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# Risk factors for recurrence of frozen shoulder after shoulder manipulation under ultrasound-guided cervical nerve root block

Ryosuke Takahashi, MD[a,*], Yukihiro Kajita, MD, PhD[a], Shunsuke Fujii, MD[a], Yohei Harada, MD, PhD[b]

[a]*Department of Orthopaedic Surgery, Ichinomiya Nishi Hospital, Aichi, Japan*
[b]*Department of Orthopaedic Surgery, Hiroshima University, Hiroshima, Japan*

A R T I C L E I N F O

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*Level of evidence:* Level III; Retrospective Case Control Design; Prognosis Study

**Background:** This study aimed to investigate risk factors for recurrence of frozen shoulder after shoulder manipulation under ultrasound-guided cervical nerve root block (MUC).

**Methods:** We retrospectively reviewed 135 frozen shoulders in 121 patients who underwent MUC. We defined frozen shoulder as a limited shoulder range of motion (ROM) (passive forward flexion <120°, external rotation <30°, or internal rotation lower than L3). Patients fulfilling any one criteria were considered to have frozen shoulder. If patients continued to have severe pain and limited ROM at 3 months after MUC, we defined as recurrence of frozen shoulder and they were offered a further MUC or arthroscopic capsular release (ACR). We compared the ROM, Constant Shoulder (CS) score, and University of California, Los Angeles score before and 3 months after MUC between patients with the successful of MUC group (Success group) with those recurrence of frozen shoulder who required a further MUC or ACR group (Recurrence group). Multiple logistic regression analysis was used to identify risk factors for recurrence of frozen shoulder after MUC.

**Results:** Patients who underwent MUC were retrospectively enrolled and divided into: the successful of MUC group (Success group, n = 112) and required a further MUC or ACR group (Recurrence group, n = 9). The Recurrence group had significantly lower external rotation and CS score before MUC than those in the Success group ($P < .05$). The Recurrence group showed significantly inferior all ROM and functional scores 3 months after MUC ($P < .05$). The levels of blood glucose and hemoglobin A1c both before and 3 months after MUC in the Recurrence group showed inferior compared with those of Success group. The difference, although not statistically significant, trended towards significance (before MUC/3 months after MUC; the glucose levels $P = .06/.06$, the hemoglobin A1c levels $P = .07/.09$, respectively). The visual analog scale pain score (at rest, during activity, at night) both before and 3 months after MUC in the Recurrence group showed significantly higher scores compared with those of Success group ($P < .05$). Multiple logistic regression analysis revealed that lower CS score before MUC was independent risk factor for recurrence of frozen shoulder after MUC.

**Conclusion:** The overall incidence of recurrence of frozen shoulder after MUC was 7.4%. The lower CS score before MUC was an independent risk factor for recurrence of frozen shoulder after MUC. Moreover, patients in the Recurrence group tended to have poorly controlled diabetes and higher visual analog scale pain score both before and 3 months after MUC.



Frozen shoulder is a condition characterized by the functional restriction of both active and passive shoulder motion, for which the glenohumeral joint radiographs are unremarkable, aside from the possible presence of osteopenia or calcific tendonitis.[26] It is one of the most commonly observed orthopedic conditions affecting the shoulder, with a prevalence of 2%-5% in the general population[25] and 10%-32% among patients with diabetes mellitus (DM).[2] This condition commonly occurs at age 40-60 years, with a peak incidence in the mid-50s.[3] Although frozen shoulder resolves within 2-3 years, a recent study indicated that pain and movement limitations may persist for longer periods.[3,22] If a patient with a frozen shoulder is unresponsive to conservative therapy, shoulder

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*Corresponding author: Ryosuke Takahashi MD, Department of Orthopaedic Surgery, Ichinomiya Nishi Hospital, 1 Kaimei-hira, Ichinomiya, Aichi 494-0001, Japan.

*E-mail address:* takahashi.ryosuke0617@gmail.com (R. Takahashi).

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manipulation under an ultrasound-guided cervical nerve root block (MUC) or arthroscopic capsular release (ACR) may be recommended.[5,9,17,18]

Although it has been reported that MUC has resulted in good clinical outcomes,[15,17,18,20] few studies have focused on recurrence in patients who had unsuccessful outcomes with shoulder manipulation.[7,14,24] Oshiro et al reported that 11 of 42 shoulders (26%) developed recurrent moderate pain and limited range of motion (ROM) after MUC.[14] Woods et al performed manipulation under anesthesia (MUA) in 730 patients with frozen shoulder and reported that a total of 141 patients (17.8%) required a further MUA, and that patients with type 1 DM had a 38% increased risk of requiring additional MUA.[24] Jenkins et al reported that repeat MUA was required in 36% of patients with DM compared with 15% of control patients.[7] The purpose of this study was to investigate risk factors for recurrence of frozen shoulder after MUC.

## Materials and methods

### Study participants

We retrospectively reviewed the outcomes of MUC in patients with frozen shoulder who provided informed consent to participate in this institutional review board-approved study between January 2015 and December 2021 (2023015). The inclusion criteria for MUC were as follows: [1] Frozen shoulder as limited shoulder ROM (passive forward flexion at <120°, external rotation (ER) at <30°, or internal rotation (IR) at the back lower than L3).[13] Patients fulfilling any one criteria were considered to have frozen shoulder. [2] Patients who did not respond to conservative therapy, such as oral non-steroidal anti-inflammatory drugs, intra-articular steroid injection, or physical therapy, for at least 3 months. Patients with rotator cuff tears, shoulder osteoarthritis, calcified tendinitis, long head of the biceps tendon injury, hemiplegia after stroke, bone metastasis in the shoulder region, history of shoulder fractures, and history of shoulder surgery were excluded.

### MUC procedure and post-MUC therapy

All procedures were performed in the same manner, and the patients were treated by a single skilled surgeon. The MUC was performed in an outpatient setting and the patient was placed in the supine position. The cervical nerve roots (C5 and C6) between the anterior and middle scalene muscles were identified using an ultrasound guide (SNiBLE; KONICA MINOLTA, Tokyo, Japan), and 15-20 mL of 1% lidocaine was injected into the C5/C6 region. Manipulation was initiated after evaluation of immediate complications and confirmation of pain absence at the shoulder joint during passive forward flexion and abduction. Manipulation was first performed in forward flexion to complete the inferior capsule release and then in ER to complete the releasing of the anterior capsule. Subsequently, ER with the arm at the side and 90° abduction on the scapular plane was performed to complete the anterior and inferior capsule release. Finally, IR was performed with the arm at 90° abduction on the scapular plane and at the extension to the vertebral height of the dominant thumb of the patient to complete the anterior and superior capsule release. After completion of the MUC, we measured the vital signs and injected 10 mL of 1% lidocaine and 2.5 mg of dexamethasone into the glenohumeral joint to prevent postprocedural pain. One day after MUC, we assessed any neurological and vascular injuries and conducted radiographic assessments to determine major complications such as pneumothorax and humeral fracture. If no complications were noted, the patients were encouraged to continue the shoulder rehabilitation program, which included passive and active ROM exercises. Rehabilitation was performed at least 3 months after MUC with the assistance of a physical therapist.

### Inclusion criteria for recurrence of frozen shoulder

We defined as recurrence of frozen shoulder that patients exhibiting a good response after MUC but later presented with recurrent symptoms (severe pain during daily activities or at night and limited ROM) at 3 months after MUC.

### Clinical assessment

We compared the ROM, Constant Shoulder (CS) score, and University of California, Los Angeles score before and 3 months after MUC between patients with the successful of MUC group (Success group) with those recurrence of frozen shoulder who required a further MUC or ACR group (Recurrence group). Multiple logistic regression analysis was used to identify risk factors for recurrence of frozen shoulder after MUC.

IR was defined as the highest vertebral body that the patient could reach using the thumb of the affected arm. IR was scored as follows: above T12, 6 points; above L5, 4 points; at the buttocks, 2 points; and below the buttocks, 0 points.

### Statistical analyses

The chi-square test was used to compare categorical variables such as patient sex, presence of DM, and affected side between the two groups. Student's *t*-test was employed for comparing age, symptom duration before MUC, Body mass index, hemoglobin A1c (HbA1c), blood glucose levels, the duration of DM, the visual analog scale (VAS) pain score (at rest, during activity, at night), ROM, and functional scores, while the unpaired *t*-test was used to compare these variables in each group. All statistical analyses were performed using the SPSS software (version 18.0; IBM Corp., Armonk, NY, USA). Statistical significance was set at $P < .05$.

## Results

In total, 176 MUC were performed during the study period. After excluding 41 shoulders of 38 patients, 135 shoulders of 121 patients were included in the study (Fig. 1). The mean age of all patients was 52.4 ± 6.7 years, and the mean follow-up period was 17.6 ± 2.6 months. Fourteen (11.6%) patients had bilateral frozen shoulders. The patients were categorized into two groups; 126 shoulders in 112 patients (92.6%) underwent a successful MUC (Success group: 42 men and 70 women; mean age, 52.5 ± 6.7 years), and 9 shoulders in 9 patients (7.4%) required a further MUC or ACR (Recurrence group: 4 men and 5 women; mean age, 51.2 ± 6.8 years).

The demographic characteristics of the patients are displayed in Table I. The Recurrence group had significantly lower ER and CS score before MUC than those in the Success group ($P < .05$). The Recurrence group showed significantly inferior all ROM and functional scores 3 months after MUC ($P < .05$) (Table II). The levels of blood glucose and HbA1c both before and 3 months after MUC in the Recurrence group showed inferior compared with those of Success group. The difference, although not statistically significant, trended towards significance (before MUC; the glucose levels 131.9 ± 24.8/201.8 ± 77.8 ($P = .06$), the HbA1c levels 6.4 ± 0.4/8.3 ± 1.4 ($P = .07$), respectively, 3 months after MUC; the glucose levels 120.8 ± 39.2/180.6 ± 65.5 ($P = .06$), the HbA1c levels 6.3 ± 0.4/9.4 ± 2.7 ($P = .09$), respectively). The VAS pain score (at rest, during activity, at night) both before and 3 months after MUC in the Recurrence group showed significantly higher compared with those of the Success group (before MUC; 11.7 ± 14.7/

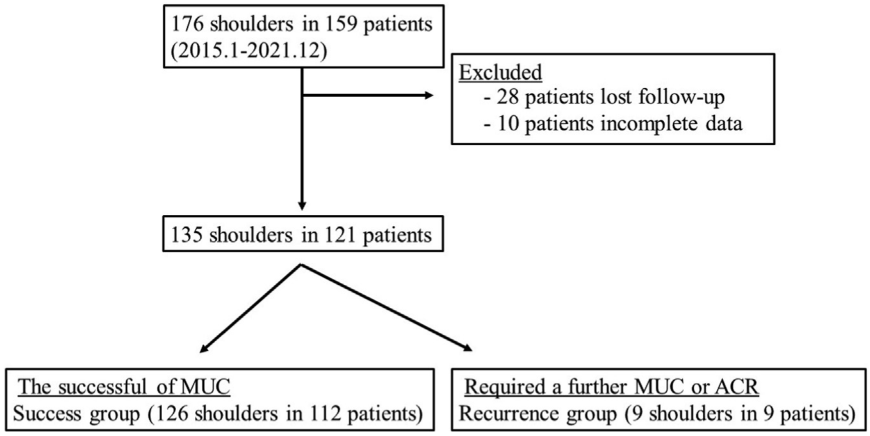


**Fig. 1** Study design flow diagram. *ACR*, arthroscopic capsular release; *MUC*, cervical nerve root block.

**Table I**
Patient's demographics at baseline.

| Variables | Success group (n = 112) | Recurrence group (n = 9) | *P* value |
|---|---|---|---|
| Number of shoulders | 126 | 9 | |
| Male/female | 42/70 | 4/5 | .68 |
| Age (y) | 52.5 ± 6.7 | 51.2 ± 6.8 | .30 |
| Duration of symptoms before MUC (mo) | 11.5 ± 14.4 | 14.5 ± 8.7 | .18 |
| Body mass index (kg/m$^2$) | 22.7 ± 3.5 | 22.7 ± 2.4 | .48 |
| Diabetes mellitus (n) | 21 (16.7%) | 3 (33.3%) | .19 |
| HbA1c (%) | 6.4 ± 0.4 | 8.3 ± 1.4 | .07 |
| Blood glucose level (mg/dL) | 131.9 ± 24.8 | 201.8 ± 77.8 | .06 |
| Duration of DM (y) | 8.7 ± 4.1 | 10.3 ± 6.9 | .15 |
| VAS pain score | | | |
| At rest | 11.7 ± 14.7 | 20.2 ± 18.3 | .03 |
| During activity | 39.7 ± 20.1 | 51.3 ± 26.3 | <.01 |
| At night | 40.1 ± 23.9 | 50.7 ± 33.2 | <.01 |
| Affected side (n) | | | |
| Dominant/nondominant | 68/58 | 4/5 | .58 |
| Preoperative findings | | | |
| ROM | | | |
| Forward flexion (°) | 100 ± 16.1 | 92.2 ± 18.5 | .12 |
| External rotation (°) | 17.8 ± 14.2 | 8.8 ± 13.6 | .04 |
| Internal rotation (point) | 1.5 ± 1.5 | 0.8 ± 1.7 | .15 |
| CS score (point) | 53.3 ± 7.9 | 46.3 ± 10 | .03 |
| UCLA score (point) | 17.9 ± 3.2 | 16.2 ± 4.8 | .16 |

*MUC*, cervical nerve root block; *HbA1c*, hemoglobin A1c; *DM*, diabetes mellitus; *VAS*, visual analog scale; *ROM*, range of motion; *CS*, constant shoulder; *UCLA*, University of California, Los Angeles.

20.2 ± 18.3 ($P = .03$), 39.7 ± 20.1/51.3 ± 26.3 ($P < .01$), 40.1 ± 23.9/50.7 ± 33.2 ($P < .01$), respectively, 3 months after MUC; 3.7 ± 9.8/17.5 ± 11.7 ($P < .01$), 15 ± 20/38.3 ± 22.2 ($P < .01$), 11.4 ± 20.3/41.7 ± 19.4 ($P < .01$), respectively) (Tables I and II). Multiple logistic regression analysis revealed that lower CS score before MUC was independent risk factor for recurrence of frozen shoulder after MUC (Table III).

In terms of adverse events, two patients (1.7%) had a vasovagal reflex and one (0.8%) had a panic attack during the block procedure in the MUC; however, they fully recovered after several hours without treatment. There were no complications such as fractures, shoulder dislocation, rotator cuff tears and neurological or other iatrogenic injuries.

## Discussion

Our results indicated that the Recurrence group had significantly lower ER and CS score before MUC than those in the Success group. Moreover, the Recurrence group showed significantly inferior all ROM and functional scores 3 months after MUC. Multiple logistic regression analysis revealed that lower CS score before MUC was independent risk factor for recurrence of frozen shoulder after MUC. Patients in the Recurrence group tended to have poorly controlled diabetes and higher VAS pain score both before and 3 months after MUC. No severe complications occurred.

MUC is a recognized treatment for patients with a persistent frozen shoulder and has been established as a safe and effective method to ameliorate pain and restore shoulder ROM.[10,15,17,18,20] Saito et al reported that MUC for frozen shoulder refractory to conservative treatments resulted in good clinical outcomes for at least 1-year of follow-up.[15] Sasanuma et al stated that MUC in 30 shoulders significantly improved the ROM and functional scores before treatment until 1 month after the procedure.[17] Moreover, regarding the timing of manipulation, a previous study showed a significant influence on clinical outcome, and the optimal time for MUC may be >6-months after symptom onset.[20] MUC at approximately 6-9 months after symptom onset is recommended for good clinical outcomes.[4,23]

Although good clinical outcomes have been reported for MUC, few studies have discussed recurrence in patients who had

**Table II**
3 months after MUC in both group.

| Variables | Success group | Recurrence group | *P* value |
|---|---|---|---|
| ROM | | | |
| Forward flexion (°) | 154.2 ± 20.8 | 95 ± 8.4 | <.001 |
| External rotation (°) | 47.5 ± 13.1 | 10.8 ± 12 | <.001 |
| Internal rotation (point) | 4.0 ± 1.4 | 1.3 ± 2.1 | .013 |
| CS score (point) | 79.8 ± 9.2 | 49.5 ± 6.3 | <.001 |
| UCLA score (point) | 27.6 ± 3.6 | 17.6 ± 1.5 | <.001 |
| HbA1c (%) | 6.3 ± 0.4 | 9.4 ± 2.7 | .09 |
| Blood glucose level (mg/dL) | 120.8 ± 39.2 | 180.6 ± 65.5 | .06 |
| VAS pain score | | | |
| At rest | 3.7 ± 9.8 | 17.5 ± 11.7 | <.01 |
| During activity | 15 ± 20 | 38.3 ± 22.2 | <.01 |
| At night | 11.4 ± 20.3 | 41.7 ± 19.4 | <.01 |

*MUC*, cervical nerve root block; *HbA1c*, hemoglobin A1c; *VAS*, visual analog scale; *ROM*, range of motion; *CS*, constant shoulder; *UCLA*, University of California, Los Angeles.

**Table III**
Multiple logistic regression analysis results.

| Variables | Odds ratio | 95% CI | *P* value |
|---|---|---|---|
| CS score | 8.7 | 0.77-0.97 | .02 |

*CI*, confidence interval; *CS*, constant shoulder

unsuccessful outcomes with shoulder manipulation.[7,14,24] Oshiro et al reported that 11 of 42 shoulders (26%) developed recurrent moderate pain and limited ROM at 3 months after MUC.[14] That study compared patients who underwent a single MUC (single group) with those who required repeat MUC (repeat group) and concluded that patients in the repeat group had severely limited ROM and showed significantly lower American Shoulder and Elbow Surgeons (ASES) score before MUC than those in the single group. Woods et al performed MUA in 730 patients with frozen shoulder and reported that a total of 141 patients (17.8%) required a further MUA, and that patients with type 1 DM had a 38% increased risk of requiring additional MUA.[24] Jenkins et al reported that repeat MUA was required in 36% of patients with DM compared with 15% of control patients.[7] Similarly, DM has been associated with poorer clinical outcomes of shoulder manipulation for frozen shoulder in previous studies.[1,16,19] Its mechanism is known to involve persistently high levels of glucose leading to the accumulation of advanced glycosylation end products that form cross-links with collagen, making it inelastic and more susceptible to degenerative processes.[11] The amount of collagen produced in patients with diabetes is estimated to be at least twice the amount produced in nondiabetic patients of a similar age, leading to progressive changes that affect joint elasticity.[12] In our study, 21 patients (16.7%) had DM in Success group and 3 patients (33.3%) in Recurrence group ($P = .19$). The levels of blood glucose and HbA1c both before and 3 months after MUC in the Recurrence group were inferior compared to those of the Success group. The difference, although not statistically significant, trended towards significance (before MUC; the glucose levels 131.9 ± 24.8/201.8 ± 77.8 ($P = .06$), the HbA1c levels 6.4 ± 0.4/8.3 ± 1.4 ($P = .07$), respectively, 3 months after MUC; the glucose levels 120.8 ± 39.2/180.6 ± 65.5 ($P = .06$), the HbA1c levels 6.3 ± 0.4/9.4 ± 2.7 ($P = .09$), respectively). To the best of our knowledge, no studies have focused on the relationship between clinical outcomes of before and 3 months after MUC and the levels of blood glucose and HbA1c. A total of 9 shoulders in 9 patients (7.4%) were recurrence of frozen shoulder after MUC who required a further MUC or ACR in our study. The exact reason is unclear why our study had fewer recurrent patients required additional procedure than previous studies, but good glycemic control before MUC in Success group might affect the outcomes.

Some authors have reported good clinical outcomes of subsequent repeat shoulder manipulation after failure of the initial shoulder manipulation.[7,14,24] Oshiro et al performed repeat MUC if patients continued to have pain and limited ROM at 3 months after the initial MUC, and reported good clinical outcome.[14] In our study, patients of recurrence of frozen shoulder after MUC who required a further MUC or ACR showed significantly lower ER and CS score before MUC than patients of successful MUC. Moreover, recurrence group showed significantly inferior all ROM and functional scores 3 months after MUC than patients of successful MUC. These findings were consistent with those of Oshiro et al.[14] The VAS pain score (at rest, during activity, at night) both before and 3 months after MUC in the Recurrence group showed significantly higher compared with those of Success group. Some authors have reported that DM was a risk factor of the severity of adhesion of coracohumeral ligament, rotator interval and long head of biceps, which were the mechanical physiological functions of the shoulder depend quite closely and sensitively on this area, especially ER.[8,21] These suggested that the severe adhesion of coracohumeral ligament, rotator interval and long head of biceps due to poor glycemic control affect the limited ER and severe pain, leading to lower ER and CS score in this study. Therefore, we believe that intensive pain relief and glycemic control, both perioperatively and at least 3 months postoperatively, are imperative to achieve successful clinical outcomes after MUC, especially patients who had lower ROM and functional score before MUC.

In our hospital, if patients continue to have pain and limited ROM at 3 months after MUC, we offered additional procedures such as a further MUC or ACR. To our knowledge, although there had no studies of performed ACR for patients recurrence of frozen shoulder after MUC, ACR allows precise and controlled release of the capsule and ligaments,[6] which may be an effective option. Further study is needed to evaluate the efficacy of MUC, and whether a further MUC or ACR are effective for patients with continued or recurrent frozen shoulder symptoms after initial MUC.

Our study has several limitations. First, this study had a retrospective design. Second, the sample size was small and the mean follow-up period was short. However, long-term follow-up was difficult because most of the patients were satisfied with the outcomes in a few months and they did not hope to visit again. Third, the evaluation of levels of blood glucose and HbA1c were only before and 3 months after MUC, all of which may have influenced the clinical outcomes. Fourth, we did not evaluate other medical comorbidities.

## Conclusion

When comparing patients who required secondary MUCs or ACRs due to a recurrence of frozen shoulder after a primary MUC, those who needed further procedures had overall lower ER and CS scores preoperatively in their initial MUCs than those whose primary MUCs were successful. Moreover, 3 months postoperatively, patients who required secondary procedures showed significantly reduced ROM in all movements and lower functional scores than patients with a successful primary MUC. Poorly controlled diabetes was much more prevalent in these patients, as well as overall higher VAS pain scores both before and at 3 months after their secondary MUC. These findings can be applied during patient counselling when obtaining informed consent for MUC procedures.

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## References


1. Ando A, Hamada J, Hagiwara Y, Sekiguchi T, Koide M, Itoi E. Short-term clinical results of manipulation under ultrasound-guided brachial plexus block in patients with idiopathic frozen shoulder and diabetic secondary frozen shoulder. Open Orthop J 2018;12:99-104. https://doi.org/10.2174/1874325001812010099.
2. Cagliero E, Apruzzese W, Perlmutter GS, Nathan DM. Musculoskeletal disorders of the hand and shoulder in patients with diabetes mellitus. Am J Med 2002;112:487-90. https://doi.org/10.1016/s0002-9343(02)01045-8.
3. Dias R, Cutts S, Massoud S. Frozen shoulder. BMJ 2005;331:1453-6. https://doi.org/10.1136/bmj.331.7530.1453.
4. Flannery O, Mullett H, Colville J. Adhesive shoulder capsulitis: does the timing of manipulation influence outcome? Acta Orthop Belg 2007;73:21-5.
5. Gallacher S, Beazley JC, Evans J, Anaspure R, Silver D, Redfern A, et al. A randomized controlled trial of arthroscopic capsular release versus hydrodilatation in the treatment of primary frozen shoulder. J Shoulder Elbow Surg 2018;27:1401-6. https://doi.org/10.1016/j.jse.2018.04.002.
6. Itoi E, Arce G, Bain GI, Diercks RL, Guttmann D, Imhoff AB, et al. Shoulder stiffness: current concepts and concerns. Arthroscopy 2016;32:1402-14. https://doi.org/10.1016/j.arthro.2016.03.024.
7. Jenkins EF, Thomas WJ, Corcoran JP, Kirubanandan R, Beynon CR, Sayers AE, et al. The outcome of manipulation under general anesthesia for the management of frozen shoulder in patients with diabetes mellitus. J Shoulder Elbow Surg 2012;21:1492-8. https://doi.org/10.1016/j.jse.2011.11.006.
8. Kanbe K. Clinical outcome of arthroscopic capsular release for frozen shoulder: essential technical points in 255 patients. J Orthop Surg Res 2018;13:56. https://doi.org/10.1186/s13018-018-0758-5.
9. Le Lievre HM, Murrell GA. Long-term outcomes after arthroscopic capsular release for idiopathic adhesive capsulitis. J Bone Joint Surg Am 2012;94:1208-16. https://doi.org/10.2106/JBJS.J.00952.
10. Loew M, Heichel TO, Lehner B. Intraarticular lesions in primary frozen shoulder after manipulation under general anesthesia. J Shoulder Elbow Surg 2005;14:16-21. https://doi.org/10.1016/j.jse.2004.04.004.
11. Monnier VM, Glomb M, Elgawish A, Sell DR. The mechanism of collagen cross-linking in diabetes: a puzzle nearing resolution. Diabetes 1996;45:S67-72.
12. Monnier VM, Sell DR, Abdul-Karim FW, Emancipator SN. Collagen browning and cross-linking are increased in chronic experimental hyperglycemia. Relevance to diabetes and aging. Diabetes 1988;37:867-72.
13. Oh JH, Kim SH, Lee HK, Jo KH, Bin SW, Gong HS. Moderate preoperative shoulder stiffness does not alter the clinical outcome of rotator cuff repair with arthroscopic release and manipulation. Arthroscopy 2008;24:983-91. https://doi.org/10.1016/j.arthro.2008.06.007.
14. Oshiro T, Yagi M, Harada K, Park K. Results of repeat manipulation under ultrasound-guided cervical nerve root block with corticosteroid and local anaesthetic injection for recurrence of frozen shoulder. J Orthop Surg Res 2020;15:586. https://doi.org/10.1186/s13018-020-02120-8.
15. Saito T, Sasanuma H, Iijima Y, Kanaya Y, Saito T, Watanabe H, et al. Short-term clinical results of frozen shoulder treated with shoulder manipulation under ultrasound-guided cervical nerve root block at outpatient setting: a case series. J Orthop Sci 2017;22:275-80. https://doi.org/10.1016/j.jos.2016.11.007.
16. Saito T, Sasanuma H, Iijima Y, Takeshita K. Prognostic factors of shoulder manipulation under ultrasound-guided cervical nerve root block for frozen shoulder for patient with diabetes mellitus: a retrospective cohort study. Int J Surg Case Rep 2021;87:106480. https://doi.org/10.1016/j.ijscr.2021.106480.
17. Sasanuma H, Sugimoto H, Kanaya Y, Iijima Y, Saito T, Saito T, et al. Magnetic resonance imaging and short-term clinical results of severe frozen shoulder treated with manipulation under ultrasound-guided cervical nerve root block. J Shoulder Elbow Surg 2016;25:e13-20. https://doi.org/10.1016/j.jse.2015.06.019.
18. Takahashi R, Iwahori Y, Kajita Y, Harada Y, Muramatsu Y, Ikemoto T, et al. Clinical results and complications of shoulder manipulation under ultrasound-guided cervical nerve root block for frozen shoulder: a retrospective observational study. Pain Ther 2019;8:111-20. https://doi.org/10.1007/s40122-018-0109-6.
19. Takahashi R, Kajita Y, Harada Y, Iwahori Y, Deie M. Clinical results of shoulder manipulation under ultrasound-guided cervical nerve root block for frozen shoulder in patients with diabetes. J Orthop 2020;21:297-301. https://doi.org/10.1016/j.jor.2020.03.019.
20. Takahashi R, Kajita Y, Harada Y, Iwahori Y, Miyashita N, Deie M. Does the timing of shoulder manipulation under ultrasound-guided cervical nerve root block for frozen shoulder affect the clinical outcome? J Orthop Sci 2022;27:122-5. https://doi.org/10.1016/j.jos.2020.11.002.
21. Thomas SJ, McDougall C, Brown ID, Jaberoo MC, Stearns A, Ashraf R, et al. Prevalence of symptoms and signs of shoulder problems in people with diabetes mellitus. J Shoulder Elbow Surg 2007;16:748-51. https://doi.org/10.1016/j.jse.2007.02.133.
22. Tsvieli O, Atoun E, Consigliere P, Polyzois I, Walecka J, Pradhan R, et al. Manipulation under anaesthetic for frozen shoulder using Codman's paradox: a safe and early return of function. Int Orthop 2018;42:339-44. https://doi.org/10.1007/s00264-017-3558-3.
23. Vastamaki H, Varjonen L, Vastamaki M. Optimal time for manipulation of frozen shoulder may be between 6 and 9 months. Scand J Surg 2015;104:260-6. https://doi.org/10.1177/1457496914566637.
24. Woods DA, Loganathan K. Recurrence of frozen shoulder after manipulation under anaesthetic (MUA): the results of repeating the MUA. Bone Joint J 2017;99-B:812-7. https://doi.org/10.1302/0301-620X.99B6.BJJ-2016-1133.R1.
25. Zreik NH, Malik RA, Charalambous CP. Adhesive capsulitis of the shoulder and diabetes: a meta-analysis of prevalence. Muscles Ligaments Tendons J 2016;6:26-34. https://doi.org/10.11138/mltj/2016.6.1.026.
26. Zuckerman JD, Rokito A. Frozen shoulder: a consensus definition. J Shoulder Elbow Surg 2011;20:322-5. https://doi.org/10.1016/j.jse.2010.07.008.