Translational manipulation under anesthesia for patients with frozen shoulder: a case series study with five-year health care utilization and post-manipulative arthroscopic findings

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ABSTRACT

Study Design: Case series study.

Objectives: Although there have been no reported complications from translational manipulation under anesthesia (tMUA) for individuals with adhesive capsulitis (AC) there are no cases reporting surgical findings post tMUA. Also, there are no studies evaluating health care utilization following tMUA. The purpose of this study was to: (1) report clinical outcomes following tMUA, (2) describe relevant health care costs and utilization following tMUA, and (3) summarize findings from two cases receiving joint arthroscopy following tMUA.

Methods: Fourteen Individuals with AC underwent tMUA. Range of motion (ROM) and Shoulder Pain and Disability Index (SPADI) values were collected at baseline and six weeks follow-up. Shoulder-related health care cost and utilization were analyzed for a five-year period following tMUA. Two additional patients with AC underwent tMUA followed by arthroscopic assessment for evidence of iatrogenic injury.

Results: Thirteen patients completed the six-week follow-up. Mean change scores for ROM and SPADI values were flexion; +38.5°, abduction; +71.1°, external rotation (shoulder abducted); +49.8°, internal rotation (shoulder abducted); +26.6°, SPADI scores; +44.4. 13 patient records were analyzed for health care utilization. Ten of the 13 patients utilized no additional shoulder-related health care. Surgical evaluation revealed no evidence of iatrogenic injury.

Discussion: Clinical outcomes were similar to previous studies. Utilization data indicated that for the majority of patients, little shoulder-related health care was utilized. Surgical evaluation provided further evidence that tMUA performed by a physical therapist is safe. Future research will be required to establish a causal relationship between tMUA and the results observed in this study.

Level of Evidence: Therapy, Level 4.

KEYWORDS

Adhesive capsulitis; frozen shoulder; glenohumeral; manipulation under anesthesia; manual therapy; health care utilization; physical therapy; health care cost

Introduction

Adhesive capsulitis (AC) or ‘frozen shoulder’ is characterized by pain and progressive loss of both active and passive shoulder range of motion (ROM) [1,2]. It has a prevalence of 2–5% in the general population and affects 11–38% of individuals with diabetes mellitus [1,3,4]. It is most common in individuals between the age of 40 and 60 years, with a higher prevalence observed in women [5].

AC is a disabling condition that has a negative impact on quality of life [6]. Individuals have difficulty performing activities of daily living (ADLs), experience high levels of pain and suffer from disturbed sleep [7]. AC’s effect on shoulder function can be severe, with some patients experiencing up to 80% loss of shoulder ROM [8].

Systematic reviews have concluded that despite the large number of studies, the ideal treatment approach for this diagnosis remains unknown [9–12]. Poor methodological quality is often cited as the primary reason for the author’s inability to draw firm conclusions from the available research [9,10,12].

The majority of patients diagnosed with AC will improve with conservative management [13–16]. However, there is a minority of patients that are refractory to treatment and for these individuals, MUA is often recommended [14,17–19]. In this procedure, the patient is placed under general anesthesia, with or without a regional brachial plexus block, and the glenohumeral joint is forcefully stretched into restricted physiologic motions such as flexion, abduction, adduction, and

external rotation [18,20,21]. The procedure is typically performed by an orthopedic surgeon [18,22,23]. Several observational studies have demonstrated good clinical outcomes with this procedure, however, the procedure is not without risk [5,17,18,22,24]. Glenohumeral dislocations, humeral fractures, nerve injuries, subscapularis tendon tears, and other iatrogenic injuries to the glenohumeral joint have been observed, which has led several authors to recommend against performing this procedure [20,25,26].

Roubal and Placzek developed a novel method for performing MUA that they termed 'translational manipulation under anesthesia' (tMUA) [27,28]. tMUA utilizes arthrokinematic joint gliding techniques commonly used by physical therapists to treat shoulder stiffness and hypomobility [28]. In this procedure, patients receive an interscalene brachial plexus block without general anesthesia [27,28]. The manipulation is carried out by grasping the proximal humerus close to the joint line and using translational (accessory) gliding to the humeral head parallel to the glenoid in multiple directions (i.e. caudal, posterior, anterior) to improve mobility [29]. Several studies have observed large short-term improvements in range of motion, pain, and shoulder function in individuals undergoing tMUA [27,28,30]. Only one study so far has reported long-term clinical outcomes [27]. Placzek et al, followed 31 patients receiving tMUA and observed improvements at 5 weeks that were maintained at 14 months [27]. To date, there are no studies that have reported health care utilization and/or expenditures following tMUA.

There have been no adverse events reported in the literature involving tMUA for AC [20,27–30]. However, there are no studies available reporting arthroscopic findings immediately following this procedure. Arthroscopy allows for direct visualization of the presence of any iatrogenic injury following MUA and is considered the gold standard for assessing shoulder pathology [25].

The purpose of this retrospective, descriptive study was threefold: (1) report short-term clinical outcomes from 14 patients with AC who underwent tMUA, (2) describe the subsequent health care utilization and costs related to their involved shoulder over a period of 5 years following tMUA, and (3) summarize arthroscopic findings from two individuals (separate from aforementioned 14 patients) who underwent joint arthroscopy immediately following tMUA.

Methods

Patients

Consecutive patients receiving treatment at the physical therapy department of Eglin Hospital, Eglin Air Base, FL with a diagnosis of AC between September, 2004 and March, 2006 were included in the case series. All tMUAs were performed by the senior author (BH), a

physical therapist. Patients were offered tMUA if they (1) had a diagnosis of AC and no contraindications to undergoing tMUA, (2) had experienced symptoms for at least three months, and (3) failed to improve following at least 6 weeks of conservative management. Conservative management consisted of analgesic medication as prescribed by their primary care provider and treatment by a physical therapist including manual therapy techniques, supervised range of motion exercises and home stretching exercises. Contraindications to undergoing tMUA include recent fracture, osteoporosis, prolonged steroid use, cancer, compromised cardiopulmonary status (relative contraindication to brachial plexus block), and inflammatory rheumatic disease [29].

Two surgical patients

Two additional patients (separate from aforementioned 14 patients) with AC underwent tMUA immediately prior to undergoing arthroscopic shoulder surgery by an orthopedic surgeon. Both patients were scheduled for arthroscopic shoulder procedures and the orthopedic surgeon requested the physical therapist perform a tMUA in conjunction with the surgery. We include these cases only to describe their operative findings immediately post tMUA. Their clinical outcomes are not presented.

Outcome measures

Clinical outcomes

For the 14 non-surgical patients receiving tMUA, glenohumeral passive ROM and Shoulder Pain and Disability Index (SPADI) scores were collected at baseline (one day prior to the procedure) and at 6-weeks.

Limited glenohumeral passive ROM has been identified as a key physical impairment in individuals with AC [15]. The following passive ROM measurements were collected for each patient using a standard arm goniometer as described by Norkin and White: flexion, abduction, external rotation with the arm at the side and internal and external rotation with the arm abducted to 90° [31]. If the patient did not have 90° of passive abduction ROM, the arm was abducted to the available range and internal/external ROM were measured from this position.

The SPADI is a self-administered questionnaire, which measures pain and disability related to shoulder disorders [32]. It is scored from 0 to 100 with lower scores reflecting lower levels of pain/disability [32]. It is commonly used in studies involving patients with AC [30,33,34] and has been shown to have adequate construct validity in this population [35]. The SPADI has also shown good to excellent test-retest reliability and responsiveness in populations with AC [32,36,37]. The instrument has a minimally important clinical difference (MCID) of between 8 and 13 points [37].

Surgical outcomes

The two shoulders that were treated with tMUA immediately prior to surgery were evaluated with diagnostic arthroscopy. Both shoulders were inspected arthroscopically for the presence and location of intra-articular pathology and for any evidence of iatrogenic injuries sustained during the tMUA procedure. These patients were included in this report because they provided a unique opportunity to describe intra-articular findings immediately post-tMUA.

Health care utilization and costs

We were interested in determining the amount and type of shoulder health care that these patients utilized following the tMUA procedure. The Defense Health Agency manages a claims database to facilitate this through the Military Health System Data Repository (MDR), a centralized database that archives, manages, and validates health care data from over 260 health care facilities and non-DoD data sources worldwide. We requested the following health care utilization elements associated with shoulder ICD-9 diagnosis codes (Appendix A in Supplemental data): visits to orthopedics (OR), primary care (PC), and physical therapy (PT), additional shoulder surgeries and costs for all shoulder-related medical care. Health care costs related to the involved shoulder were abstracted as the total cost of the encounter to the payer (Tricare), regardless of whether the care occurred in a Military Treatment Facility or in the civilian network. Cost totals were calculated from shoulder related visits with the health care provider (OR, PC, PT), procedures, imaging studies, and prescription medications. We categorized all care as occurring within three different time periods: 0 to 12 weeks, 13 weeks to 1 year, and 2 years to 5 years following the date of the tMUA. Shoulder diagnosis codes as defined by the International Classification, Ninth Revision, Clinical Modification (ICD9) were used to identify shoulder related care received. A list of the ICD9 codes used for this analysis can be found in Appendix A (Supplemental data). If it was not clear from the MDR data that the care was for the shoulder that underwent the tMUA procedure, we manually cross-checked the encounter in the electronic medical record to ensure all care described was for the correct shoulder.

Description of procedures

The procedure used to treat the 14 patients who received tMUA (excluding the 2 surgical cases) was adapted from protocols described by Placzek et al. and Boyles et al. [29,30]. The treatment may be divided into three stages: a pre-manipulative management, translational manipulation under anesthesia (tMUA), and post-manipulation management.

Pre-manipulation procedures

Patients received shoulder x-rays (if none in the previous 6 months) to rule out competing diagnoses (e.g.

severe osteoarthritis) and to identify any presence of severe osteoporosis. Patients then met with an orthopedic surgeon, underwent a clinical evaluation and were prescribed a six-day course of oral corticosteroids (methylprednisolone 4 mg six-day dose-pack) to begin the day prior to the tMUA. All patients also met with an anesthesia provider to ensure they were appropriate to undergo the regional interscalene brachial plexus block.

Manipulative procedures

All patients received an interscalene brachial plexus block administered by an anesthesia provider. The anesthesia, as well as the manipulative procedures, were delivered in the post-anesthesia care unit (PACU) of the hospital. After the administration of the brachial plexus block, the clinician (BH) again evaluated the patient's glenohumeral passive range of motion to assess whether the lack of shoulder mobility was truly from AC and not the result of muscle guarding. If the limited shoulder mobility was indeed from AC, the tMUA procedure was performed. See Appendix B in Supplemental data for a detailed description of the manipulative procedures (have also included video instructions for online content).

Post-manipulative procedures

Following the tMUA, patients were released from the hospital with instructions for exercises and ice application for the first 24 hours following the procedure. As soon as they regained motor and sensory function of their involved extremity (typically within 8–12 hours), they were instructed to perform shoulder pendulum exercises (see Appendix C in Supplemental data) and elevation active assisted range of motion (AAROM) exercises for 10 minutes every 2 hours (unless sleeping) followed by application of ice to their shoulder for 20 minutes. All patients followed up with the physical therapist 24 hours after the procedure and received gentle manual therapy interventions directed toward movement impairments, followed by application of ice with the goal of controlling pain and maintaining the mobility improvements achieved during the tMUA. Patients attended follow-up sessions with the physical therapist for three consecutive days during the first week. After this, patients attended three visits per week for four to five weeks. All patients were given a standardized protocol of AAROM exercises to be performed at home three times per day (see Appendix C in Supplemental data). In-clinic interventions were not standardized but adhered to the following general guidelines. Patients initially were treated with gentle or low-grade glenohumeral joint mobilization and stretching techniques followed by ice application for the first six to seven days. As pain levels improved, an impairment-based, regional approach was utilized to address the specific strength and mobility deficits identified in the shoulder, ribcage, cervical, and thoracic spine regions during follow-up evaluations.

Table 1. Demographics of patients in case series.

Patient	Gender	Age (y)	Symptom duration (mo)	Primary or secondary	Co-morbidities
1	F	52	6	Primary	Depression, Hyperlipidemia, Insomnia
2	M	40	3	Secondary ^a	None
3	M	56	9	Primary	Diabetes
4	F	51	6	Primary	Hypothyroidism
5	F	60	12	Primary	Hypertension
6	F	55	4	Secondary ^b	Anxiety Disorder, Hypothyroidism, Obesity, Diabetes Mellitus, Hyperlipidemia, Osteoporosis
7	F	52	6	Primary	Hyperlipidemia, Depression, Diabetes Mellitus, Obesity,
8	M	53	12	Primary	Hypertension, Obesity, Transverse Myelitis
9	F	56	9	Primary	Depression, Hypertension, Diabetes Mellitus
10	F	46	3	Primary	Hyperlipidemia, Smoking
11	F	53	12	Primary	Hypothyroidism, Hypertension, Hyperlipidemia, Smoking
12	F	43	6	Primary	Chronic pain, Hypertension, Hyperlipidemia, Osteoporosis
13	F	45	8	Primary	Cervical Stenosis
14	F	50	6	Primary	Insomnia, Smoking

Abbreviations: y, years; mo, month.

^aDeveloped AC following shoulder surgery (sub-acromial decompression).

^bDeveloped AC following proximal humerus fracture.

Table 2. Mean passive ROM and SPADI scores at baseline and six-week follow-up.

	Baseline	6 weeks	Change score***
SPADI*	67.8 ± 16.0 (34–89)	23.3 ± 19.6 (1–65)	44.4 (31.8, 57.1)
Flexion PROM**	124.3 ± 7.9 (112–135)	162.8 ± 4.8 (155–174)	38.5 (33.0, 44.0)
Abduction PROM	89.5 ± 12 (75–110)	160.6 ± 9.0 (140–170)	71.1 (60.0, 82.2)
External Rotation (SA) PROM	29.0 ± 10.6 (0–45)	78.8 ± 10.9 (61–100)	49.8 (38.5, 61.1)
Internal Rotation (SA) PROM	39.0 ± 13.0 (10–62)	65.6 ± 15.0 (35–90)	26.6 (21.4, 31.8)
External Rotation (ntrl) PROM	29.2 ± 11.2 (0–42)	62.5 ± 11.4 (35–80)	33.3 (26.5, 40.1)

Abbreviations: SPADI, Shoulder Pain and Disability Index; PROM, passive range of motion; SA, shoulder abduction; ntrl, neutral.

*Values are mean ± SD (range). Scale is from 0–100, with 0 representing no pain and no disability; **Values are mean degrees ± SD (range); ***Values are mean change score (95% CI) from baseline to 6-weeks.

Description of procedures for two surgical patients

The same manipulative techniques used for the 14 case series patients were used for the two surgical patients. Both patients received general anesthesia as well as a regional interscalene block. After the anesthesia was administered, the physical therapist came to the operating room and performed the tMUA. Following the tMUA, the surgeon then immediately performed a diagnostic glenohumeral arthroscopy and assessed the joint for any iatrogenic injuries sustained during the tMUA. Following this assessment, the surgeon proceeded with the scheduled operative procedure as indicated.

Data analysis

Statistical analysis was conducted using SPSS, version 18.0. Descriptive statistics were used to observe the passive ROM values and SPADI scores at baseline and six weeks. Change scores and 95% confidence intervals (CIs) were also calculated. Health care utilization was reported as frequency counts for each service visit to physical therapy (PT), orthopedics (OR), or primary care (PC) for the five-year period following the date of the tMUA, categorized by individual patient. Health care cost was reported as observed total cost of shoulder-related care for each service for the five-year period, categorized by individual patient.

Results

Clinical outcomes and health care cost and utilization from patients treated with tMUA

Fourteen patients (11 females), with a mean age of 51 (range 40–60) were originally included in this case series study. Twelve patients had a diagnosis of primary AC and two with secondary AC. One patient did not complete the six-week evaluation (#14) and therefore no clinical outcomes (SPADI, ROM) were collected for this individual. However, this patient's records are included in the five-year review of health care cost expenditures and utilization. One patient (#3) passed away five months following the tMUA procedure (as a complication of cardiovascular disease) and therefore their health care costs expenditures and utilization data were not available and are not included. Demographic information, including comorbidities, for each patient is included in Table 1.

Table 2 shows the mean values, SDs, range of scores and mean change scores (with 95% confidence intervals) for passive ROM and SPADI scores at baseline and 6-weeks.

The number of visits to OR, PC, and PT in the three time periods following the tMUA are presented in Figure 1. Health care costs associated with these visits are presented in Figure 2, separated by the three time periods. Three patients had higher visits and cost totals in the second period (patient #7 and #10) and third period

Figure 1. Orthopaedic, physical therapy and primary care health care visits for each patient 0–5 years following translational manipulation under anesthesia. Five year timeframe broken down into 3 periods: 0–12 wk, 13–52 wk and 2–5 yr. Patient 7 (see *) graph separated to accommodate for higher totals on y-axis. Source: Results from Arthroscopic Visualization Post tMUA. Abbreviations: wk, week; yr, year; PC, primary care; PT, physical therapy; Ortho, orthopaedic.

Figure 2. Orthopaedic, physical therapy and primary care health care costs for each patient 0–5 years following translational manipulation under anesthesia. Five year timeframe broken down into 3 periods: 0–12 wk, 13–52 wk and 2–5 yr. Patient 7 (see *) graph separated to accommodate for higher totals on y-axis. Source: Results from Arthroscopic Visualization Post tMUA. Abbreviations: wk, week; yr, year; PC, primary care; PT, physical therapy; Ortho, orthopaedic.

(patient #1 and #7). The medical records for these three patients were reviewed to obtain details regarding their care and to ensure it was for the same shoulder treated with tMUA. Patient #1 had one PC visit and a course of

PT encounters (9 visits) for subacromial impingement syndrome (SIS) in period 3, 14 months after the tMUA. Patient #10 had arthroscopic shoulder surgery (subacromial decompression) for SIS 7 months following the

Figure 3. Image obtained during diagnostic arthroscopy of patient #1 immediately following tMUA and immediately prior to arthroscopic labral repair.

Notes: The arrow is pointing to a capsular tear, likely incurred during the tMUA. The anterior/inferior labrum was not damaged. Note the red, hyperemic appearance of the tissue indicating general synovitis.

Figure 4. Image obtained during diagnostic arthroscopy of patient #2 immediately following tMUA and immediately prior to arthroscopic lysis of adhesions.

Note: The arrow is pointing to mature scar tissue that had formed a 'veil' over the humeral head.

tMUA and had a course of PT and OR visits following this. Patient #7 had a complicated course of care following the tMUA procedure. She underwent an initial tMUA in April, 2005, followed by a repeat tMUA in November 2005 at the request of her orthopedic surgeon. She then had arthroscopic lysis of adhesions in December, 2005. Shortly after this surgery, in January, 2006, she suffered a fall, landing on her involved shoulder. This surgery failed to resolve her symptoms and in February 2007 she underwent a shoulder hemiarthroplasty. In February 2008, she had another arthroscopic surgery with lysis of adhesions. This ultimately failed to produce desired results and in October, 2008 she underwent a reverse hemiarthroplasty and total shoulder arthroplasty.

Surgical findings from arthroscopic visualization post tMUA

Surgical patient #1

The first patient was a 42-year-old male with diabetes mellitus who was scheduled to have surgery to repair a detached anterior and superior labrum. However, prior to his surgical date he developed AC and therefore the surgeon requested that a tMUA be performed in conjunction with the surgery. At the time of his surgery and tMUA procedure, he had been suffering from AC for eight months. Following the tMUA, the surgeon initially conducted an examination with the patient under anesthesia followed by a diagnostic glenohumeral arthroscopy. The shoulder was found to have excellent return of motion with no pathologic laxity noted. The diagnostic arthroscopy confirmed the preoperative diagnosis of a labral lesion, with the labrum detached anteriorly and superiorly (Figure 3). Additionally, scar tissue was noted in the anterior and posterior shoulder capsule which was removed with a shaver and electrocautery. Prior to performing the scheduled labral repair, the joint structures were carefully inspected for the presence of any iatrogenic injuries incurred during the tMUA; none were found. The glenoid and humeral surfaces were pristine without evidence of cartilaginous wear. The biceps tendon and rotator cuff were found to be without tears. The posterior labrum was found to be intact and without compromise. The labral repair was then performed and the patient had an uncomplicated post-operative course, making a full recovery of shoulder function.

Surgical patient #2

The second patient was a 42-year-old female who had developed secondary AC following a humeral neck fracture 14 months previously. She was scheduled for a diagnostic arthroscopy surgery with lysis of adhesions. Again, the surgeon requested that we perform a tMUA in conjunction with the surgery. Immediately following the tMUA, the surgeon examined the shoulder and conducted a diagnostic arthroscopy. The glenohumeral joint was found to have mature scar tissue throughout (Figure 4). As with surgical patient #1, there were no iatrogenic injuries observed to any structures in the shoulder. The rotator cuff and biceps tendons, glenoid, labrum, and humeral surfaces were found to be in perfect condition. Range of motion had improved, but full motion had not been restored. Because of this, the surgeon elected to continue with the scheduled lysis of adhesions. The patient had an uncomplicated course of rehab and made a full recovery of shoulder function.

Discussion

This observational case series study showed large improvements in passive ROM and SPADI scores for each of the 13 patients who completed the 6 week follow up.

The mean change in SPADI scores exceeded the MCID for this instrument [37]. These improvements in shoulder function and disability are consistent with previous studies and add to the growing number of published cases showing rapid improvements in clinical outcomes for individuals with AC that has been previously refractory to treatment [27,30].

To our knowledge, the five-year data presented here are the first long-term health care cost and utilization outcomes reported for patients with AC. Identifying differences in costs and resource utilization between distinct treatment approaches has been cited as a research priority for this population [7,38]. We believe our results could help inform the design of future studies, with larger cohorts of patients, using cost effectiveness and health care utilization as outcomes.

Because of the small sample size, lack of comparison group, and the fact that these data were collected retrospectively, we are limited in our ability to draw any causal conclusions. However, we believe several aspects of this health care utilization analysis warrant further discussion. For 10 of the 13 patients, no subsequent care was observed following the initial course of rehabilitation after the tMUA. This suggests that for these patients, the positive results observed in the weeks following the procedure may have been maintained over the ensuing five-years. Two of the patients (#1 and #10) developed subacromial pain syndrome in the ipsilateral shoulder relatively early following the resolution of AC. Both of these patients received a course of treatment and did not require further care for their shoulder over the remainder of the five-year observational period. There was one patient (#7) that utilized a large amount of long-term shoulder-related health care following the tMUA. She had many subsequent orthopedic procedures that were associated with numerous PT and PC visits as well. In total, following the initial tMUA procedure, patient #7 had 160 shoulder related visits at a cost of \$79,474, which greatly exceeded the combined shoulder-related cost for the care of the other 12 patients. The total combined shoulder-related health care costs for the remaining 13 patients over the 5-year period was \$37,960 (217 visits), with an average of \$3,163 per patient.

Several authors have cited the safety of the procedure itself as a reason tMUA should be considered for individuals with AC [29,30]. There have been more than 50 published cases of the use of tMUA, and no adverse events have been reported [27,28,30,39]. This is in contrast to multiple reports of iatrogenic injuries sustained during traditional MUA [20,25]. However, comparison between the two approaches has not been possible because studies have only reported arthroscopic findings following traditional MUA, and no such reports exist for tMUA. To our knowledge, the descriptions presented here of arthroscopic findings immediately following tMUA are the first of their kind. And while firm conclusions

regarding the safety of tMUA cannot be drawn from only two surgical cases, we feel several of the arthroscopic findings warrant discussion.

Surgical Patient #1 had evidence of tearing of the anterior/inferior glenohumeral capsule adjacent to, but not extending to the glenoid labrum. This capsular tearing is an expected occurrence during tMUA and is not considered pathological [25,40]. Loew observed in several patients that the capsular tears resulting from MUA occurred adjacent to the labrum, running from anterior to inferior, toward the capsular pouch [25]. This is the precise location that an arthroscopic capsular release is performed [25]. The capsular tear observed in surgical patient #1 was also in this same location. Future studies will be required to determine the typical patterns of capsular tearing and associated clinical relevance in tMUA versus arthroscopic, traditional MUA or other interventions such as hydrodilatation [41].

For surgical patient #2, despite several trials of the manipulative techniques, only minor improvements in passive range of motion were seen immediately following the tMUA. Arthroscopic examination immediately following tMUA did not reveal capsular tearing. There was thickened, mature scar tissue evident throughout the joint capsule. It is possible there are certain patients with AC that have capsular changes that are less amenable to tMUA and would achieve superior results with arthroscopy or another intervention. Future research could potentially explore potential relationships between arthroscopic findings and success with the tMUA procedure.

A primary concern surrounding forceful manipulation of the shoulder joint is the risk of injury to intra-articular or periarticular structures [20,25]. Surgical evaluation of both patients described in this report found no evidence of iatrogenic injuries sustained during the tMUA. While this is encouraging and adds to the growing body of evidence suggesting tMUA performed by a physical therapist is a safe procedure, future studies could go further to investigate intra-articular findings in the joint following tMUA.

There are two additional weaknesses to this study that have not been stated. First, the same individual conducted all of the tMUA procedures as well as the rehabilitation following the procedures. This may limit the generalizability of the findings. Second, because the treating clinician was aware that the surgical patients would be evaluated arthroscopically after the tMUA, he may have been inclined to alter the technique (i.e. reduce forces used) to limit the chance of injury.

Conclusion

The short-term clinical outcomes observed in this case series study add to the growing body of research that indicates tMUA performed by a physical therapist can result in rapid improvements in pain and shoulder

function in individuals suffering from AC [27,28,30,39]. Five-year health care cost and utilization data indicate that for the majority of patients who received tMUA in this case series study, very little shoulder-related health care was utilized once the initial course of rehabilitation was completed. Therefore, tMUA may be a viable treatment option for patients with AC not only due to the excellent clinical outcomes achieved but also because of the decreased long-term health care resources utilized afterwards. Surgical findings immediately following tMUA in two patients provide additional evidence that tMUA is a safe technique. Future research, in the form of randomized controlled trials will be required to establish whether a true cause and effect relationship exists between tMUA and the results observed in these patients.

Ethics approval

The Madigan Army Medical Center Institutional Review Board/Ethics Committee approved this study.

Disclosure statement

No potential conflict of interest was reported by the authors.

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