Hand lesion after arthroscopic rotator cuff repair: Association with complex regional pain syndrome

Abstract

Background: It is known that complex regional pain syndrome (CRPS) occurs after arthroscopic rotator cuff repair (ARCR); however, few studies have investigated this complication. Therefore, the purpose of the present study was to evaluate CRPS after ARCR.

Methods: A total of 182 patients who underwent ARCR were enrolled in this study. The average age of patients was 62.8±10.0 years, with an average follow-up period of 21.5±38.1 months. CRPS criteria outlined by the Ministry of Health, Labor, and Welfare study team for CRPS in Japan (MHLWJ) and International Association for the Study of Pain (IASP 2005) were utilized for diagnosis. There are two rating systems for the “clinical purpose” and “research purpose” in both criteria, respectively. Clinical outcomes, including Japanese Orthopaedic Association (JOA) and University of California, Los Angeles scores, were evaluated using univariate and multivariate analysis.

Results: CRPS exclusively occurred in the hand of the operated limb, developing within 3 months of surgery. Two or more of the following symptoms were noted in patients with the hand lesion associated with CRPS: edema (93.4%), restricted range of motion (83.4%), hyperalgesia (30.1%), paridrosis (20.4%), and atrophic change (12.2%). Under these

conditions, the incidences of CRPS were 24.2% (44/182) when evaluated by the MHLWJ rating system for the “clinical purpose;” 11% (22/182) by the MHLWJ rating system for the “research purpose;” 6% (11/182) by the IASP 2005 for the “clinical purpose;” and 0.5% (1/182) by the IASP 2005 for the “research purpose.” Results of multivariate analysis demonstrated that “Function” in the JOA score was a risk factor for the development of CRPS after ARCR, when evaluated by a system for the “clinical purpose” of the MHLWJ.

Conclusion: Following ARCR, CRPS-induced hand lesions occur more frequently than is generally believed, thereby suggesting that its impact on surgical outcomes should be clarified in the future.

Introduction

Rotator cuff tears often occur in middle-aged and elderly individuals. Recently, arthroscopic rotator cuff repair (ARCR) is regarded as the gold standard treatment [1,2]. In previous studies, there were no differences in outcomes between the arthroscopic and mini-open rotator cuff repair techniques [3,4]; however, fewer complications were reported after ARCR than after open repair [5]. Vascular and neurologic injury, fluid extravasation, stiffness, and iatrogenic tendon injury may occur following surgery [6,7].

Complex regional pain syndrome (CRPS) may occur after ARCR [8,9], which is induced by various etiologic factors, including minor traumas, fractures, sprains, immobilization, and surgical interventions. CRPS induces atrophic change, range of motion (ROM) limitations, hyperalgesia, paridrosis, and edemas of the involved limb [10]. The incidence of CRPS after ARCR is reported to be 11.0-21.7% in Japanese literature [11-14]; however, little attention has been paid to this complication in studies in English literature.

It is also well known that CRPS occurs after ARCR; however, few studies have investigated this complication. Therefore, the present study aimed to evaluate CRPS after ARCR.

Methods

This retrospective study was approved by the institutional review board of the author's

institution. Written consent was obtained from the patients of the study.

Patients

Between January 2009 and June 2014, 210 patients underwent ARCR for a rotator cuff tear at our institution. Inclusion criteria were as follows: (1) individuals who had arthroscopic rotator cuff repair, (2) individuals followed up with for at least 6 months, and (3) individuals who underwent imaging and physical examination before surgery. Exclusion criteria were as follows: (1) individuals who underwent open repair, (2) individuals who had fractures and degenerative arthritis, and (3) individuals who had undergone bilateral surgery. Consequently, a total of 182 patients with rotator cuff tears were candidates for the present study.

Surgical technique

Arthroscopic surgery was considered for patients who did not respond to nonoperative treatment for 3 months or more, which included the administration of anti-inflammatory medication, physical therapy, and subacromial/glenohumeral injections of corticosteroids or hyaluronic acid.

All procedures were performed in a beach-chair position under general anesthesia. First, glenohumeral inspection was done through a posterior portal and then transferred to the subacromial bursa. Following the creation of a lateral portal, the detached tendon edge was identified, and its mobility was evaluated by grasping the edge of the tendon and reducing the tendon to the footprint. Using the anterior, anterolateral, or posterolateral portal, capsular

release, tenotomy/tenodesis of the long head of the biceps tendon and distal clavicle excision were performed as required. Acromioplasty was performed in all patients. Cuff repairs were accomplished using a single-row, double-row, or suture bridge technique depending on the tendon mobility and tear configuration**.**

Postoperative regimen

Postoperatively, patients were immobilized in a sling for 6 weeks, with an abduction pillow, and they were given instructions to maintain the shoulder at 30-40° of internal rotation and 20° of abduction. Elbow, wrist, and finger ROM exercises were initiated immediately after surgery. Passive forward elevation of the shoulder commenced the day after surgery. At 4 weeks post-surgery, active-assisted motion of the shoulder was initiated, and at 6 weeks, active motion was permitted. At 8 weeks, isometric muscle-strengthening exercises were introduced, and at 12 weeks, isotonic muscle strengthening was initiated.

Diagnosis of CRPS

The present study utilized the criteria suggested by the Ministry of Health, Labor, and Welfare CRPS study team in Japan (MHLWJ). A diagnosis of CRPS was determined when at least two or more corresponding items were fulfilled both subjectively and objectively in the rating system for the “clinical purpose,” or when at least three or more items in the system for the “research purpose” were fulfilled. Details of the MHLWJ criteria are shown in Table 1 [15].

87 Diagnostic criteria outlined by the International Association for the Study of Pain in
88 2005 (IASP 2005) were also used for diagnosis. A diagnosis of CRPS was determined when
89 the three or more corresponding items were fulfilled subjectively and two or more items
90 objectively in the rating system for “clinical purpose,” or when the four items were fulfilled
91 subjectively and two or more items objectively in the system for the “research purpose.”
92 IASP 2005 criteria are shown in Table 2 [16,17].

93 A well-trained orthopedist blinded to the study diagnosed CRPS using these criteria.

94 Once diagnosed, Neurotropin® (Nippon Zoki Pharmaceutical Co., Osaka, Japan) was
95 administered orally. Tramadol or pregabalin, or both drugs were added if needed. A whirlpool
96 bath and stellate ganglion block using a laser beam were routinely applied. The patients in
97 whom the symptoms persistently continued were referred to an anesthesiologist who
98 specializes in nerve block.

99 *Outcome measures*

100 Patient information, including age, sex, and follow-up duration, were collected prior to
101 surgery. Preoperative pain levels were assessed using the visual analog scale (VAS at
102 rest/night and during motion). ROM was assessed using a goniometer, and muscle strength
103 was measured using a hand-held dynamometer (Micro FET2; Hoggan Health Industry, Salt
104 Lake City, UT, USA). The presence of contracture was determined when the manipulation or
105 arthroscopic capsular release was performed during surgery. Clinical outcomes were assessed

by the Japanese Orthopaedic Association (JOA) and University of California, Los Angeles (UCLA) scores. Fatty degeneration of the rotator cuff muscles was evaluated by magnetic resonance images taken before surgery, using the Goutallier classification [18]. The operating time and circulating fluid used were estimated during surgery.

Statistical analysis

All statistical analysis was performed using JMP11 software (SAS Institute Inc., Cary, NC, USA). The level of significance was defined as $P < .05$ for all calculations. To analyze the risk factors of CRPS, univariate analysis was performed using chi-square or Fisher tests. Logistic multivariate analysis was performed to further evaluate the significant parameters obtained from univariate analysis. The presence of CRPS assessed by the MHLWJ "clinical purpose" were set as the dependent variable, and the variables that were significantly different in univariate analysis ($P < 0.05$) were set as independent variables. However, variables associated with the high variable of the correlation coefficient were selected to establish the last model of the multivariate analysis.

Results

Of 182 patients enrolled in the present study, CRPS exclusively occurred in the hand of the operated limb, developing within 3 months of surgery. The following two or more symptoms were noted in patients with the hand lesion associated with CRPS: edema (93.4%;

125 Fig. 1a and 1b), restriction of ROM (83.4%), hyperalgesia (30.1%), paridrosis (20.4%), and
126 atrophic change (12.2%; Fig. 2a and 2b). Under these conditions, the incidences of CRPS
127 were 24.2% (44/182) when evaluated by the MHLWJ rating system for the "clinical purpose;"
128 11% (22/182) by the MHLWJ rating system for the "research purpose;" 6% (11/182) by the
129 IASP 2005 for the "clinical purpose;" and 0.5% (1/182) by the IASP 2005 for the "research
130 purpose."

131 Subsequently, we investigated risk factors for CRPS following ARCR, based on the data
132 obtained by the rating system for the MHLWJ "clinical purpose." Using chi-square and
133 Fisher exact tests, results of univariate analysis demonstrated that the following variables
134 were potential risk factors: the tear size (P = 0.023), active and passive internal rotation (P =
135 0.012 and P = 0.011, respectively), "pain" in the JOA score (P = 0.007), "function" in the
136 JOA score (P = 0.029), total JOA score (P = 0.005), and "pain" in the UCLA score (P =
137 0.009). Details are shown in Table 3 and Table 4.

138 Multivariate analysis was conducted following univariate analysis from a significantly
139 different variable. Since correlation was high in active internal rotation and passive internal
140 rotation (correlation coefficient: 0.963), "pain" in the JOA score, "pain" in the UCLA score
141 (correlation coefficient: 0.936), and the total JOA score had a high correlation with active
142 internal rotation (correlation coefficient: 0.510), "pain" in the JOA score (correlation
143 coefficient: 0.692), and "function" in the JOA score (correlation coefficient: 0.562). We

144 removed passive internal rotation and “pain” in the UCLA score and total JOA score from the
145 last model. The last model of the multivariable analysis was comprised of the tear size, active
146 internal rotation, “pain” in the JOA score, “function” in the JOA score, and disease duration.
147 Results of multivariate analysis demonstrated that the “function” in the JOA score (odds
148 ratio: 1.15 with 95% confidence interval: 1.01-1.31) was a risk factor for the development of
149 CRPS following surgery ($P < 0.05$). Details are presented in Table 5. “Function” in the JOA
150 score reflects abduction strength.
151

152 **Discussion**

153 Specific complications associated with ARCR include failed repair, hardware problems,
154 captured shoulder, traction in the lateral position, direct injury, compression secondary to
155 fluid extravasation, and tourniquet-like problems associated with wrapping of the operative
156 extremity [7]. CRPS also occurs after ARCR, although there have been few studies published
157 in the English literature concerning this complication; its incidence is reported to be 0.4%
158 (1/263 patients) and 1.9% (1/53 patients) [8,9]. Unfortunately, these studies did not detail
159 how the diagnosis was determined.

160 Several studies in the Japanese literature have reported the incidence of CRPS following
161 ARCR: 21.7% (13 of 60 cases) in the rating system for the “clinical purpose” and 13.3%
162 (8/60) by the system for the “research purpose” according to the MHLWJ criteria [12], and

14.8% (5/37 cases) and 11.7% (22/187 cases) according to the modified MHLWJ criteria [13,14]. These studies consistently demonstrated that CRPS-associated lesions occurred in the hand of the operated limb within 3 months of surgery, as observed in the present study, in which a similar incidence was observed (11-24.2%). However, the incidence rate decreased to 6% (11/182 patients) when evaluated by the rating system for the “clinical purpose” according to IASP 2005 criteria; this further reduced to 0.5% (1/182 patients) by the system for the “research purpose” in this criteria. Therefore, these results indicate that the incidence of CRPS is largely influenced by the criteria employed.

In 1994, the International Association for the Study of Pain (IASP) introduced the term “CRPS” and advocated the criteria for its diagnosis [19-21]. Since the IASP criteria from 1994 lacked specificity (0.36) and were very sensitive (0.98) [22], IASP criteria were re-established in 2005 [16]. In 2010, the Ministry of Health, Labor, and Welfare study team in Japan developed CRPS criteria that are more specific (specificity 0.79; sensitivity 0.83) and appropriate for the Japanese population [15], i.e., the IASP 2005 criteria. As demonstrated, the incidence of CRPS after ARCR varied between these two criteria. Compared with the IASP 2005 criteria, the MHLWJ criteria were developed on a relatively loose basis, aiming to capture the patients with CRPS in the wider range and initiate therapy as early as possible to ensure the success of the treatment. In addition, a rating system for the clinical purpose, rather than the research purpose, was used in the MHLWJ criteria, since we focused on

evaluating the incidence of CRPS after ARCR, rather than on the research for CRPS itself. Consequently, it was demonstrated that the hand lesion associated with CRPS occurs after ARCR (incidence rate: 24.2%), and it is predominantly accompanied by edema and ROM restriction at the site.

It was notable that although not in multivariate analysis, the tear size was significantly associated with the development of CRPS in univariate analysis. Hirooka et al. reported that the preoperative pain level in patients with small or medium tears is greater than in those with large or massive tears [23]. Moriishi et al. demonstrated that the postoperative pain level in patients with small or medium tears is greater than in those with large or massive tears [24]. Considering that in univariate analysis, “pain” in the JOA or UCLA score was also associated with the development of CRPS, we thought there would be an association between the tear size and pain level in the development of this sequelae after surgery.

There are three spread patterns of symptoms in CRPS due to the aberrant regulation of the central nervous system (CNS), including contiguous spread, independent spread and mirror-image spread [25]. A previous study utilized functional magnetic resonance imaging (fMRI) and revealed that aberrant CNS regulation is closely associated with the development of CRPS [26]. Furthermore, a recent study used fMRI to demonstrate that pain in patients with a rotator cuff tear is significantly associated with neurophysiologic dysfunction in CNS [27]. Based on these results, the CRPS-associated hand lesion in our patients may have

occurred in an independent spread pattern through aberrant regulation of the CNS after ARCR. This remains to be elucidated in the future.

To substantiate the importance of CRPS after ARCR, it is of great importance that the clinical outcomes be evaluated in these patients. Kobayashi et al. [13] reported that there is no significant difference in UCLA scores at the 2-year postoperative time point between the patients with or without CRPS, and they concluded that coexistence of CRPS does not affect shoulder function following surgery. However, the outcomes of the hand lesion associated with CRPS remain unclear. Studies investigating the clinical outcomes in patients with or without CRPS after ARCR are currently underway at our institution.

There were several limitations to the present study. First, the sample size of the present study was small. Second, the present study was performed in a retrospective cohort. Third, CRPS may develop after 3 months post-surgery; however, previous studies have consistently indicated that it occurred within this period [11-14]. A strength of the present study was that by using multivariable analysis, the “function” in the JOA score (weak of abduction) prior to ARCR was found to be a risk factor for CRPS after surgery.

Conclusions

The incidence of CRPS after ARCR was 0.5-24.2% in the present patients, and results of multivariate analysis demonstrated that weakness of abduction strength is significantly

220 associated with the development of CRPS after surgery. In conclusion, the findings of the
221 present study indicate that CRPS-induced hand lesions more frequently occur after ARCR
222 than is generally believed, thereby suggesting that the impact of CRPS on the surgical
223 outcomes should be clarified in the future.
224
225 **Conflict of Interest**: None.

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297

298 **Table 1** Japanese complex regional pain syndrome diagnostic criteria for clinical purposes
299 (MHLWJ) (SOURCE: Reproduced with permission from reference 15. Copyright 2010
300 Wolters Kluwer Health, Inc.)

A.1. Must report at least one symptom in two or more of the following five categories, at some time	**A.2. Must display at least one sign in two or more of the five following categories, at the physical examination**
1. Trophic changes: reports of trophic changes of hair and/or skin and/or nail and/or bone.	1. Trophic changes: evidence of trophic changes of hair and/or skin and/or nail and/or bone.
2. Motor dysfunctions: reports of decreased range of motion and/or motor dysfunction (muscle weakness, tremor, dystonia).	2. Motor dysfunctions: evidence of decreased range of motion and/ or motor dysfunction (muscle weakness, tremor, dystonia).
3. Abnormal sensory processing: reports of pain disproportionate to the inciting event and/or burning pain and/or hyperesthesia.	3. Abnormal sensory processing: evidence of allodynia (to light touch) and/or hyperalgesia (to pin prick)

4. Asymmetric sudomotor activity: reports of sweating changes and/or sweating asymmetry.	4. Asymmetric sudomotor activity: evidence of and/or sweating and/or asymmetry.
5. Asymmetric edema: reports of edema.	5. Asymmetric edema: evidence of edema.

For research purposes, diagnostic decisions were determined according to the existence of at least one symptom in three or more categories and at least one sign (observed at evaluation) in three or more categories.

Table 2 Proposed clinical diagnostic criteria for complex regional pain syndrome (IASP 2005) (SOURCE: Reproduced with permission from reference 16. Copyright 2007 Oxford University Press)

1) Continuing pain, which is disproportionate to any inciting event
2) Must report at least one symptom in three of the four following categories: • Sensory: Reports of hyperalgesia and/or allodynia • Vasomotor: Reports of temperature asymmetry and/or skin color changes and/or skin color asymmetry • Sudomotor/Edema: Reports of edema and/or sweating changes and/or sweating asymmetry • Motor/Trophic: Reports of decreased range of motion and/or motor dysfunction (weakness, tremor, dystonia) and/or trophic changes (hair, nail, skin)
3) Must display at least one sign at time of evaluation in two or more of the following categories: • Sensory: Evidence of hyperalgesia (to pinprick) and/or allodynia (to light touch and/or deep somatic pressure and/or joint movement)

- Vasomotor: Evidence of temperature asymmetry and/or skin color changes and/or asymmetry
- Sudomotor/Edema: Evidence of edema and/or sweating changes and/or sweating asymmetry
- Motor/Trophic: Evidence of decreased range of motion and/or motor dysfunction (weakness, tremor, dystonia) and/or trophic changes (hair, nail, skin)

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4) There is no other diagnosis that better explains the signs and symptoms

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For research purposes, diagnostic decision rule should be at least one symptom in all four symptom categories and at least one sign (observed at evaluation) in two or more categories.

Table 3 Analysis of risk factors by univariate analysis (epidemiologic parameters)

Parameter		Patients with CRPS (N=44)	Patients without CRPS (N=138)	P-value
Age (years)		63.1 ± 9.2	62.8 ± 10.3	0.780
Sex				0.147
	Male	33	86	
	Female	11	52	
Side				0.862
	Right	25	81	
	Left	19	57	
Trauma				0.605
	Yes	20	70	
	No	24	68	
Diabetes				0.203
	Yes	3	21	
	No	41	117	
Contracture				0.201
	Yes	12	25	
	No	32	113	
Disease duration (months)		13.0 ± 20.6	24.2 ± 41.9	0.112
Tear size				0.023*
	Small/Middle	25	51	
	Large/Massive	19	87	
Operating time (minutes)		127.0 ± 44.6	116.8 ± 39.6	0.183
Circulating fluid (L)		25.7 ± 12.3	25.5 ± 13.6	0.931

Values are presented as mean ± standard deviation; *P<0.05. Abbreviation: CRPS, complex regional pain syndrome.

Table 4 Analysis of risk factors by univariate analysis (clinical parameters)

Parameter		Patients with CRPS (N=44)	Patients without CRPS (N=138)	P-value
Active ROM (°)	Flex	99.7 ± 28.3	106.7 ± 37.9	0.235
	External rotation	35.2 ± 17.0	36.6 ± 19.4	0.844
	Internal rotation	3.1 ± 2.7	4.7 ± 3.3	0.005*
	Abduction	83.9 ± 36.2	96.3 ± 46.2	0.126
Passive ROM (°)	Flex	126.4 ± 23.4	133.2 ± 28.6	0.077
	External rotation	42.8 ± 19.4	43.3 ± 19.4	0.849
	Internal rotation	3.4 ± 2.9	5.1 ± 3.5	0.006*
	Abduction	110.0 ± 38.1	120.9 ± 41.2	0.098
VAS	At rest	2.4 ± 2.5	2.9 ± 2.7	0.296
	At activity	6.0 ± 2.3	6.1 ± 2.9	0.588
	At night	6.0 ± 3.0	5.1 ± 3.1	0.125
JOA score	Pain	10.0 ± 4.6	12.9 ± 6.3	0.007*
	Function	4.7 ± 2.8	5.8 ± 3.1	0.029*
	ADL	7.0 ± 1.7	7.2 ± 1.9	0.061
	ROM	19.3 ± 5.0	20.2 ± 5.7	0.436
	Total	60.6 ± 8.4	66.2 ± 11.6	0.005*
UCLA score	Pain	2.5 ± 1.7	3.5 ± 2.2	0.009*
	Function	6.3 ± 2.0	6.5 ± 2.2	0.531
	ROM flex	3.1 ± 0.8	3.1 ± 1.1	0.817
	Strength flex	2.9 ± 2.2	3.0 ± 1.6	0.116
	Total	14.8 ± 3.9	16.1 ± 4.3	0.086
Goutallier classification	SSP	1.91 ± 0.84	1.98 ± 0.89	0.644
	SSC	1.27 ± 0.80	1.34 ± 0.75	0.642
	ISP/TM	1.25 ± 0.73	1.45 ± 0.78	0.148

Values are presented as mean ± standard deviation; *P<0.05. Abbreviations: CRPS,

complex regional pain syndrome; ROM, range of motion; VAS, visual analog scale; JOA, Japanese Orthopaedic Association; UCLA, University of California Los Angeles; SSP, supraspinatus; SSC, subscapularis; ISP/TM, infraspinatus/teres minor.

Table 5 Analysis of risk factors according to multivariate analysis

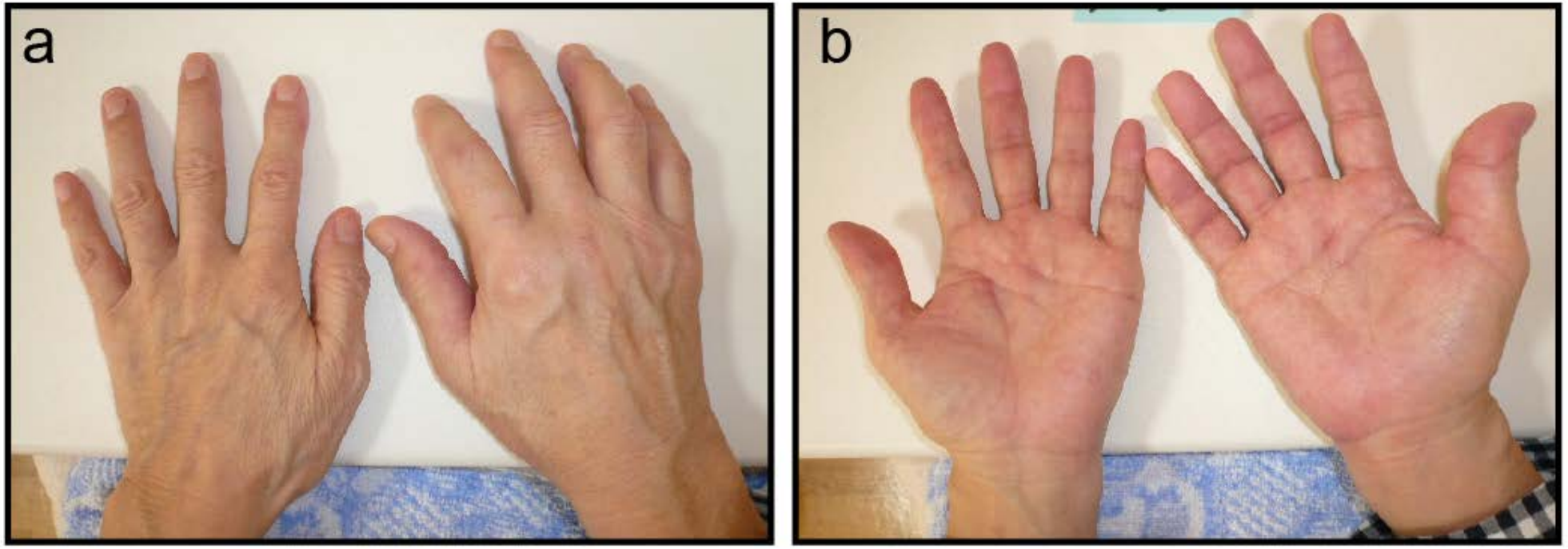
				95% for CI	
Variable		P-value	OR	Lower	Upper
Tear size	(Large/Small)	0.087	1.96	0.91	4.28
Active ROM	Internal rotation	0.058	1.13	1	1.3
JOA score	Pain	0.093	1.06	0.99	1.14
JOA score	Function	0.034*	1.15	1.01	1.31
Disease duration		0.39	1.01	0.99	1.03

*P<0.05. Odds ratios are presented as without complex regional pain syndrome/with complex regional pain syndrome. Abbreviations: CI, confidence interval; OR, odds ratio; ROM, range of motion; JOA, Japanese Orthopaedic Association.

Figure legends

Fig. 1 Swelling with edema on the opisthenar side (a) and the palm side (b) of the right hand.

Fig. 2 Atrophic changes on the opisthenar side (a) and the palm side (b) of the left hand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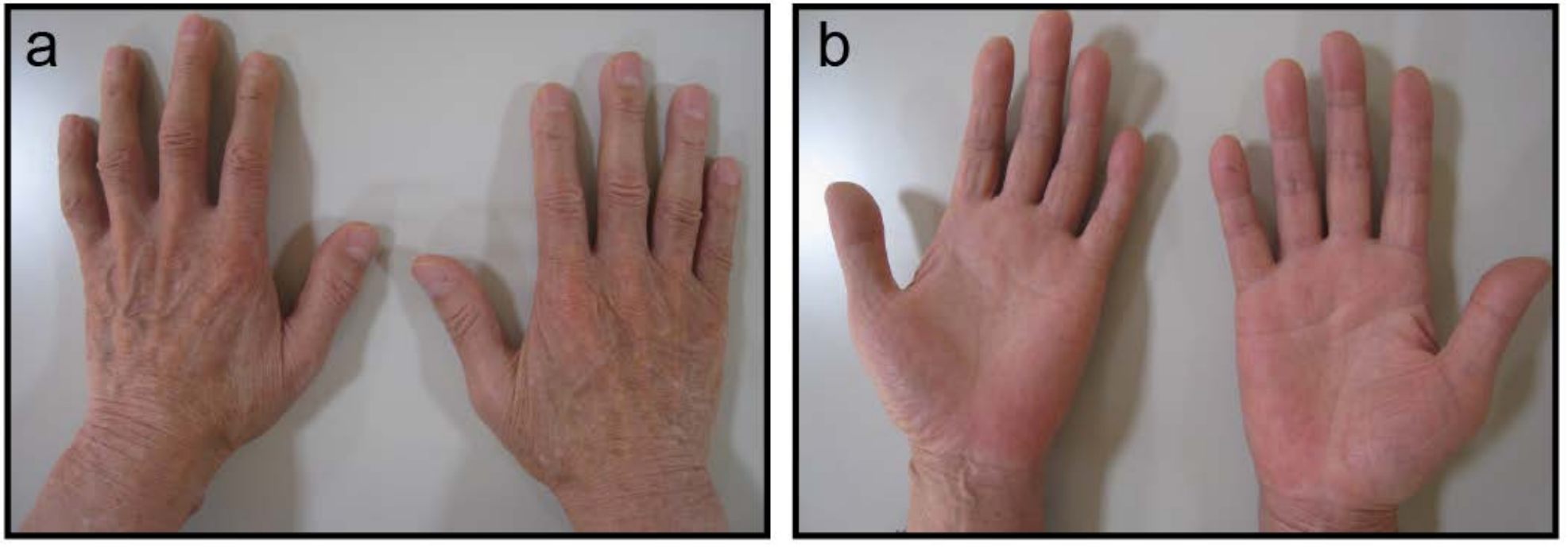
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