Prospective Evaluation

Contrast Dispersion Pattern and Efficacy of Corticosteroid at the Glenohumeral Joint in Adhesive Capsulitis

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Background: Corticosteroid injection has a wide range of success in adhesive capsulitis but the reason for this has not yet been explained. We hypothesized that this difference might be due to the distribution of the corticosteroids injected into the joint cavity because particulate steroid deposits in the capsule and will not be moved over time by shoulder motion.

Objectives: The purpose of this study is to determine whether the therapeutic efficacy of particulate corticosteroid injection into the glenohumeral joint differs according to the dispersion pattern.

Study Design: Prospective evaluation.

Setting: Outpatient clinics at a tertiary university hospital

Methods: Seventy-two patients diagnosed as having adhesive capsulitis received a corticosteroid injection at the glenohumeral joint. The posterior capsule and the subscapular bursa were selected as dispersion sites and the dispersion of contrast dye was expressed as a ratio (%). Two weeks and 3 months after the injection clinical improvement ("not improved," "slightly improved," "much improved"), numeric rating scale (NRS), and passive range of motions (PROM) were evaluated. The dispersion of the contrast dye was compared according to the clinical improvements by an analysis of variance test. Pearson correlation test was done to find the relationship between PROM and the dispersion and between change of NRS and the dispersion.

Results: The distribution in the subscapular area was 30.0% in the "much improved" group, 22.0% in the "slightly improved" group, and 37.1% in the "no improvement" group which was not significantly different ($P = 0.179$). Correlations between changes of NRS and the dye distribution were not statistically significant ($P = 0.429$ at 2 weeks and $P = 0.629$ at 3 months).

The change of passive external rotation 3 months after the injection was significantly correlated with the dye distribution ($P = 0.035$).

Limitations: Because of diverse pathologic findings in adhesive capsulitis, further studies will be needed to address the effect of the dye distribution on the pain improvement according to pathologic findings revealed by magnetic resonance imaging (MRI).

Conclusion: External rotation of the shoulder in adhesive capsulitis has greater improvement as the corticosteroid solutions injected into the glenohumeral joint are increasingly dispersed to the subscapularis area. However, this does not affect the pain improvement after the injection.

Key words: Adhesive capsulitis, dispersion, contrast dye, subscapularis, glenohumeral joint, corticosteroid, range of motion, numeric rating scale

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Adhesive capsulitis is characterized by a painful, gradual loss of active and passive shoulder motion resulting from fibrosis and contracture of the joint capsule (1). Recent studies with shoulder magnetic resonance imaging (MRI) have shown that there are various pathologic focuses in adhesive capsulitis (2). There are many conservative treatments for adhesive capsulitis, and these conservative treatments usually are associated with a good prognosis (3).

Corticosteroid injection at the glenohumeral joint is commonly used in the treatment of adhesive capsulitis. A systematic review revealed that intraarticular corticosteroid injection improves the clinical outcome in patients with adhesive capsulitis and increases the passive range of shoulder motion (4). This type of intraarticular corticosteroid injection is known to be safe, and adverse effects are either rare or insignificant (5). However, corticosteroid injection is not a perfect treatment. Corticosteroid injection has a wide range of success among patients, from 52% to 82%. Vad et al (6) suggested that these discrepancies might be due to the different stages of adhesive capsulitis (stage II versus stage III), and corticosteroid injection must be individualized according to a patient's status. However, the reason the therapeutic effects of corticosteroid injection differ in the same stage has not yet been explained.

We hypothesized that this difference may be due to the distribution of the corticosteroids injected into the joint cavity. Even though the glenohumeral joint cavity is a free space with extensional pouches including the axillary pouch, the subscapular bursa, and the bicipital groove, differences of pressure can be present between each pouch, and the distribution of the injected corticosteroids can be different according to the degree of ligamentous and capsular thickening or to the degree of adhesion. Moreover, the particulate steroid triamcinolone used in the treatment of adhesive capsulitis deposits in the capsule and is not moved over time by shoulder motion.

There have been no studies addressing the therapeutic efficacy in adhesive capsulitis of corticosteroid injection at the glenohumeral joint according to the dispersion pattern. Therefore, we conducted a study to determine whether the therapeutic efficacy of particulate corticosteroid (triamcinolone acetonide) injection into the glenohumeral joint differs according to the dispersion pattern.

Methods

Patient Selection

Seventy-two patients who were diagnosed as having adhesive capsulitis and were without a history of shoulder surgery or previous glenohumeral joint injection during the last 3 months were selected to participate in this study. The diagnosis of the adhesive capsulitis consisted being positive for a limited range of motion of the shoulder joint(s) and pain of the ipsilateral shoulder joint during movement. Plain radiography, ultrasonography, or an MRI study was used to exclude calcific tendinitis and rotator cuff tears. Factors known to affect the efficacy of the corticosteroid injection including diabetes mellitus, hyperlipidemia, and other endocrine diseases were investigated. Therefore, we restricted this study to primary idiopathic adhesive capsulitis without any underlying definite etiology. In addition, we selected patients with stage II adhesive capsulitis which characterizes synovial inflammation and adhesion, as described in a previous study (7). Numeric rating scale (NRS) and passive range of motions (PROM) of the affected shoulder joint in 4 directions (flexion, abduction, internal rotation, and external rotation) were evaluated before the injection at the glenohumeral joint. NRS was recorded when patients felt the pain during their daily activities. The PROM was checked in a sitting posture by one experienced physician who did not know the contrast dispersion pattern and was determined to be an angle at which a patient felt the moderate or severe pain or discomfort. Internal rotation was checked in the 90 abduction state of the shoulder and external rotation was checked in the neutral position of the shoulder.

All patients received a corticosteroid injection at the glenohumeral joint under the guidance of fluoroscopy (Model: Artis Zee Ceiling, Siemens Medical Solutions, Erlangen, Germany). Two weeks after the injection, NRS and PROM were re-evaluated. Clinical improvement was expressed in terms of the patient's global impression of change (PGIC) (8): "not improved," "slightly improved" (less than 50% reduction of the initial pain), and "much improved" (more than 50% reduction of the initial pain). Then, patients were asked to maintain for 3 months the self-exercise involving stretching and PROM exercise that was taught by 2 experienced physical therapists. Three months after the injection, NRS, PGIC, and PROM of the affected shoulder joint were assessed a second time.

We obtained an informed written consent from all patients who participated in this study. We conformed to the ethical guidelines of the 1975 Declaration of Helsinki, and this study was approved by our institutional review board.

Image-guided Corticosteroid Injection at the Glenohumeral Joint

Patients lay on a table in the supine position with the shoulder joint externally rotated. The skin of patients' shoulders was sterilized with 1% chlorhexidine. After verifying the injection point through fluoroscopic images, a 22-gauge spinal needle was injected into the upper medial quadrant of the humeral head, close to the joint line in a parallel direction with the beam, and was advanced to contact the humerus. This same method was used in a previous study for targeting the rotator cuff interval (9). After the needle contacted the humerus, 3 mL of radio-opaque dye (Iobrix®, Taejoon Pharm Co. Ltd., Seoul, Korea) solution was injected to confirm the intraarticular position of the needle and to see the distribution of the dye. After confirming the dye's intraarticular position 40 mg of triamcinolone acetonide (Tamceton®, HanAll BioPharma Co. Ltd., Seoul, Korea) mixed with 2 mL of 1% lidocaine solution was injected.

Dispersion of Contrast Dye after the Glenohumeral Joint Injection

After the injection, fluoroscopic images of the anterior-posterior (AP) view were captured to investigate the dispersion of contrast dye and analyzed through the imageJ software (version 1.47, NIH, Bethesda, MD, USA). Two different areas were selected as dispersion sites: the posterior capsule with axillary pouch and the subscapular bursa (Fig. 1). The threshold color was set as white. The minimum displayed value was adjusted to contain the dye dispersion, and the maximum displayed value was 255 in an 8-bit image. Each image region was measured, and the area was calculated. The dispersion of contrast dye was expressed as a ratio (%) of the total area.

The Effect of Shoulder Motion or Body Posture on the Dispersion of Contrast Dye

To know whether the dispersion of the injected materials was affected by shoulder motion, 7 patients were selected who were diagnosed as having adhesive capsulitis and who underwent the corticosteroid injection to the glenohumeral joint. Corticosteroid injection at the glenohumeral joint was performed with an anterior approach under image guidance. After the injection, patients were asked to sit up and to move their shoulders freely for a minute. Then, patients returned to a supine position, and the AP and lateral views were checked in the same position before the shoulder motion. AP images before and after the shoulder motion were analyzed, and the dispersion of the contrast dye was compared using the imageJ program.

To determine whether the dispersion of the injected materials was affected by the body posture, 4 patients with adhesive capsulitis participated in the same protocols above, but instead of moving their shoulders freely after the injection they assumed a prone posture for one minute. AP images were analyzed before and after the prone posture for one minute, and the dispersion of the contrast dye was compared using the imageJ program.

Fig. 1. *Description of dye dispersal sites.*

Statistical Analysis

Paired t-tests were performed to determine the potential effect of shoulder motion or body posture on the dispersion. After determining the possible effect of shoulder motion or body posture on the dispersion pattern, the dispersion of the contrast dye was compared according to the clinical improvements by an analysis of variance (ANOVA) test. Pearson correlation test was done to find the relationship between PROM and the dispersion and between change of NRS and the dispersion. All statistical analyses performed during this study were done using SPSS 21.0 software (IBM, Armonk, NY, USA).

Results

Seventy-two patients participated in this study (24 men, 48 women, average age 55.2 ± 10.9 years). Ten patients had diabetes mellitus, 2 patients had thyroid disease, and 2 patients had other endocrine diseases. The initial NRS was 5.3 ± 1.7, and the PROM was 117.5 ± 33.6 in flexion, 95.1 ± 41.4 in abduction, 58.2 ± 25.9 in external rotation, and 56.7 ± 27.3 in internal rotation.

The average distribution of dye was 27.6 ± 23.0% in the subscapular area and 72.4 ± 23.0% in the posterior capsule area (Fig. 2). Other dye distributions in the biceps groove, glenohumeral joint line, and axillary pouch were negligible because the dye moved to the dependent location. Shoulder motion affected the dispersion pattern; the distribution of the dye in the subscapular area of 7 patients changed from 20.7 ± 6.7% before the exercise to 23.8 ± 11.1% after the exercise (ranging from -3.6% to 10.0%, *P* = 0.155, Fig. 3). Body posture also affected the dispersion pattern; the distribution of the dye in the subscapular area of 4 patients changed from 23.5 ± 7.7% in the supine position to 28.3 ± 13.3% after changing to a prone position (ranged from -3.6% to 10.0%, *P* = 0.238, Fig. 3).

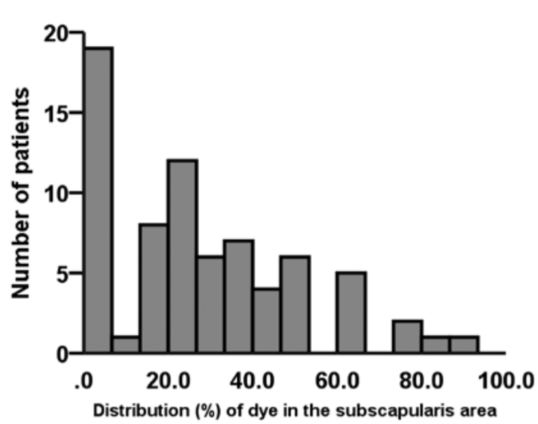

Fig. 2. *A comparison of the dye distribution in the subscapular and posterior capsule areas.*

Changes in the PROMs in 4 directions at 2 weeks and 3 months after the injection are presented in Fig. 4, and correlations between changes of PROMs in 4 directions 3 months after the injection and the dye distribution to the subscapularis area are presented in Fig. 5. The change of passive external rotation 3 months after the injection was significantly correlated with the dye distribution (r = 0.287, *P* = 0.035); however, the changes of other PROMs did not have any significant correlation with the dye distribution.

Among the 72 patients, 35 patients were described as much improved, 29 patients as slightly improved, and 8 patients as not improved during the 2 weeks following the injection. At 3 months following the injection, 26 patients were described as much improved, and 20 patients reported their status as slightly improved. When we divided the patients into 3 groups according to the degree of the improvement at 2 weeks after the injection, the average distribution of dye in the subscapular area was 30.0 ± 25.1% in the much improved group, 22.0 ± 18.4% in the slightly improved group, and 37.1 ± 23.0% in the no improvement group (Table 1), which was not significantly different (ANOVA *P* = 0.179). This was the same result when the patients were divided by the degree of the improvement at 3 months after the injection (ANOVA *P* = 0.462).

NRS was not recorded in 9 patients at 2 weeks after the injection and 13 patients at 3 months after the injection. NRS in 63 patients changed to 2.2 ± 1.1 at 2 weeks after the injection and NRS in 59 patients changed to 3.0 ± 1.2 at 3 months after the injection, which were statistically significant (paired t-test *P* < 0.001). Correlations between changes of NRS and the dye distribution to the subscapularis area were not statistically significant (r = -0.101, *P* = 0.429 at 2 weeks and r = -0. 064, *P* = 0.629 at 3 months in Fig. 6).

Discussion

We found that improvement of external rotation after the injection was significantly correlated with the dispersion of the dye to the subscapularis area. However, distribution of the dye after the corticosteroid injection at the glenohumeral joint in adhesive capsulitis did not correlate with the degree of pain improvement.

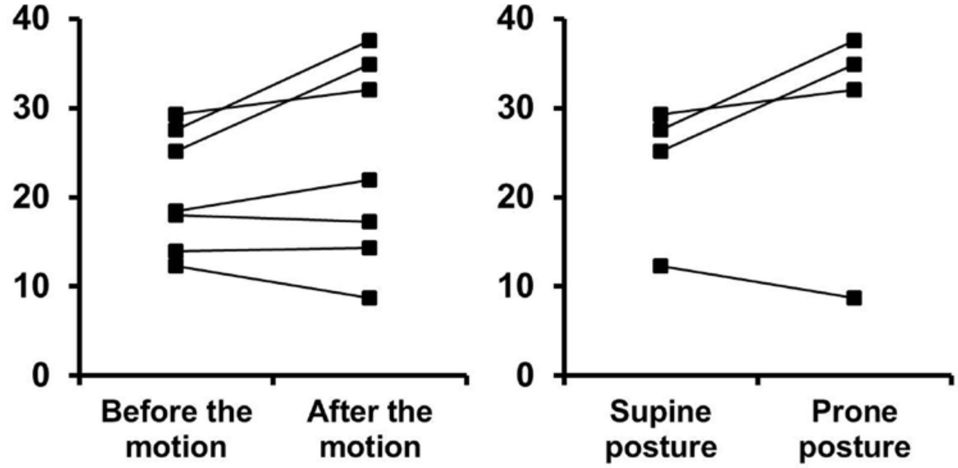

Fig. 3. *A comparison of the dye distribution due to PROM ≥ shoulder motion and postural changes.*

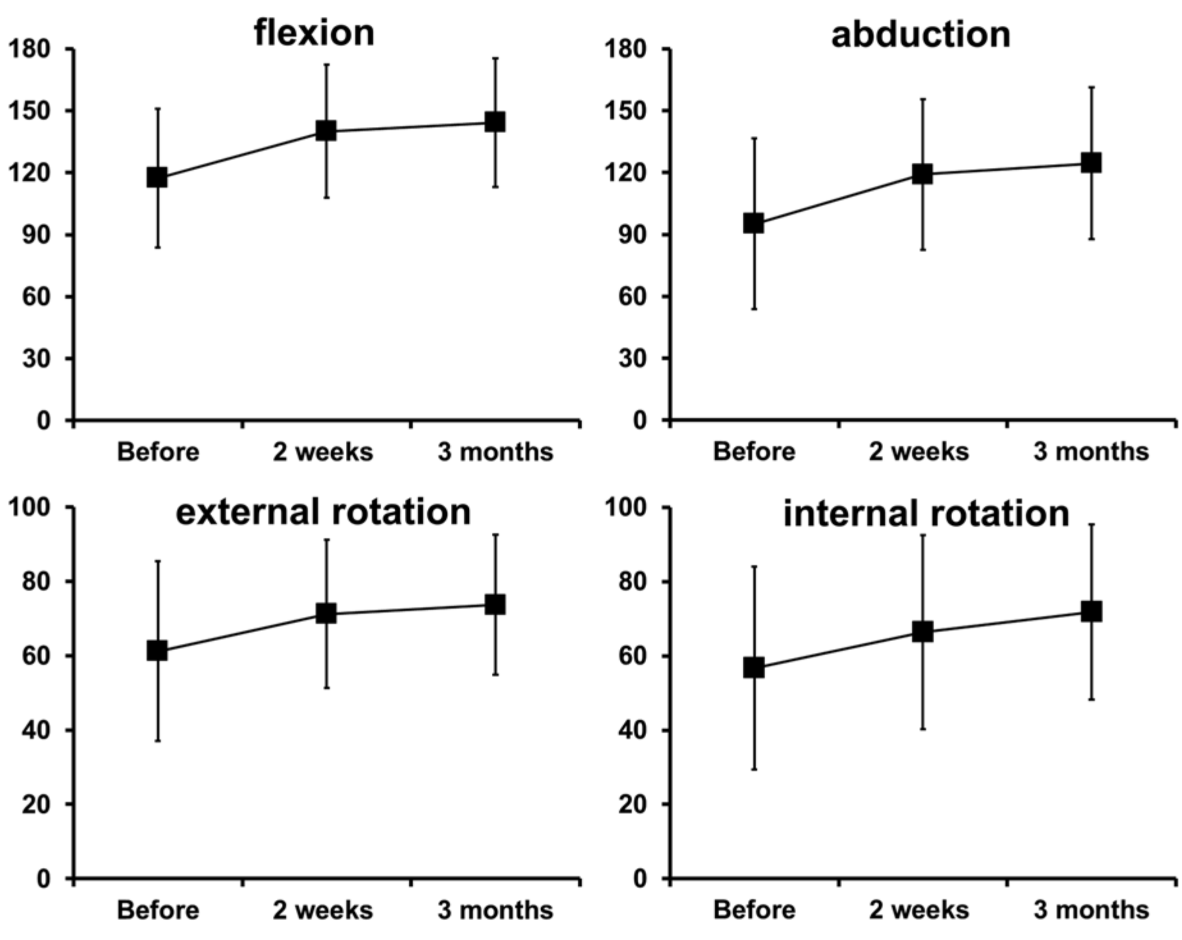

Fig. 4. *Improvement of PROM at 2-week and 3-month follow-up.*

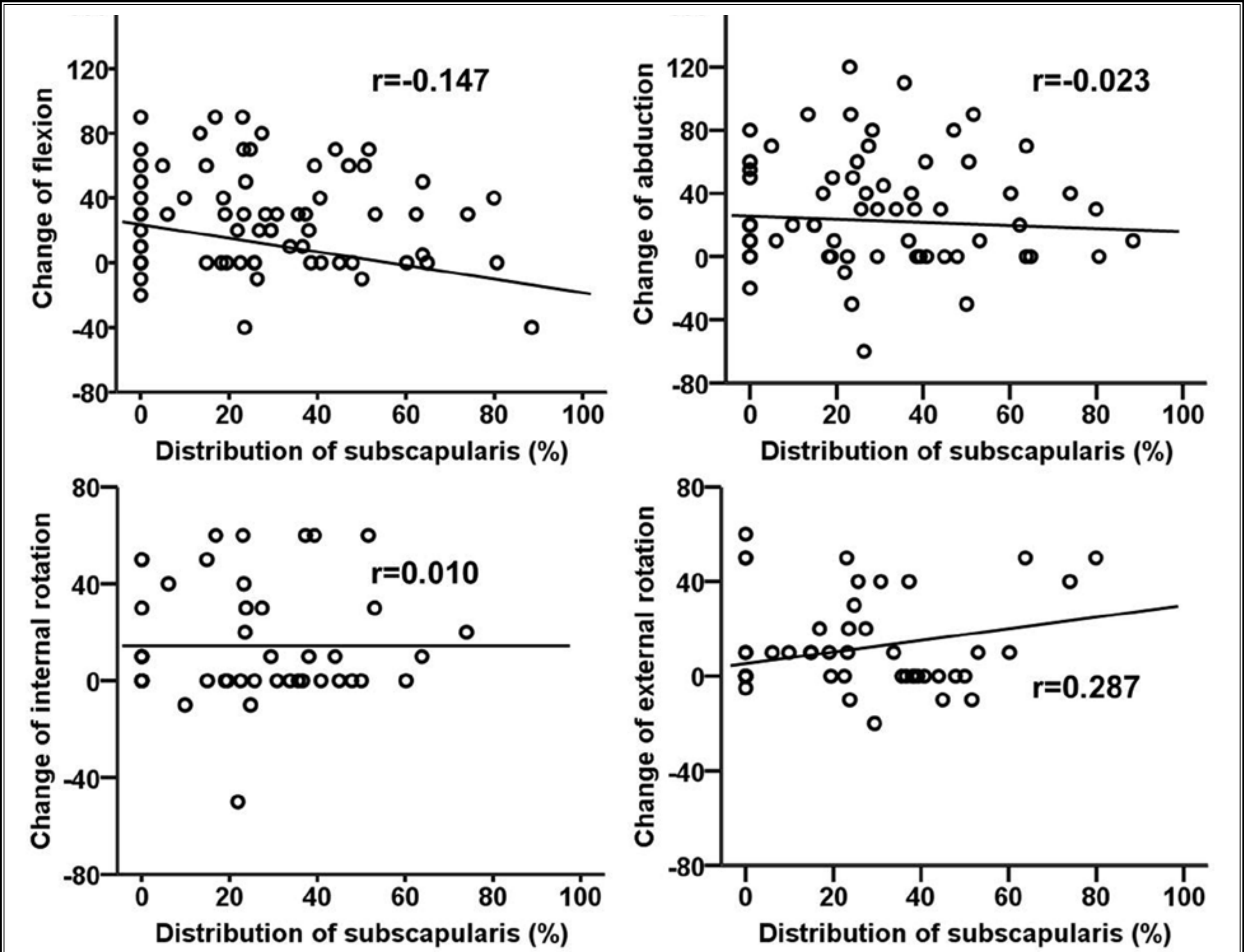

Fig. 5. *Correlation between PROM and dye distribution.*

Table 1. *Distribution of contrast dye to subscapularis area according to the improvement of the pain after glenohumeral joint injection.*

	2 weeks after the injection		3 months after the injection	
	Number of patients	**Distribution of dye (%)**	**Number of patients**	**Distribution of dye (%)**
Much improved	35	30.0 ± 25.1	26	30.9 ± 25.3
Slightly improved	29	22.0 ± 18.4	20	29.0 ± 23.3
Not improved	8	37.1 ± 26.5	26	23.2 ± 20.4
ANOVA *P*-value		0.179		0.462

Ogul et al (10) reported that contrast material injected into the glenohumeral joint leaked into the subscapular recess in 3 of 4 patients (75%) with adhesive capsulitis, which was similar to our results; leakage of contrast dye to the subscapular recess was present in 55 of 72 patients (76.4%). This finding is also consistent with the study by Carbone and colleagues (11) that showed distention of the bursa in the subscapularis recess in adhesive capsulitis.

We found that shoulder movement ≥ motion or position change affected approximately 5% (and no more than 10%) of dispersion to each area. Because dispersion of contrast dye to the subscapular bursa ranges from 0% to 90%, capsular distention must present as a

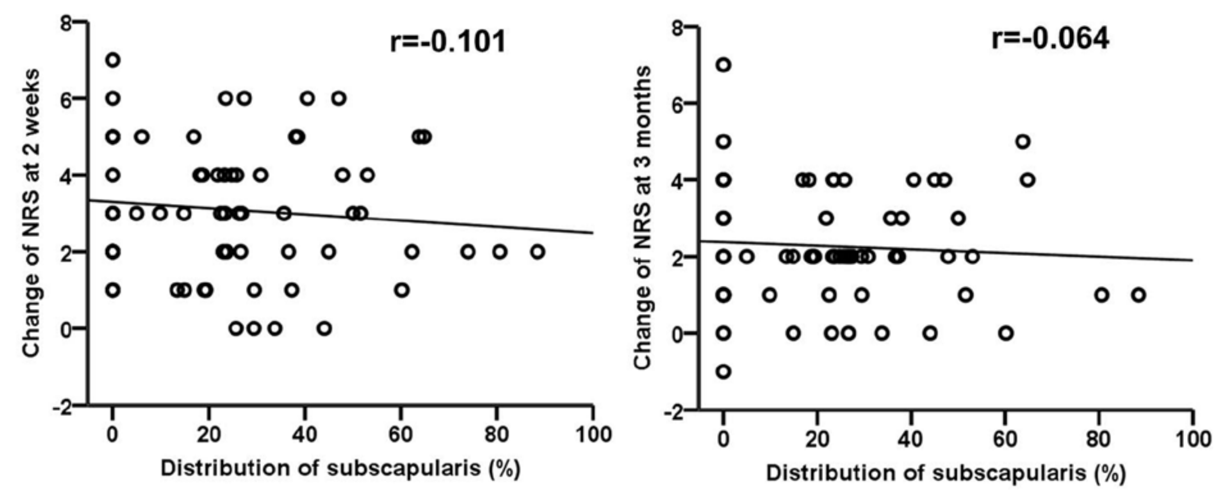

Fig. 6. *Correlation between change of NRS and dye distribution.*

specific dispersion pattern of contrast dye. This suggests that dispersion of the contrast dye would be affected by the mechanical properties of the capsular structures, such as distensibility or stiffness rather than the shoulder motion or body posture. Although Moore et al (12) suggest that the glenohumeral capsule should be modeled as a continuous sheet of fibrous tissue, pathologic conditions such as adhesive capsulitis invalidates a continuous model, and stiffness and distensibility will vary according to the localized area. The results of Ogul et al (10) that show that extravasation of contrast dye varies according to the disease entities supports this assumption. We did not investigate which patient showed a specific dispersion pattern including a preference for the subscapularis area. Further studies focused on examining the difference of stiffness and distensibility between specific areas within the capsular structures will assist prediction of the dispersion pattern.

Based on the results from our study, dye dispersion pattern correlates with the improvement of external rotation of the shoulder. Increased dispersion of contrast dye indicates increased external rotation of the shoulder 3 months after the injection. Considering that the role of the subscapular bursa is to reduce the friction between the subscapularis muscle and the coracoid process (13), and capsular disruption into the subscapular bursa improved the range of external rotation in adhesive capsulitis (14), the correlation between dispersion to the subscapular bursa and the external rotation can be explained.

Although the natural history of primary adhesive capsulitis shows no differences between conservative treatment and no treatment in 2- to 27-year follow up studies (15), adhesive capsulitis has a significant adverse impact on quality of life and many patients were willing to pay money to be free of adhesive capsulitis (16). Consequently, we are convinced that improvement of pain and PROM at 3 months after injection is fundamentally meaningful.

We compared the dispersion pattern of the contrast dye according to the degree of pain improvement, not comparing the improvement of pain according to the dispersion pattern. Dispersion of contrast dye to the posterior capsule with axillary pouch or subscapular bursa was a continuous variable, and this measure did not show any clear cut-off value to classify the patients into 2 groups according to the dispersion pattern. When we arbitrarily classify the patients into a subscapular bursa group and a posterior capsule group by the criteria of 10% dispersion to the subscapular area, we do not find any significant difference of pain improvement between groups using the chi-square test. The result is the same when we set the criteria of 50% dispersion to the subscapular area.

Though the steroid injection reduced pain evoked by daily activities significantly, dispersion of the contrast dye was not different according to the degree of this pain improvement. Dispersion of the contrast dye did not show any correlation with change of NRS either. Candido et al (17) proved that visual analogue scale scores in low back pain with unilateral radiculopathy are equivalent irrespective of contrast flow patterns, which supports this explanation. One explanation is that adhesive capsulitis had several pathologic findings including the glenohumeral joint, the rotator cuff interval, and the axillary pouch (18-20). Three patients underwent an MRI of their shoulder in this study. One patient displayed normal findings, and the others showed synovial proliferation and soft tissue adhesion at the rotator cuff interval. Dispersions of the contrast dye to the subscapularis were 0% and 11.6% in the 2 patients who showed synovial proliferation and soft tissue adhesion at the rotator cuff interval, and both patients were classified as much improved 2 weeks and 3 months after the injection. Although there are only 2 cases, these suggest the possibility that preventing the injected steroid solution from dispersing into the subscapularis area may provide a better effect in patients who display pathologic findings at the rotator cuff intervals.

Conclusion

We found that external rotation of the shoulder in adhesive capsulitis had greater improvement as the corticosteroid solutions injected into the glenohumeral joint are increasingly dispersed to the subscapularis area. However, this did not affect the pain improvement after the injection. This relationship might be due to the diversity of pathologic findings in adhesive capsulitis, and further studies will be needed to address the effect of distribution of the corticosteroid solutions on the pain improvement according to pathologic findings revealed by MRI.

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