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Risk factors related to complications of the fingers and hand after arthroscopic rotator cuff repair – carpal tunnel syndrome, flexor tenosynovitis, and complex regional pain syndrome

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Hypothesis/Background: Complications involving the fingers and hand after arthroscopic rotator cuff repair (ARCR) include complex regional pain syndrome, carpal tunnel syndrome (CTS), and flexor tenosynovitis (TS). The aims of this study were to diagnose the complications after ARCR and investigate the risk factors that could predispose individuals to these finger and hand complications.

Methods: Fifty patients (50 shoulders) who underwent ARCR participated in this study. The patients' ages ranged from 36 to 84 years (mean, 63 years). Before ARCR, we determined the disease history of the fingers and hand (CTS or TS) and subjectively assessed their symptoms using a questionnaire that included a scale ranging from 1 (no symptoms or no disability) to 5 (the worst symptoms or severest disability). ARCR was performed in all patients using suture anchors. The mean observation period after surgery was 15.5 months (range, 12-48 months). We diagnosed complications involving the fingers and hand after ARCR and investigated the preoperative, intraoperative, and postoperative risk factors that could predispose patients to these complications using univariable and multivariable analyses.

Results: After ARCR, 20 patients (20 hands) (40%) had complications of the fingers and hand. Among them, the diagnosis was CTS in 2 hands, TS in 15 hands, and both CTS and TS in 3 hands. None of the hands exhibited complex regional pain syndrome. These complications occurred at an average of 1.8 months (range, 0.1-4 months) after ARCR. In the 47 patients who did not have symptoms just before the operation, both univariable and multivariable analyses between the complication group ($n = 17$) and the no-complications group ($n = 30$) showed a significant difference in the presence of a past history of CTS or TS (complication frequency: past history: 88%, no past history: 25%) ($P < .05$) and the preoperative subjective assessment for edema of the fingers and hand (complication frequency: edema $\geq$ 2 points: 89%, edema < 2 points: 24%) ($P < .05$). There were no relationships between the other candidate intraoperative and postoperative factors and complications.

Conclusion: In all 20 hands with complications of the fingers and hand after ARCR, the diagnosis was CTS or TS. Complications of the fingers and hand after ARCR easily occurred in patients with a past history of CTS or TS and in patients with edema as per a subjective assessment. We speculate that the ARCR triggered the occurrence of CTS and TS postoperatively in patients who had subclinical CTS or TS before surgery.

Among the complications of the fingers and hand that occur after arthroscopic rotator cuff repair (ARCR), complex regional pain syndrome (CRPS) type I has been reported.[1,17,23,24,26,33] The prevalence of CRPS has been reported to range from 0% to 14.8% after ARCR.[1,14,18,23] Regarding the risk factors related to CRPS after ARCR, severe preoperative pain,[13] preoperative shoulder range of motion (ROM) limitations in active external rotation,[13] and poor function as

Institutional review board approval was obtained from the Ethical Committee of Izumi Orthopedic Hospital (study no. IOH IRB-002) before the start of this study. Informed consent was obtained from the subjects.

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per the Japanese Orthopedic Association score[30] have been reported. After open rotator cuff repair, the prevalence of CRPS has been reported to range from 13% to 20%.[8,10,11,31] Regarding the risk factors related to CRPS after open rotator cuff repair, female sex,[10] a long duration between the onset of pain and surgery,[31] and postoperative shoulder ROM limitations in active flexion and external rotation[31] have been reported, although these studies were written in Japanese rather than English.[10,31]

In our retrospective[4] and prospective[5] studies about the complications of the fingers and hand that occur after ARCR, we observed cubital tunnel syndrome, carpal tunnel syndrome (CTS), and flexor tenosynovitis (TS), but no patients exhibited CRPS. However, no studies have investigated the factors related to complications of the fingers and hand after ARCR, including cubital tunnel syndrome, CTS, and TS. The aims of this study were to diagnose complications in the fingers and hand after ARCR and to investigate the risk factors that could predispose patients to these complications.

Materials and methods

Institutional review board approval was acquired before initiation of this study, and informed consent was obtained from all patients. From 2015 to 2019, 51 patients underwent arthroscopic repair for rotator cuff tears. We excluded one patient complicated with a distal radius fracture; the remaining 50 patients (50 shoulders) were prospectively examined. All of the patients were followed up for more than one year after surgery. The baseline demographic characteristics of all patients before ARCR are shown in Table I.

We examined the disease history of the fingers and hand (CTS or TS) and subjectively assessed their symptoms using a questionnaire before ARCR. Regarding the disease history of the fingers and hand (CTS or TS) on the operated side, we checked whether surgery or injection had been performed. In a previous study,[32] the symptoms of the fingers and hand were subjectively assessed using a questionnaire regarding pain, difficulty in flexion, difficulty in extension, triggering, stiffness, edema, numbness, performance, and difficulty in performing activities in daily life; the scale ranged from 1 (no symptoms or no disability) to 5 (the worst symptoms or the severest disability) for each assessment. One of the authors (M.H.), who is an orthopedic shoulder surgeon, examined all patients directly (face to face) to assess the symptoms of the fingers and hand before ARCR. For patients with symptoms such as pain or numbness, whether the symptoms were related to a diagnosis of CTS or TS was confirmed. As per the diagnostic criteria for CTS and TS used in previous studies,[21,22] the diagnoses of CTS and TS were confirmed (Table II). To subjectively assess the symptoms, the questionnaire was administered by a nurse or physical therapist blinded to the patient groups and who did not exchange information with the doctors who examined the patients face-to-face to assess their symptoms. The preoperative baseline demographic characteristics of all patients before ARCR are shown in Table I.

After general anesthesia was induced, the patient was placed in the beach-chair position. ARCR was performed using suture anchors in all patients. After surgery, the arms were immobilized using an UltraSling (UltraSling, DONJOY, Ontario, Canada). On postoperative day 1, all patients in this consecutive series began an organized exercise program including active ROM exercises of the fingers and elbow under the supervision of a physical therapist. The patients began performing passive ROM shoulder exercises 1 to 3 weeks (mean, 1.5 weeks) after surgery. The mean observation period after surgery was 15.5 ± 4.9 months (range, 12-48 months). The intraoperative and postoperative findings of all patients are shown in Table III.

Table I
Baseline demographic characteristics of the included patients before ARCR.

	Mean ± SD or N (%)
Age, years	63.2 ± 10.2
Sex, n (%)	
Male	37 (74)
Female	13 (26)
Operated side, n (%)	
Dominant	48 (96)
Nondominant	2 (4)
Reason for onset of shoulder pain, n (%)	
Acute	22 (44)
Chronic	28 (56)
Job, n (%)	
Manual labor	31 (62)
Desk work	12 (24)
None	7 (14)
Diabetes mellitus, n (%)	8 (16)
Symptom duration, mon	20.2 ± 31.2
Preoperative Hand 20*	27.7 ± 17.6
Preoperative JOA score	64.2 ± 9.5
Preoperative active range of motion of the shoulder	
Forward flexion, deg	118 ± 33.3
External rotation in 0 degrees of abduction, deg	48 ± 19.1
Internal rotation at back† (C7~Th12, L1~L5, buttocks)	12 (24), 36 (72), 2 (4)
Preoperative passive range of motion of shoulder	
Forward flexion, deg	143 ± 18.7
Preoperative grip strength, kg	
Operated side	30.5 ± 11.5
Ratio (operated side/nonoperated side)	0.96 ± 0.21

ARCR, arthroscopic rotator cuff repair; *JOA*, Japanese Orthopedic Association.
*Subjective assessment for upper extremity function.
†Measured by the vertebral level that the patient could reach with the thumb.

We examined the fingers and hand on the operated side for complications, including numbness, pain, edema, and movement limitations, for one year after ARCR, diagnosed them, and attempted to proactively treat them. The mechanisms underlying the development of the complications in the fingers and hand were classified into the following three categories: (1) current diseases that were present just before the operation (presence of a past history preoperatively, presence of preoperative symptoms), (2) subclinical diseases that were present before surgery (presence of a past history preoperatively, absence of preoperative symptoms), and (3) acute diseases that had newly developed after surgery (absence of a past history preoperatively, absence of preoperative symptoms). CTS and TS were diagnosed based on the aforementioned criteria. A diagnosis of CRPS was made as per the Budapest clinical diagnostic criteria.[6,7]

In the first investigation, we investigated the following risk factors that could predispose patients who did not have a current disease just before the operation to complications involving the fingers and hand after ARCR: (1) preoperative factors including age, sex, job, reason for the onset of shoulder pain, duration between symptom onset and surgery (symptom duration), past history of CTS or TS, subjective assessment for the symptoms in the fingers and hand, subjective assessment for upper extremity function (Hand 20), Japanese Orthopedic Association score, ROM of the shoulder, and grip strength; (2) intraoperative factors including the use of an arm holder, tear size, subscapularis tendon tear, operation method, biceps tendon release or tenodesis, number of anchors, operation time, postoperative analgesia, and postoperative continuous intravenous infusion; and (3) postoperative factors including the frequency of use of suppositories or injections within one week after the operation, start time of shoulder ROM exercises, retears, and the Japanese Orthopedic Association score one year after ARCR; ROM of the shoulder at 3, 6, and 12 months; and stiffness at 12 months. In the second investigation, for subjects who

Table II
Diagnostic criteria for carpal tunnel syndrome and flexor tenosynovitis and grading for flexor tenosynovitis.

Diagnostic criteria for CTS
1. Finger numbness (thumb, index, middle, or ring finger)
2. Pinch disorder
3. Abnormal physical findings: Tinel's sign, Phalen's test, the carpal compression test, atrophy and muscle weakness of the abductor pollicis brevis, abnormal Perfect O sign
4. Delay in distal motor latency of the median nerve beyond 4.2 milliseconds
All patients with finger numbness (thumb, index, middle, or ring finger) underwent conduction velocity testing of the median nerve.
Diagnostic criteria for TS
1. Motion pain or movement limitations of the fingers
2. Abnormal physical findings regarding more than one of the following: triggering, tenderness around the metacarpophalangeal (MP) joints, and swelling of the flexor tendon.
Swelling of the flexor tendon was considered present when an orthopedic clinician noted thickening of the flexor tendon distal or proximal to the A1 pulley while pulling the volar MP joint as the patient actively flexed the fingers.
Grading for TS
Grade I. Pain or tenderness at the A1 pully
Grade II. Triggered but actively extend digit
Grade III. Locking requiring passive extension
Grade IV. Fixed flexion contracture
Carpal tunnel syndrome (CTS) or flexor tenosynovitis (TS).

Table III
Baseline demographic characteristics of the included patients during and after ARCR.

	Mean ± SD or N (%)
During ARCR	
Arm holder, n (%)	
Yes	29 (58)
No	21 (42)
Rotator cuff tear size, n (%)	
Small (< 1 cm)	8 (16)
Medium (1-3 cm)	25 (50)
Large (3-5 cm)	11 (22)
Massive (> 5 cm)	4 (8)
Subscapularis tendon tear, n (%)	2 (4)
Operation method, n (%)	
All scopic surgery	37 (74)
Arthroscopic-assisted surgery (mini open with assisted arthroscopy)	13 (26)
Biceps tendon release or tenodesis, n (%)	17 (34)
Anchors	5.7 ± 2.4
Operation time, min	204 ± 45.4
Postoperative analgesia, n (%)	
Ultrasonographic single brachial plexus block	24 (48)
Intrasubacromial injection*	26 (52)
Postoperative continuous intravenous infusion, n (%)	
Fentanyl citrate and acetaminophen	41 (82)
Fentanyl citrate alone	9 (18)
Observation period after surgery	15.5 ± 4.9
After ARCR	
1 week	
Frequency of suppository use within one week after the operation	2.4 ± 2.7
Frequency of injections within one week after the operation	1.4 ± 2.0
Start time of passive range or motion exercise after operation, weeks	1.5 ± 0.8
3 mo	
Passive range of motion of the shoulder three months after the operation	
Forward flexion, deg	129 ± 19.8
6 mo	
Passive range of motion of the shoulder six months after the operation	
Forward flexion, deg	142 ± 18.1
1 yr	
Preoperative active range of the motion of shoulder one year after the operation	
Forward flexion, deg	150 ± 13.8
External rotation at 0 degrees of abduction, deg	50 ± 19.4
Internal rotation at back† (C7~Th12, L1~L5, buttock)	41 (82), 8 (16), 1 (2)
Preoperative passive range of motion of the shoulder	
Forward flexion one year after the operation, deg	156 ± 12.8
Stiffness one year after the operation‡, n (%)	2 (4)
Retear one year after the operation, n (%)	4 (8)
JOA score one year after the operation	92 ± 6.8

ARCR, arthroscopic rotator cuff repair; *JOA*, Japanese nalic Association.
*Single ropivacaine hydrochloride intrasubacromial bursa injection.
†Measured by vertebral level that the patient could reach with the thumb.
‡Stiffness was diagnosed in the operative shoulder when passive forward flexion of less than 120° was achieved.

did not have a current disease just before the operation, we also investigated the relationships between a preoperative disease history of the fingers and hand and preoperative subjective assessment for symptoms in the fingers or hand. In the third investigation, for patients with acute disease not including those who had a current or subclinical disease just before the operation, we investigated the associations of the same factors with complications of the fingers and hand after ARCR as in the first investigation.

In the statistical analysis of the first and third investigations, we compared the patients with complications of the fingers and hand (complication group) to those without complications (no complications group). For univariable analysis, Fisher's exact test and the Mann-Whitney U test were used, and differences at $P < .05$ were considered to be significant. For the factors that were significantly different s per Fisher's exact test, multivariable logistic regression models were created. In addition, for the factors that were significantly different as per the Mann-Whitney U test, cutoff values for complications were calculated using receiver operating characteristic curve analysis. To compare the cutoff values and the factors we examined, univariable analysis was performed using Fisher's exact test, and multivariable logistic regression analysis was performed. In the statistical analysis of the second investigation, we compared the preoperative subjective assessment of the symptoms in the fingers or hand between the patients with a preoperative disease history of the fingers and hand (past history group) and those without the history (no past history group). Fisher's exact test and the Mann-Whitney U test were used, and differences at $P < .05$ were considered to be significant. Calculations were performed using EZR (Saitama Medical Center, Jichi Medical University, Saitama, Japan).[9]

Results

Regarding the preoperative disease history in the fingers and hand before ARCR, TS was present in 9 patients (18%), including 1 with a history of surgery involving the middle finger and 8 with a history of injections; the injections were made in the thumb in 3 patients, in the middle finger in 3, in the ring finger in 1, in the little finger in 1, and in an unclear region in 1 (one patient had a past history of TS in both the middle and little fingers). CTS was present in 4 patients (8%), including 1 with a history of surgery and 3 with a history of injections. Two patients had a past history of both TS and CTS. Preoperatively, the subjective assessment for the symptoms of the fingers and hand determined using the questionnaire (1: no symptoms or no disability ~ 5: the worst symptoms or the most severe disability) was 1.3 ± 0.7 points for pain, 1.1 ± 0.4 for difficulty in flexion, 1.1 ± 1.1 for difficulty in extension, 1.1 ± 0.5 for triggering, 1.4 ± 0.8 for stiffness, 1.2 ± 0.5 for edema, 1.3 ± 0.7 for numbness, 1.3 ± 0.7 for performance, and 1.3 ± 0.7 for difficulty performing activities of daily living. By directly examining (face to face) the patients, the orthopedic shoulder surgeon found that 3 patients had current symptoms just before the operation, including TS of the middle finger in 1 hand, CTS in 1 hand, and both TS of the middle finger and CTS in 1 hand. The two patients with TS in the middle finger had a past history of injection, and the one patient with CTS alone had a past history of injection.

After ARCR, 20 patients (20 hands) (40%) had complications of the fingers and hand, such as numbness, pain, edema, and movement limitations on the operated side, which occurred an average of 1.8 ± 0.9 months (range, 0.1-4 months) after ARCR. Among the 20 patients, the diagnosis was CTS in 2 hands, TS in 15 hands, and both CTS and TS in 3 hands. None of the 18 hands with TS exhibited triggering of the fingers.

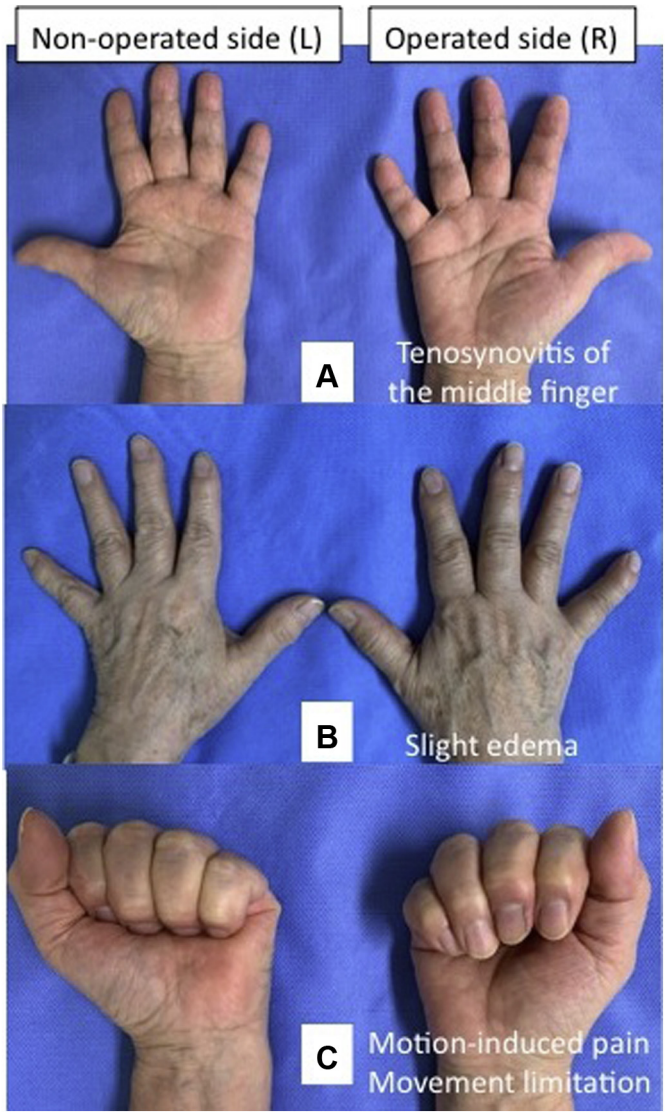

Figure 1 A 51-year-old female patient. Flexor tenosynovitis (TS) was present in the middle finger on the operated side (*Right* side) after arthroscopic rotator cuff repair (ARCR). Pain, edema, and movement limitations occurred 1.5 months after ARCR, and the patient was diagnosed with TS in the middle finger. She did not have a past history or symptoms in the fingers or hand before ARCR, and the mechanism underlying the complications after ARCR was an acute disease that developed after surgery. At onset, the patient experienced slight edema in the middle finger and dorsal hand on the operated side (R: *Right* side) relative to the contralateral side (L: *Left* side) (**A**, palmar anterior-posterior view; **B**, dorsal anterior-posterior view). The patient also experienced motion-induced middle finger pain and movement limitations in the index, middle, and ring fingers (palmar anterior-posterior view when fingers flexed; **C**).

None of the hands exhibited CRPS. Regarding the mechanisms of the development of CTS and TS in the 20 patients diagnosed with either condition, a current disease had been present just before the operation in 3 hands (CTS in 1, TS in 1, both CTS and TS in 1), a subclinical disease had been present before surgery in 7 hands (CTS in 1, TS in 4, both CTS and TS in 2), and an acute disease had developed after surgery in 10 hands (TS in 10) (Fig. 1). All 20 hands diagnosed with CTS or TS were treated with corticosteroid injections, and the symptoms in all 20 hands resolved completely.

In the first investigation, for the 47 patients without a current disease just before the operation (CTS in 1, TS in 1, and both CTS and TS in 1), we compared those with complications of the fingers and

hand (complication group: 17 hands) to those without complications (no complications group: 30 hands) to investigate the preoperative, intraoperative, and postoperative risk factors that could predispose them to complications in the fingers and hand after ARCR (Table IV). Univariable analysis showed that female sex (complication frequency: female, 67%; male, 25%), the presence of a past history of CTS or TS (complication frequency: past history: 88%, no past history: 25%), and edema according to the preoperative subjective assessment (complication group: 1.5 points, no complications group: 1.0 points) were significant factors predisposing patients to complications (all $P < .05$) (Table IV). There were no relationships between the other candidate intraoperative and postoperative factors and complications. Multivariable logistic regression models for the risk factors that were significantly different showed that although female sex was not a significant factor, the odds ratio (95% confidence interval, P value) of the presence of a past history of CTS or TS was 22.9 (1.71, 307.0, $P < .01$) (Table V). The cutoff value for edema as per the preoperative subjective assessment for complications was 2.0 points (specificity: 0.96, sensitivity: 0.47, area under the curve: 0.71, 95% confidence intervals: 0.59-0.84). The frequency of complications in the patients with a preoperative subjective assessment score of 2 or more points for edema was significantly higher than that in the patients with a score of 2 points or less (complication frequency: edema $\geq$ 2 points: 89%, edema < 2 points: 24%) ($P < .05$) (Table IV). The multivariable logistic regression models showed that the odds ratio (95% confidence interval, P value) of a preoperative subjective edema score of 2 or more points was 30.2 (1.28, 711.0, $P < .05$) (Table V).

In the second investigation, for the 47 patients without a current disease just before the operation (CTS in 1, TS in 1, and both CTS and TS in 1), we compared the preoperative subjective assessment for the symptoms in the fingers or hand between the patients with a preoperative disease history of the fingers and hand (past history group: 8 hands) and those without this past history (no past history group: 39 hands). The preoperative subjective scores regarding difficulty in flexion, triggering, stiffness, numbness, and performance of the patients in the past history group were significantly higher than those of the patients in the no past history group (all $P < .05$) (Table VI). In addition, although the difference was not significant, the score for difficulty in extension in the past history group tended to be higher than those in the no past history group ($P = .0741$) (Table VI). Although the difference was not significant, the frequency of having a past history tended to be higher in the patients with a preoperative subjective score of edema of 2 or more points than in those with a score of 2 points or less (past history frequency: edema $\geq$ 2 points: 33%, edema < 2 points: 13%) ($P = .16$) (Table VI).

In the third investigation, for the 40 patients who did not have a current disease or subclinical disease just before the operation, we compared the patients with complications of the fingers and hand (complication group: 10 hands) with those without complications (no complications group: 30 hands) to investigate the preoperative, intraoperative, and postoperative risk factors that could predispose them to complications in the fingers and hand after ARCR (Table VII). All 10 patients in this complication group had an acute disease that was diagnosed as TS. Univariable analysis showed a significant difference in the preoperative subjective edema scores (complications group: 1.5 points, no complications group: 1.0 points) (Table VII). Although the difference was not significant, univariable analysis showed that the frequency of complications in female patients tended to be higher than that in male patients (complication frequency: female, 50%; male, 18%) ($P = .08$) and that the number of postoperative injections performed within 1 week after ARCR in the complication group tended to be higher than that in the no complication group (postoperative injection frequency within 1 week: complication group: 2.1, no complication group: 0.7) ($P = .06$) (Table VII). There were no relationships between the other candidate preoperative, intraoperative, and postoperative factors and complications. The cutoff value for the preoperative subjective edema score was 2.0 points (specificity: 0.96, sensitivity: 0.50, area under the curve: 0.73, 95% confidence intervals: 0.56 - 0.89). The frequency of complications in the patients with a preoperative subjective assessment score of 2 or more points for edema was significantly higher than that in the patients with a score of 2 points or less (complication frequency: edema $\geq$2 points: 83%, edema < 2 points: 15%) ($P < .05$) (Table VII). The multivariable logistic regression models showed that the odds ratio (95% confidence interval, P value) of a preoperative subjective edema score of 2 or more points was 29.0 (2.77, 303.0, $P < .05$).

Discussion

In our study, 20 patients (40%) had complications of the fingers and hand after ARCR. Among them, the diagnosis was CTS in 2 hands, TS in 15 hands, and both CTS and TS in 3 hands; none of the hands exhibited CRPS. In our retrospective[4] and prospective[5] studies, we also reported that the complications of the fingers and hand that occurred after ARCR were mainly CTS or TS and that none of the hands exhibited CRPS after ARCR. Our current and previous studies suggest that CTS or TS can easily occur after ARCR. Therefore, when complications in the fingers and hand occur after ARCR, it is important for us to primarily suspect CTS or TS.

CTS and TS are among the most common diseases treated by orthopedic doctors, and it has been reported that these two diseases frequently occur and share a relationship.[21] The main symptoms of CTS are pinch impairment and numbness of the fingers and hand,[21] and the main symptom of TS is pain with triggering of the fingers and hand.[16] In addition, CTS and TS have been reported to occur after trauma or surgical intervention, resulting in the presentation of CRPS-like symptoms, including numbness, pain, edema, and movement limitations in the fingers and hand[12,15,29]; therefore, it is important to distinguish CRPS from these conditions. Three main criteria have been used for a CRPS diagnosis, including the International Association for the Study of Pain criteria,[27] the criteria of the Ministry of Health, Labor, and Welfare study team for CRPS in Japan,[28] and the Budapest criteria.[6,7] The incidence of CRPS is largely influenced by the criteria used, as there is a large difference between the International Association for the Study of Pain or Ministry of Health, Labor, and Welfare study team for CRPS in Japan and Budapest criteria; namely, the presence or absence of 1 item: “no other diagnosis better explains the signs and symptoms.” The Budapest criteria includes this 1 item, whereas the International Association for the Study of Pain and Ministry of Health, Labor, and Welfare study team for CRPS in Japan criteria does not. In our study, we chose the Budapest criteria for CRPS; as per its unique item, we were able to diagnose CTS or TS before diagnosing CRPS, resulting in no cases of CRPS.

In our study, the mechanisms underlying symptom development of the 20 patients with complications of the fingers and hand after ARCR included a current disease in 3 hands, a subclinical disease in 7 hands, and an acute disease in 10 hands. For the 47 patients who did not have a current disease just before the operation, regarding the risk factors that could predispose patients to complications in the fingers and hand after ARCR, univariable analysis showed a significant difference between sexes, although the difference between sexes was not significant in multivariable analysis. In previous studies on CTS and TS, the frequency of onset of CTS in women was 3 times higher than that in men,[21] and the frequency of onset of TS in women was 6 times higher than that in males.[2,19,20,34] In this study, complications of the fingers and hand

Table IV
Risk factors related to complications of the fingers and hand after ARCR in subjects without a current disease just before the operation.

	Total	Complications of the fingers after ARCR (excluding 3 patients)*						*P* value
		Yes (n = 17)			No (n = 30)			
		Mean ± SD	n	%	Mean ± SD	n	%	
Sex								
Male	35		9	25		26	75	.00165
Female	12		8	67		4	33	
Preoperative history of disease in the fingers and hand†								
Present	8		7	88		1	12	.0019
Absent	39		10	25		29	75	
Preoperative subjective assessment of symptoms in the fingers or hand‡								
Edema ≥ 2 points	9		8	89		1	11	.000553
Edema < 2 points	38		9	24		29	76	
1. Pain	47	1.3 ± 0.7			1.2 ± 0.6			.647
2. Difficulty in flexion	47	1.1 ± 0.3			1.0 ± 0.1			.266
3. Difficulty in extension	47	1.2 ± 0.3			1.0 ± 0.1			.0992
4. Triggering	47	1.1 ± 0.3			1.0 ± 0.1			.266
5. Stiffness	47	1.4 ± 0.7			1.2 ± 0.6			.399
6. Edema	47	1.5 ± 0.5			1.0 ± 0.1			.000312
7. Numbness	47	1.4 ± 0.9			1.2 ± 0.3			.206
8. Performance	47	1.4 ± 0.6			1.2 ± 0.5			.186
9. Difficulty in daily life activities	47	1.7 ± 0.9			1.2 ± 0.5			.126

ARCR, arthroscopic rotator cuff repair.
*We investigated the risk factors related to complications of the fingers and hand after arthroscopic rotator cuff repair in the 47 patients, not including the 3 patients who had a current disease just before the operation.
†Preoperative history of the fingers and hand for disease, including carpal tunnel syndrome or flexor tenosynovitis.
‡Subjective assessment for symptoms of fingers and hand with a scale ranging from 1 (no symptoms or no disability) to 5 (the worst symptoms or the severest disability).

after ARCR easily occurred in men. We speculate that our results are consistent with those of these previous studies on CTS and TS.

Regarding risk factors that could predispose patients to complications, both univariable and multivariable analyses showed significant effects from the presence of a past history of CTS or TS and a preoperative subjective edema score of 2 or more points. In terms of the relationships between a preoperative disease history of the fingers and hand and the preoperative subjective assessment for symptoms in the fingers or hand, the frequency of a past history tended to be higher in patients with a preoperative subjective edema score of 2 or more points than in those with lower scores, although the difference was not significant. In addition, most patients with a preoperative past history of disease had symptoms such as difficulty in flexion, triggering, stiffness, numbness, and performance as per the preoperative subjective assessment. These results suggest that most patients with a past history of CTS or TS have preoperative symptoms in the fingers or hand and that, in those patients, complications of the fingers and hand can easily occur after ARCR. Thus, we speculate that the cases of subclinical CTS or TS that were present before surgery were aggravated by ARCR, resulting in CTS and TS occurring after ARCR.

TS was divided into 4 grades[3] (Table II). In previous studies, the most common symptom of TS has been reported to be pain with triggering of the fingers and hand,[16] while fixed flexion contracture has not been shown to trigger TS, and the diagnosis of TS is often difficult.[29] Fixed flexion contracture TS is diagnosed when an orthopedic clinician notes tenderness of the flexor tendon distal or proximal to the A1 pulley during active or passive flexion of fingers and when active movement limitation is observed without passive movement limitation.[29] In our study, all 10 patients with an acute disease were diagnosed with TS. None of the 18 hands with TS also exhibited triggering of the fingers. These results suggest that the TS that occurs after ARCR is fixed flexion contracture TS rather than traditional TS.

In our study, in the 40 patients who did not have a current disease or subclinical disease just before the operation, we investigated the risk factors that were related to TS (in 10 hands) as an acute disease after ARCR. Both univariable and multivariable analyses showed a significant difference in the preoperative score for edema of the fingers and hand. These results suggest that most patients with preoperative edema in the fingers and hand are predisposed to developing TS as acute disease after ARCR. Among the 10 hands with TS as an acute disease, 5 (50%) had slight edema in the fingers and hand as per the subjective questionnaire. However, the face-to-face examination by an orthopedic shoulder surgeon before ARCR showed that none of the patients had edema. These results suggest that the patients with TS as an acute disease after ARCR might have had subclinical TS before ARCR that was not detected by the doctor in the preoperative examination. We speculate that the case of subclinical TS that was present before surgery was aggravated by ARCR, resulting in TS as an acute disease occurring after ARCR.

In terms of the factors that were related to TS as an acute disease after ARCR in the 10 hands, the frequency of complications in the female patients tended to be higher than that in the male patients, although the difference was not significant. As we mentioned before, the frequency of TS in women has been reported to be 6 times higher than that in men.[2,19,20,34] Our results appear to be consistent with the results of these previous studies. In addition, it has been reported that TS easily occurs after distal radius fractures (DRFs).[16,25,35] While there were no significant differences in the frequency of TS after DRF between the groups treated with conservative and operative treatments,[35] a comparison of the conservative (n = 40) and operative (n = 38) treatment groups showed that TS occurred after DRF in 5 hands in the operative treatment group in the retrospective study.[25] In that study, it was unclear why the frequency of TS after DRF in the operative treatment group was high, but it was speculated that, owing to poor rehabilitation or wrist pain after the DRF operation, finger stiffness occurred, resulting in a mismatch of the flexor tendons and the surrounding retinaculum of the A1 pulley, leading to symptoms of TS. In terms of

Table V
Multivariable logistic regression model variables used to investigate the risk factors associated with complications of the fingers and hand after ARCR in all subjects except the 3 subjects with a current disease just before the operation.

Factor	Variable	Total	n	Percentage	Odds ratio	95% confidence interval	*P* value
Sex	Female	12	8	67	2.85	0.42-19.2	.282
Preoperative history of disease in the fingers or hand*	Present	8	7	88	22.9	1.71-307.0	.0018
Preoperative subjective assessment for symptoms in the fingers or hand†	Edema ≥ 2 points	9	8	89	30.2	1.28-711	.0345

*Preoperative history of disease of the fingers and hand, including carpal tunnel syndrome or flexor tenosynovitis.
†Subjective assessment for symptoms of fingers and hand with a scale ranging from 1 (no symptoms or no disability) to 5 (the worst symptoms or the severest disability).

Table VI
Relationships between a preoperative disease history of the fingers and hand and preoperative subjective assessment for symptoms in the fingers or hand in all subjects except the 3 patients with a current disease just before the operation.

Preoperative subjective assessment for symptoms in the fingers or hand†	Total	Preoperative history of disease of the fingers and hand*						*P* value
		Yes (n = 8)			No (n = 39)			
		Mean ± SD	n	%	Mean ± SD	n	%	
Edema ≥ 2 points	9		3	33		6	67	.167
Edema < 2 points	38		5	13		33	87	
1. Pain	47	1.5 ± 1.0			1.2 ± 0.5			.36
2. Difficulty in flexion	47	1.3 ± 0.4			1.0 ± 0.1			.02
3. Difficulty in extension	47	1.3 ± 0.4			1.1 ± 0.2			.0741
4. Triggering	47	1.3 ± 0.4			1.0 ± 0.1			.02
5. Stiffness	47	1.8 ± 1.0			1.2 ± 0.5			.0303
6. Edema	47	1.4 ± 0.5			1.2 ± 0.3			.154
7. Numbness	47	1.8 ± 1.3			1.2 ± 0.3			.0197
8. Performance	47	1.8 ± 0.7			1.2 ± 0.5			.000937
9. Difficulty in daily life activities	47	1.6 ± 0.5			1.3 ± 0.7			.13

*Preoperative history of disease of the fingers and hand, including carpal tunnel syndrome (CTS) or flexor tenosynovitis (TS).
†Subjective assessment for symptoms of fingers and hand with a scale ranging from 1 (no symptoms or no disability) to 5 (the worst symptoms or the most severe disability).

Table VII
Risk factors related to complications of the fingers and hand after ARCR in the subjects without a current or subclinical disease just before the operation.

	Total	Complications of the fingers after ARCR (excluding 10 patients)*						*P* value
		Yes (n = 10)			No (n = 30)			
		Mean ± SD	n	%	Mean ± SD	n	%	
Preoperative								
Sex								
Male	32		6	18		26	82	.08
Female	8		4	50		4	50	
Preoperative subjective assessment for symptoms in the fingers or hand†								
Edema ≥ 2 points	6		5	83		1	17	.00202
Edema < 2 points	34		5	15		29	85	
1. Pain	40	1.1 ± 0.3			1.2 ± 0.6			.624
2. Difficulty in flexion	40	1.0 ± 0.0			1.0 ± 0.1			.57
3. Difficulty in extension	40	1.1 ± 0.3			1.0 ± 0.1			.415
4. Triggering	40	1.0 ± 0.0			1.0 ± 0.1			.57
5. Stiffness	40	1.1 ± 0.3			1.2 ± 0.6			.524
6. Edema	40	1.5 ± 0.5			1.0 ± 0.1			.00045
7. Numbness	40	1.1 ± 0.3			1.2 ± 0.3			.945
8. Performance	40	1.1 ± 0.3			1.2 ± 0.5			.737
9. Difficulty in daily life activities	40	1.7 ± 1.2			1.2 ± 0.5			.603
Postoperative								
Postoperative injection frequency within 1 week after ARCR								
Number	40	2.1 ± 2.6			0.7 ± 1.0			.06

ARCR, arthroscopic rotator cuff repair.
*We investigated the risk factors related to complications of the fingers and hand after arthroscopic rotator cuff repair in the patients, excluding the 10 patients who had a current or subclinical disease just before the operation.
†Subjective assessment for symptoms of fingers and hand including a scale ranging from 1 (no symptoms or no disability) to 5 (the worst symptoms or the severest disability).

the factors that were related to TS as an acute disease after ARCR in the 10 hands, the number of postoperative injections performed within 1 week after ARCR tended to be higher in the group with finger and hand complications than in the group without these complications. We speculate that it was difficult for the patients to move their fingers owing to shoulder pain after ARCR and finally that the symptoms of TS were started by a similar mechanism as those of TS after the DRF operations.

Regarding treatment outcomes, in our study, 20 hands diagnosed with CTS or TS were treated with corticosteroid injections, and the symptoms in all hands resolved completely. These results suggest that rapid corticosteroid injection administration could be effective in treating complications. To prevent worsening of the symptoms of CTS or TS, immediately after the patients experienced these symptoms, we began to treat the complications with corticosteroid injections. Therefore, we could not know how long these complications would persist after ARCR. In terms of the clinical outcomes in patients with complications of the fingers and hand after ARCR who were diagnosed with CRPS, Kobayashi et al[10] reported that the coexistence of CRPS does not affect shoulder function after surgery. However, we believe that it could be of great importance to evaluate the outcomes of hand lesions caused by complications of the fingers and hand after ARCR, including CRPS, CTS, or TS; this is because patients with complications after ARCR have difficulty performing activities of daily life if the symptoms of CTS and TS persist, even if the shoulder symptoms disappear after ARCR.

We hypothesized that intraoperative factors such as the use of an arm holder would be associated with complications in the fingers and hand after ARCR because, for example, the covering of the forearm with an elastic bandage during the use of an arm holder would lead to compression of the forearm, consequently resulting in the onset of complications. However, in our study, there were no relationships between the intraoperative factors and the complications. We speculate that this is due to the very small sample size.

In our study, 20 patients (20 hands) (40%) had complications of the fingers and hand after ARCR, with a frequency higher than that reported in previous studies on CTS, TS, and CRPS, which ranged from 0% to 35% after ARCR.[1,4,5,14,18,23] This relatively high frequency might be because we included slight symptoms as complications. By including these symptoms, we were able to diagnose and treat them to prevent them from worsening. This study had several limitations. The first is that our study had a very small sample size. Additional investigations with large study populations and comparisons between 2 groups are needed. Second, the diagnoses may have been biased because the author who diagnosed these complications is an orthopedic shoulder surgeon (the investigator). However, we do not consider this limitation to have caused a large bias because the investigator did not diagnose these patients by observing results but by following established diagnostic criteria for CTS, TS, and CRPS.

Conclusions

After ARCR, 20 patients (40%) had complications of the fingers and hand. The diagnosis was CTS in 2 hands, TS in 15 hands, and both CTS and TS in 3 hands. Complications easily occurred in patients with a past history of CTS or TS and those with edema as per the subjective assessment. We speculate that the cases of subclinical CTS or TS that were present before surgery were aggravated by ARCR, resulting in CTS and TS occurring after the procedure.

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