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Correlation between Results of Preoperative Impingement Test and Clinical Outcomes after Arthroscopic Rotator Cuff Repair

Sung Bae Park, Joong Bae Seo✉, Jee Won Ryu, Yong Eun Shin

Department of Orthopedic Surgery, Dankook University Medical College, Cheonan, Korea

Background: The aim of the present study was to determine the correlation between the amount of pain reduction after local anesthetic injection into the subacromial space preoperatively and clinical outcome after arthroscopic rotator cuff repair.
Methods: A total of 127 patients who underwent arthroscopic rotator cuff repair and followed up at least 1 year were analyzed retrospectively. Preoperatively, a visual analogue scale (VAS) for pain was measured in all patients before and after the ultrasound guided impingement test. The participants were divied into four groups according to pain redution ater impingement test (Group A: >75%, Group B: 50%–75%, Group C: 25%–50%, Group D: <25%). VAS for pain, shoulder range of motion, shoulder isometric strength, ASES score were evaluated preoperatively and at 3, 6, 9, and 12 months postoperatively.
Results: After surgery, the amount of pain reduction shows significantly at 3, 6 months in Groups A, B as compared to Groups C, D ($p<0.05$). Among the range of motion of shoulder joint, forward flexion was significantly improved in Group A at 3 months ($p<0.05$). The ASES score significantly improved at 3, 6 months in Groups A, B as compared to Group C, D ($p<0.05$).
Conclusions: Preoperative degree of pain reduction after impingement test correlates with the improvement of pain after arthroscopic rotator cuff repair, especially in the early phase. Therefore, the impingement test could be effectively used.
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Key Words: Shoulder; Impingement test; Rotator cuff tear; Pain

Introduction

Rotator cuff tears are a leading cause of prolonged shoulder pain and disability[1] that impose a substantial health-economic burden on individual patients and society in general.[2] The incidence of rotator cuff tears and need for surgical repair have reportedly rapidly increased in selected patient cohorts.[3,4]

When a surgeon considers rotator cuff repair, not only anatomic repair and healing of the injured lesion, but also improvement of pain is important.[5,6] Substantial postoperative pain interrupts intensive postoperative rehabilitation, leading to long-term dissatisfaction. Because reduction of pain is known to be the most important reason patients have surgery, pain improvement after rotator cuff repair has become the most important parameter of outcome measurement.[7] However, it is difficult to predict how much pain will be reduced after surgical repair in each patient.[8]

Although numerous diagnostic tools, such as magnetic resonance imaging (MRI) and magnetic resonance arthrogram, have been developed with advances in medical science, a number of physical examinations are performed to increase the accuracy of diagnosis. Moreover, several studies have shown that the impingement test, originally introduced by Neer,[9] can also be used to predict the outcome of arthroscopic subacromial decompression.[10,11]

The present study was conducted to identify the correlation between the amount of pain reduction after injection of lidocaine into the subacromial space preoperatively and the

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✉**Correspondence to:** Joong Bae Seo
Department of Orthopedic Surgery, Dankook University Medical College, Kinesiologic Medical Science, Dankook University Graduate School, 119 Dandae-ro, Dongnam-gu, Cheonan 31116, Korea
Tel: +82-41-550-3060, **Fax:** +82-41-556-0551, **E-mail:** ssjb1990@dku.edu
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symptomatic and functional outcomes after arthroscopic rotator cuff repair and subacromial decompression. We hypothesized that the amount of pain reduction after preoperative injection of lidocaine into the subacromial space relates to the pain reduction and functional improvement after arthroscopic rotator cuff repair and subacromial decompression, and can be a predictor of the outcome following surgery.

Methods

Subjects

After approval from the Institutional Review Board of the Dankook University Medical College, a total of 261 patients who underwent arthroscopic rotator cuff repair under general anesthesia for full thickness rotator cuff tears were assessed retrospectively from January 2012 to June 2015.

This study included individuals with full thickness small- to medium-sized supraspinatus tears, who had failed at least 6 months of conservative treatment. The anteroposterior dimension (size) and retraction of the cuff tear was measured with a probe during the arthroscopic procedures. A rotator cuff tear was suspected clinically when the patient complaint of pain localized to the anterolateral aspect of the shoulder and when physical examination elicited a positive Neer[12] and Hawkins and Kennedy[13] impingement sign. Routine radiographic evaluation including an anteroposterior view of the glenohumeral joint, a supraspinatus outlet view, an axillary view, a Rockwood view, and MRI were conducted to provide adequate diagnosis and preoperative plan. An impingement test was performed the day before surgery in all cases, and the visual analogue scale (VAS) for pain was measured before and after the preoperative impingement test. Following arthroscopic rotator cuff repair and subacromial decompression, patients who were available for functional outcome assessment at least 1 year postoperatively were included.

However, 38 patients refused to undergo the impingement test or had missing data. Furthermore, 96 patients with radiographic evidence of glenohumeral or acromioclavicular arthritis, previous fractures around the shoulder joint, clinical evidence of instability or infection, partial thickness, or large to massive tears were also excluded. As a result, a total of 127 patients were evaluated in this study. The study group comprised 73 men and 54 women with a mean age of 55.1 ± 7.8 years (range, 38–74 years). The mean follow-up period for the evaluation was 16.9 ± 7.9 months (range, 12–48 months). The dominant shoulder was involved in 108 patients (85.0%). The mean duration of symptoms before surgery was 12.7 ± 8.3 months (range, 6–25 months). There were 61 small (<1 cm) and 66 medium (1–3 cm) rotator cuff tears (Table 1).

Pre- and Postoperative Evaluation

1) Impingement test

A pre-injection VAS for pain was measured by the Neer and Hawkins impingement test. The VAS for pain was scaled from 0 to 10, with 10 indicating the highest level of pain and 0 indicating free of pain. After physical examination, the impingement test[9] was performed in a standardized manner in all cases. The patients were positioned upright and sitting with the arm dropped at the side and the affected shoulder was prepared using a sterile technique. The ultrasound assessment was performed with the arm in the internal rotation position. The arm was positioned in pronation on the patients' backs. The long axis of the transducer was located between the acromion and the greater tuberosity of humerus, and was also positioned perpendicular to the supraspinatus tendon. The impingement test was performed from the lateral side of the transducer and

Table 1. Demographic Data

Variable	Total	Group*				*p*-value
		Group A	Group B	Group C	Group D	
Subject	127	41	36	34	16	
Gender (male/female)	73/54	20/21	21/15	23/11	9/7	0.436
Age (yr)	55.1 ± 7.8 (38–74)	56.5 ± 8.3 (38–74)	54.1 ± 7.1 (43–73)	54.3 ± 8.1 (38–72)	55.2 ± 7.8 (41–73)	0.542
Tear size						0.188
Small (<1 cm)	61	22	17	16	6	
Medium (1–3 cm)	66	19	19	18	10	
Diabetes mellitus	17	4	6	4	3	0.742
Hypertension	47	17	14	11	5	0.819

Values are presented as number only or mean ± standard deviation (range).
*Four groups were divided according to the amount of pain reduction (%) after the impingement test; Group A: 75%–100%, Group B: 50%–74%, Group C: 25%–49%, Group D: 0%–24%.

ultrasonography was used to ensure appropriate positioning of the needle in the subacromial space. Ultrasonography was performed using a Siemens Acuson S2000 (Siemens Medical Solutions USA, Inc., Malvern, PA, USA) with a linear array transducer at a frequency of 9 MHz. In the next stage, 8 ml of 2% lidocaine (Huons, Seongnam, Korea) were injected using a 23-gauge needle (Fig. 1). The time interval between the pre- and post-injection VAS for pain evaluation was about 30 to 60 minutes to ensure diffusion of the agent in the subacromial space and allow for onset time.[14] Post-injection VAS for pain was measured using the same maneuver as was used before the impingement test.

2) Other functional outcome evaluations

The range of motion of the shoulder joint, including forward flexion, external rotation, and internal rotation by the level of the vertebral body, were measured. Shoulder isometric strength of the forward flexion, external rotation, and internal rotation were checked using the Oxford scale[15] and a digital dynamometer (NIDEC-SHIMPO Corp., Kyoto, Japan). The American Shoulder and Elbow Surgeons (ASES) standardized form[16] was used as an outcome evaluation tool. All evaluations were assessed preoperatively and at 3, 6, 9, and 12 months postoperatively.

3) Group classification

According to the results of impingement test, the participants were divided into four groups: Group A, pain reduction of 75% or more after the impingement test; Group B, pain reduction of 50% or more, but less than 75%; Group C, pain reduction of 25% or more, but less than 50%; Group D, pain reduction of less than 25%. No significant differences among groups were observed with respect to gender (p=0.436), age (p=0.542), or number of days from onset (p=0.286). In addition, according to the classification of DeOrio and Cofield,[17] the distribution of tear size did not differ significantly among groups (p=0.188). Finally, no significant differences among groups were noted for diabetes mellitus (p=0.742) and hypertension (p=0.819) (Table 1).

Surgical Procedure

Under general anesthesia, each patient was placed in the beach chair position. The anteroposterior dimension and retraction of the cuff tear were measured with a probe during arthroscopic procedures and categorized according to the classification of DeOrio and Cofield.[17]

All repairs were performed by the senior author with the arthroscopic technique using suture anchors (double row suture bridge technique) for full coverage according to tear configuration. The number of medial anchors was decided upon tear size. Arthroscopic acromioplasty was conducted using techniques similar to those described by Altchek et al.[18] and Gartsman[19] in all cases. At the end of the procedure, 20 ml of 0.75% ropivacaine (AstraZeneca, Södertälje, Sweden) were injected into the subacromial space.

Postoperative Rehabilitation

All shoulders were immobilized with an abduction brace for 6 weeks. Pendulum exercise was started on the day after surgery. Immediate controlled passive motion of forward elevation, abduction, external rotation, and internal rotation was allowed from 5 days postoperatively with the brace off. Muscle strengthening exercise was encouraged after weaning off the brace. All sports activities were permitted at 6 months after the operation.

Statistical Analyses

The repeated measures ANOVA was used to compare the symptomatic and functional outcomes after arthroscopic rotator cuff repair with acromioplasty between the four groups under study. Univariate regression analysis was used to evaluate the correlation between the pre- and post-injection VAS for pain difference and improvement of VAS for pain after surgery. The analyses were performed using IBM SPSS ver. 19.0 (IBM Co., Armonk, NY, USA), with a $p<0.05$ considered statistically significant.

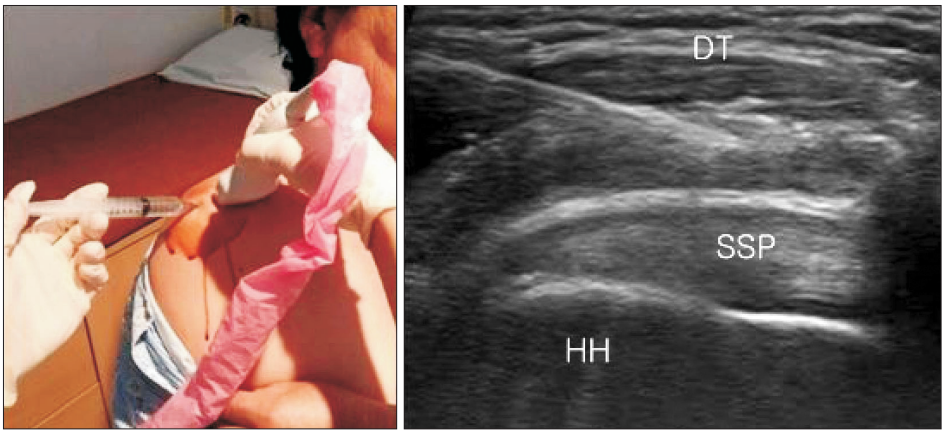

Fig. 1. Ultrasound Guided Impingement Test.
DT: deltoid, SSP: suraspinatus tendon, HH: humeral head.

Results

The mean pre-injection VAS for pain of Group A was 7.0 ± 1.3 and the mean post-injection VAS for pain of Group A was 0.9 ± 0.9, while those of Group B were 7.4 ± 1.9 and 2.6 ± 0.9, those of Group C were 6.3 ± 1.9 and 3.8 ± 1.3, and those of Group D were 5.9 ± 2.9 and 5.0 ± 2.4, respectively (Fig. 2). Although different degrees of pain reduction were observed, most participants reported pain reduction after the impingement test. The VAS for pain was improved significantly at postoperation 3 and 6 months than preoperation in group A and B, at 9 months in Groups A, B, and C ($p<0.05$), and at 12 months in all groups ($p<0.05$). The mean VAS for pain also improved significantly at 3 and 6 months postoperatively in Groups A and B when compared to Groups C and D ($p<0.05$) (Table 2, Fig. 2). These results demonstrate that the amount of pain reduction after the impingement test is significantly related to improvement of pain postoperatively.

Among groups, the range of forward flexion significantly improved in Group A at 3 months postoperatively ($p<0.05$) (Fig. 3). The correlation of the difference between preoperative and postoperative range of external rotation and internal rotation between groups was not significantly different ($p=0.789$, 0.725). The correlation of the difference between preoperative and postoperative isometric strength of the forward flexion, external rotation, and internal rotation between the four groups under study also did not differ significantly ($p=0.825$, 0.764, 0.723, respectively).

The ASES score improved at 3 and 6 months postoperatively

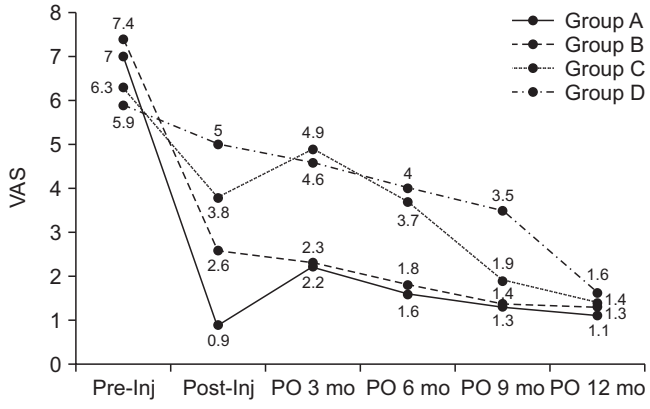

Fig. 2. VAS pain scores from preoperative day to 12 months postoperative day. The mean VAS for pain improved significantly at 3 and 6 months postoperatively in Groups A and B relative to Groups C and D. Four groups were divided according to the amount of pain reduction (%) after the impingement test; Group A: 75%–100%, Group B: 50%–74%, Group C: 25%–49%, Group D: 0%–24%.
VAS: visual analogue scale, Pre-Inj: pre-injection, Post-Inj: post-injection, PO: postoperative.

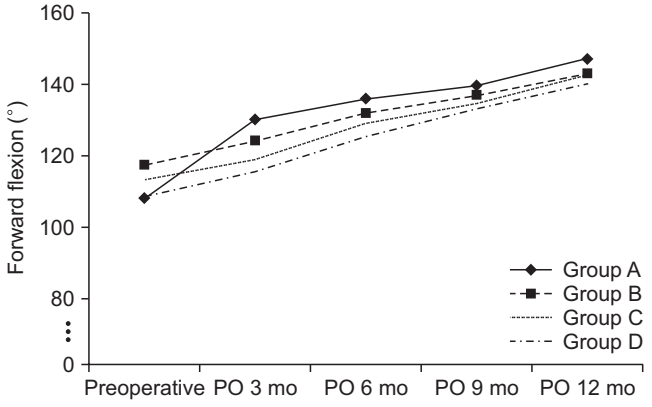

Fig. 3. Range of forward flexion. The range of forward flexion significantly improved in Group A at 3 months postoperatively. Four groups were divided according to the amount of pain reduction (%) after the impingement test; Group A: 75%–100%, Group B: 50%–74%, Group C: 25%–49%, Group D: 0%–24%.
PO: postoperative.

Table 2. Visual Analogue Scale Pain Scores from Preoperative Day to 12 Months Postoperative Day

Follow-up duration	Group*				*p*-value
	Group A	Group B	Group C	Group D	
Preoperative					
Pre-injection	7.0 ± 1.3	7.4 ± 1.9	6.3 ± 1.9	5.9 ± 2.9	0.554
Post-injection	0.9 ± 0.9	2.6 ± 0.9	3.8 ± 1.3	5.0 ± 2.4	<0.001
Postoperative					
3 months	2.2 ± 1.6	2.3 ± 2.0	4.9 ± 2.1	4.6 ± 3.4	0.012
6 months	1.6 ± 1.7	1.8 ± 1.6	3.7 ± 2.2	4.0 ± 2.5	0.019
9 months	1.3 ± 1.4	1.4 ± 1.5	1.9 ± 1.2	3.5 ± 2.0	0.174
12 months	1.1 ± 1.7	1.3 ± 1.3	1.4 ± 1.2	1.6 ± 2.1	0.226

Values are presented as mean ± standard deviation.
*Four groups were divided according to the amount of pain reduction (%) after the impingement test; Group A: 75%–100%, Group B: 50%–74%, Group C: 25%–49%, Group D: 0%–24%.

Table 3. American Shoulder and Elbow Surgeons Scores from Preoperative Day to 12 Months Postoperative Day

Follow-up duration	Group*			
	Group A	Group B	Group C	Group D
Preoperative	43.8 ± 8.6	45.1 ± 9.2	44.2 ± 7.8	41.6 ± 8.8
Postoperative				
3 months	72.7 ± 7.4	69.3 ± 8.6	42.8 ± 9.1	43.6 ± 7.5
6 months	78.2 ± 8.9	75.6 ± 8.8	52.7 ± 8.5	50.2 ± 6.7
9 months	80.7 ± 6.8	78.7 ± 8.1	70.2 ± 8.6	56.9 ± 6.9
12 months	82.1 ± 6.9	83.0 ± 9.3	78.9 ± 7.3	79.1 ± 9.2

Values are presented as mean ± standard deviation.
*Four groups were divided according to the amount of pain reduction (%) after the impingement test; Group A: 75%–100%, Group B: 50%–74%, Group C: 25%–49%, Group D: 0%–24%.

in Groups A and B, at 9 months in Groups A, B, and C, and at 12 months in all groups ($p<0.05$). The score also significantly improved at 3 and 6 months postoperatively in Groups A and B when compared to Groups C and D ($p<0.05$) (Table 3).

According to the results of univariate regression analysis, the following equation was established: (reduction of VAS for pain in impingement test)×0.216+5.64=postoperative 12 months VAS for pain.

Discussion

In rotator cuff disorders, pain is usually the most serious symptom that concerns patients.[20,21] Many patients have paid attention to pain itself, and pain is thought to be the main cause of patients' decision for undergoing surgery.[21]

If the amount of pain reduction can be predicted preoperatively, it could be helpful when discussing the outcome of surgery with patients. However, it is difficult to predict how much pain will be reduced after surgical repair in each patient.[8] No definite clinical factors have been found to reliably account for and determine the amount of pain reduction after rotator cuff surgery.[22]

We found that patients whose VAS for pain was improved in Groups A and B were more likely to experience a reduction of pain than patients whose VAS for pain was improved in Groups C and D, especially at 3 months and 6 months postoperatively ($p=0.012$, 0.019, respectively). The VAS for pain at 12 months follow-up among the four groups was not significantly different ($p=0.226$) (Table 2). The ASES score also improved at 3 and 6 months postoperatively in patients whose pain was improved in Groups A and B with pain reduction ($p=0.026$, 0.037, respectively). We also demonstrated that the range of forward elevation improved in patients whose pain was improved in Group A at 3 months postoperatively ($p=0.038$). Our data revealed a significant correlation between the amount of pain reduction after the preoperative impingement test and the decrease in VAS for pain after surgery, especially 3 and 6 months postoperatively.

The impingement test[9] is one of the best known examinations for predicting symptomatic and functional outcome after rotator cuff surgery and subacromial decompression.[8,10,11] This test was initially designed to confirm the diagnosis of subacromial impingement syndrome. Oh et al.[8] modified the original impingement test for their study and concluded that the amount of pain reduction after a modified impingement test was related to pain reduction following rotator cuff repair. Furthermore, Skedros and Pitts[14] suggested that there is temporal variation in the onset of effect in the impingement test. The authors claimed that assessing pain at 10 minutes for a Neer-type impingement test can fail to accurately determine a positive test in a substantial percentage of patients. Therefore, we waited for about 30 to 60 minutes to ensure diffusion of the agent in the subacromial space and to allow for onset time, after which we subsequently re-checked the visual analog scale for pain. We also regulated the time of the impingement test to the day before the surgery. In this way, the patients' precise preoperative pain degree could be appropriately reflected.

Conversely, Kirkley et al.[10] analyzed 30 patients with rotator cuff tendinosis and argued that the impingement test was a poor tool for predicting the success of subacromial decompression. The authors found no correlation between the reduction of pain after the impingement test and the change in Western Ontario Rotator Cuff Index and the ASES score following subacromial decompression.

In contrast, Oh et al.[8] demonstrated that there is a significant correlation between the amount of pain reduction after the modified impingement test and the change in VAS for pain at the final follow-up visit, in agreement with our results. Furthermore, Mair et al.[11] categorized 55 patients with impingement syndrome based on the degree of pain reduction following the impingement test. The authors defined a positive impingement test as a patient with more than 75% pain relief and demonstrated that patients with a positive impingement test had a successful outcome after surgery. They further purported that the impingement test could be an effective tool to predict outcome after arthroscopic subacromial decompression. In the present study, we divided the patients into four groups according to this reference and obtained similar results. Similarly, Altchek et al.[18] concluded that a positive impingement test was the best predictor of the postoperative functional Hospital for Special Surgery score, and that this score was correlated with the total postoperative score.

The authors performed the impingement test under the guidance of ultrasonography to increase the accuracy. The accuracy of the blind impingement test was 70% to 80%,[23-25] and the accurate placement of the injection was confirmed through the positive impingement test.[23] Similarly, Oh et al.[8] reported that

21.6% of patients experienced worsening or no change in the level of pain after the modified impingement test. However, in the present study, only 2 of 96 patients (2.1%) felt no change in pain level after the preoperative impingement test. Moreover, no patients reported worsening of pain after injection.

It should be noted that our study has the following limitations. First, the participants were limited to those with small- to medium-sized rotator cuff tears, making it difficult to apply the results to entire rotator cuff tears or other shoulder disorders. Second, we investigated VAS for pain only at passive motion and did not evaluate it during patients' active motion of shoulder joints. Third, the participants were divided into four groups according to the pain reduction amount after the impingement test. Therefore, other factors for grouping that could have affected functional outcomes were not considered. Fourth, although pain is closely related to healing of the rotator cuff, healing after rotator cuff repair was not evaluated in the present study. However, the significance of our results lies in the fact that the present study sought to analyze the correlation between the preoperative impingement test and postoperative clinical outcomes in rotator cuff tears.

Conclusion

Preoperative degree of pain reduction after the impingement test was found to correlate with the improvement of pain after arthroscopic rotator cuff repair, especially in the early phase. Therefore, the impingement test could be used as a reliable predictor of outcome following arthroscopic rotator cuff repair within 6 months postoperatively.

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