients, four underwent reoperation in our clinic. In three of these four patients, the preoperative US diagnosis was confirmed during surgery. Intraoperative diagnosis of the remaining patient was perineural fibrosis. Campagna et al. concluded that incomplete transection of TCL was not relevant in the assessment of carpal tunnel decompression in their MRI study.[7] Considering the limitations of MRI, US could be considered to be a very potent imaging method for detecting the partial integrity of TCL after failed surgery, although more studies are needed to provide additional support for increased use of US in these cases.[12]

MN swelling (increased CSA of MN) appears to be the most common US finding after failed carpal tunnel surgery. Recent literature provides support for the CSA of MN as the most accurate criterion in the preoperative diagnosis of CTS.[11,13] However, increased CSA of MN has been reported to remain abnormal for a long time even after successful release;[10] hence, we believe that this finding has limited clinical utility in postoperative evaluations. For this reason, we did not use the quantitative values of the CSA of MN in this study and did not consider it to be a pathognomonic finding in persistent

symptoms.

Perineural fibrosis or fibrous proliferation was the second most common US finding in our study. Perineural fibrosis, which may be either superficial or deep to the MN, may cause a tethering or compression of the nerve within the released carpal tunnel. US appears to be helpful for detecting the site and extent of fibrosis and demonstrating the tethering or adhesions related to MN.

Flexor tenosynovitis is also considered to be a cause of recurrence of CTS symptoms after surgical release.[8,9,14] We were able to detect only two patients with tenosynovitis; one of them was treated with conservative therapy, and symptom relief was achieved without any further surgical intervention. We believe that US helps to identify patients who can be cured without any additional surgical intervention.

Entrapment of the palmar cutaneous branch of MN, pillar pain, infection at the surgical site and postoperative skin or palmar fascia necrosis are considered to be rare causes of persistent symptoms.[2,8,9] Although infection could be diagnosed easily without the need of additional imaging in the majority of patients, the symptoms of pillar pain are very vague and insidious, and there are no defined imaging modalities that can help surgeons in diagnosis. Similarly, entrapment of the palmar cutaneous branch of MN can only be diagnosed by clinical evaluation. On the other hand, iatrogenic nerve lesions such as partial nerve transection and neuroma formation could be easily diagnosed by US.[15]

Apart from diagnosing CTS, US appears to be a useful imaging modality in demonstrating MN thickening, perineural fibrosis and incomplete transection of TCL after surgical release. US findings in persistent carpal tunnel disease may aid surgeons in selecting the proper treatment in complicated cases.

Conflics of Interest: No conflicts declared.

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