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Glenoid microfracture in active-duty military patients: minimum 5-year follow-up demonstrates 75% survival

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Background: To present midterm patient-reported outcomes and survivorship data of active-duty military patients undergoing microfracture for full-thickness cartilage defects of the glenoid.
Methods: All consecutive patients from January 2013 through December 2016 who underwent glenoid microfracture for full-thickness cartilage injuries with complete outcome scores were identified. Twenty patients met the final inclusion criteria for the study, and all were active-duty military at the time of surgery. A separate subgroup analysis was performed to determine if dominant-shoulder involvement portends worse outcomes.
Results: The mean follow-up was 81.45 ± 19.43 months (range, 60-108). Of the 20 patients, 5 required a secondary surgical procedure within 5 years of their index procedure, with an average time to failure of 45.6 ± 13.15 months. For the 15 patients who did not fail, there was a statistically significant increase in the mean American Shoulder and Elbow Surgeons score (57.20 vs. 88.27, $P < .0001$) and Single Assessment Numeric Evaluation (45.00 vs. 86.33, $P < .0001$). Mean pain decreased significantly as measured by the pain visual analog scale (5.40 vs. 1.37, $P < .0001$). Range of motion in forward elevation, external rotation, and internal rotation did not change significantly postoperatively ($P = .4528$, .4810, and .1919, respectively). Concomitant procedures did not predict changes in pain, American Shoulder and Elbow Surgeons, or Single Assessment Numeric Evaluation scores. A majority of patients (13/20, 65%) were able to remain on unrestricted military active-duty service, but 7 (35%) underwent medical discharge, including the 5 patients who had experienced treatment failure, plus 2 additional patients.
Conclusion: Glenoid microfracture can result in pain relief and symptomatic improvement for a select group of active-duty military patients, with 75% survivorship at 5 years. Approximately one in three (35%) patients, however, were unable to remain on active-duty military service.

Active-duty service members experience shoulder pain and dysfunction at rates that far outpace those observed among civilian patients.[2,14,15,23,24,26,39,45,47,55,57,59] While the physical demands of active-duty service are classically associated with the development of glenohumeral instability and superior labral tears, ongoing research continues to identify additional forms of glenohumeral pathology that these patients are at risk of developing.[11,21,24,37,41,44,55] Specifically, the combination of high demand placed on the glenohumeral joint by service members coupled with the institutional inability to fully curtail this demand creates an environment ripe for the development of chondral injury and subsequent osteoarthritis.[6,10,25,42,49]

Optimal management of isolated glenohumeral chondral injuries in young, active patients remains controversial.[20,35,46,49,52,56] Oftentimes unable or unwilling to limit physical demands on the shoulder, arthroplasty remains a less than ideal solution for painful early degenerative changes in younger patients.[7,10,12,29] Furthermore, it has been reported that young active-duty patients face a high rate of persistent limitations and subsequent discharge from active-duty service following shoulder arthroplasty.[29] While

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This study was performed at Carthage Area Hospital.

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cartilage transplantation or autologous chondrocyte implantation has been proven to be efficacious in other joints, there is a lack of high-quality comparative supportive evidence in the setting of glenoid lesions.[10,20,33,49]

Microfracture and other forms of marrow stimulation surgery have gained popularity as an acceptable first-line treatment for young patients with symptomatic chondral lesions of the glenoid.[16,35,46,56] Through the release of multipotent stem cells via perforation of subchondral bone, microfracture allows generation of a stable fibrocartilage patch in an area of cartilage injury.[17,53,54] While short-term results have been promising, long-term outcome studies raise concern for a high risk of reoperation or treatment failure.[16,35,56] Despite these risks, there exists a select group of patients who benefit greatly from this procedure and are able to return to sport and activity following microfracture. The utility of this procedure in military patients wishing to remain on active-duty service, however, is unknown.

The primary purpose of this study is to present midterm patient-reported outcomes and survivorship data of active-duty military patients undergoing microfracture for full-thickness cartilage defects of the glenoid. The secondary purpose is to determine if dominant arm involvement affects outcomes. We hypothesize that glenoid microfracture produces substantial improvements in patient-reported outcome measures (PROMs), with a majority of patients able to both remain on active-duty service and avoid secondary surgical procedures. Additionally, we hypothesize that involvement of the dominant extremity portends worse clinical outcomes.

Methods

This study is a retrospective analysis of active-duty military patients under the age of 50 who underwent glenoid microfracture between January 2013 and December 2016. Data were collected upon enrollment in a prospective research database throughout the course of treatment and assessed retrospectively. Institutional review board approval was obtained prior to beginning the study.

Patient population

Inclusion criteria encompassed active-duty military patients over the age of 18 and under the age of 50 who underwent glenoid microfracture for a painful, full-thickness glenoid chondral lesion. All patients were treated at a single institution serving a single military base. All patients had a minimum of 5 years of follow-up with complete outcomes scores both preoperatively and postoperatively at last follow-up appointment. Excluded from this study were patients younger than 18 or older than 50, patients with a history of ipsilateral shoulder surgery, patients undergoing either concomitant labral repair or rotator cuff repair, patients with Outerbridge 0 – III injuries, and patients with less than 5 years of follow-up.[38]

All patients had activity-related pain as their primary chief complaint and noted pain severe enough to interfere with both their military duty requirements and activities of daily living. Prior to being considered for surgery, all patients had failed at least 3 months of conservative treatment including anti-inflammatory medications, physical therapy, home exercise, and limited-duty profiling. All patients underwent preoperative magnetic resonance arthrogram, which was reviewed retrospectively by the operating surgeon in conjunction with arthroscopic images and operative reports.

Patient age, sex, laterality, and military occupation were obtained in addition to outcome measures including the American Shoulder and Elbow Surgeons (ASES) score and the Single Assessment Numeric Evaluation (SANE). Additional outcomes collected included pain as measured by the pain visual analog scale (VAS), active range of motion (ROM) in forward elevation, external rotation (ER) and internal rotation (IR), complications, and active-duty status.[28,30] Outcome measures are collected as part of standard of care at all patient visits and were obtained by the treating surgeon. ROM in forward elevation and ER were measured with a goniometer and IR was measured by determining the highest spinal level to which the patient could place the dorsum of the hand. Complications and return to active duty were also collected routinely as part of the postoperative evaluation. Patients with subjective military duty limitations were classified as failure to return to active duty.

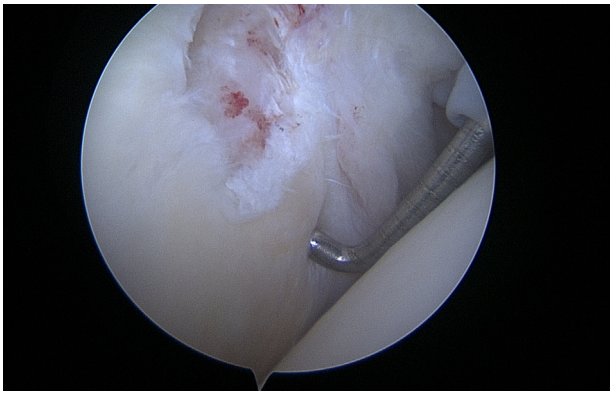

Figure 1 Right shoulder of a 32-year-old male with an 8.0 × 14.0 mm full-thickness glenoid osteochondral defect, as viewed from the posterior viewing portal.

Surgical technique

Patients were positioned in a modified beach chair position following administration of general anesthesia and a presurgical interscalene block. A Spider hydraulic arm holder (Smith & Nephew, Andover, MA, USA) was then employed to stabilize the operative shoulder and the patient was draped. Complete diagnostic arthroscopy of the glenohumeral joint was performed and the chondral lesion was identified (Fig. 1). Concomitant procedures frequently including arthroscopic biceps tenodesis (ABT), arthroscopic-assisted sub-pectoral biceps tenodesis, and arthroscopic acromioclavicular joint resection arthroplasty were performed (Table I). Following the completion of concomitant intra-articular procedures, the loose cartilage and chondral flaps abutting the defect were débrided with an arthroscopic shaver, ring curette and/or arthroscopic biter. Once the lesion was well-contained, a ring curette was utilized to create vertical walls circumferentially around the defect. We then proceeded to débride the layer of calcified cartilage with a curette, ensuring to not violate the subchondral bone. A microfracture awl was then used to penetrate the subchondral bone to the depth of the awl tip (approximately 3 – 4 mm), with the holes spaced approximately 3 – 4 mm apart (Fig. 2). Once complete, arthroscope inflow was terminated in order to ensure that there was appropriate defect fill with bone marrow elements (Fig. 3).

Postoperative rehabilitation

Patients were discharged home the same day of their procedure. All patients were instructed to begin pendulum shoulder movement once the interscalene nerve block had worn off. Narcotic pain medications were prescribed for up to

Table I
Preoperative/Intraoperative patient characteristics.

	Total (N = 20)
Age, y, mean ± SD (range)	38.85 ± 9.17 (22-50)
Follow-up, mo, mean ± SD (range)	81.45 ± 19.43 (60-108)
Male, N (%)	19 (95.00%)
Combat arms, N (%)*	15 (75.00%)
Dominant shoulder involvement, N (%)	12 (60.00%)
History of a traumatic event, N (%)	10 (50.00%)
MRI evidence of chondral injury, N (%)	8 (40.00%)
Time to surgery from symptom onset, mo, mean ± SD	31.65 ± 51.73
Surgical time, min, mean ± SD	64.70 ± 16.46
Glenoid lesion area, cm^2, mean ± SD	2.17 ± 1.15
Concomitant procedures	
ASAD, N (%)	20 (100.00%)
ABT, N (%)	6 (30.00%)
AASPBT, N (%)	5 (25.00%)
ASB, N (%)	4 (20.00%)
Débridement of humeral head osteochondral defect, N (%) (average size 1.75 ± 1.5 cm^2)	4 (20.00%)

ASAD, arthroscopic subacromial decompression; *ABT*, arthroscopic biceps tenodesis; *AASPBT*, arthroscopic-assisted sub-pectoral biceps tenodesis; *ASB*, arthroscopic subacromial bursectomy; *ADHH*, arthroscopic débridement of the humeral head; *SD*, standard deviation; *MRI*, magnetic resonance imaging.

*Defined as patients whose military duties require regular high-demand physical readiness training, manipulation of firearms, moving across uneven terrain and obstacles with heavy loads, hand to hand combat training and other warfighting tasks (ie infantry, artillery, military police).

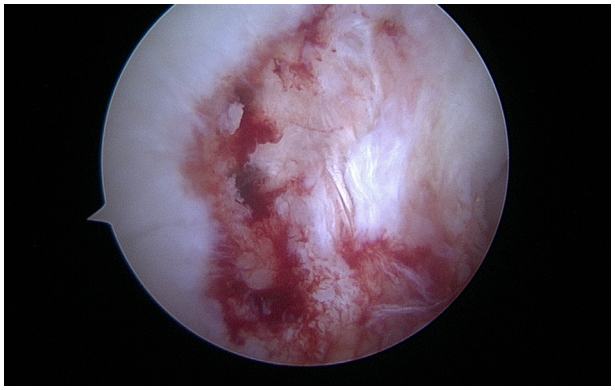

Figure 2 The same patient from Figure 1, following lesion preparation and microfracture.

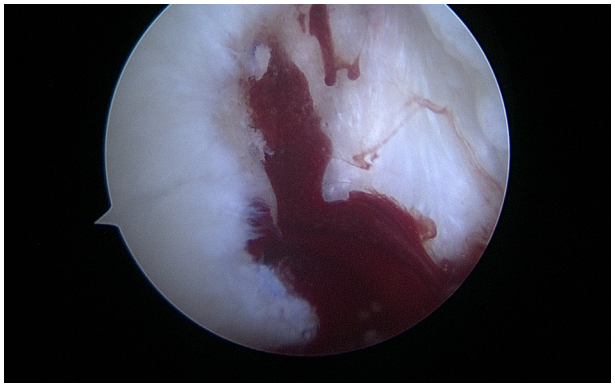

Figure 3 Inflow from the pump has been shut off to allow for visualization of lesion fill with bone marrow contents.

10 days postoperatively. Patients were given a sling for comfort for the first 2-4 weeks. Passive ROM was permitted and encouraged immediately after surgery, with rapid progression to active-assist and active ROM as tolerated. All patients attended physiotherapy at the same military physical therapy group and followed the same protocol, although the treating therapist or therapist aide did vary from patient to patient. Light strengthening was permitted at 6 weeks postoperatively, pending restoration of ROM, and unrestricted strengthening was permitted at 12 weeks postoperatively. Return to unrestricted activity was allowed at 4 months postoperatively after the patient was cleared by physical therapy and the patient reported subjective readiness to return to full duty. For 3 months after surgery, patients were placed on a limited duty profile to decrease the occupational physical requirements characteristic of their work and were restricted from participating in the army physical fitness test for an additional 3 months. Treatment failure was defined as continued pain with inability to return to unrestricted active duty.

Statistical analysis

Statistical analysis was conducted using IBM SPSS Statistics, version 25.0 (IBM Corp, Armonk, NY, USA) and GraphPad Prism, version 9.0.0 (GraphPad Software, San Diego, CA, USA). As clinical significance thresholds following glenoid microfracture have not been determined, previously published values for the minimal clinically important difference (MCID), substantial clinical benefit (SCB), and patient acceptable symptomatic state (PASS) following shoulder arthroplasty were used. Similarly, previously published values for maximum orthopedic improvement (MOI) for the SANE and ASES following arthroscopic rotator cuff repair were used in lieu of microfracture specific metrics.[4,19,50,51] Continuous data were described by a combination of mean, standard deviation, range, and 95% confidence interval (CI). A paired t-test was used to compare the differences between the preoperative and postoperative results. Chi-square was used to analyze categorical variables. A separate subgroup analysis was performed to determine if outcomes differed between dominant and nondominant arm involvement. Multiple linear regression was used to identify relationships between the presence of concomitant procedures and outcome variables. Statistical significance was set at $P < .05$ in all cases.

Results

During the study period, the senior surgeon performed microfracture on 46 patients with grade IV glenoid lesions. Twenty patients underwent concomitant labral repair for anterior, posterior or combined instability, 3 patients underwent concomitant rotator cuff repair and 3 patients could not be reached for follow-up, leaving a total of 20 patients with a mean follow-up of 81.45 ± 19.43 months available for analysis (Table I, Fig. 4). A majority of patients were male and in a combat arms military occupation specialty, with an average age of 38.85 years. The average size of the glenoid defect was 2.17 ± 1.15 cm^2. Concomitant procedures performed can be seen in Table I.

Five patients progressed to failure at the time of final follow-up and therefore were excluded from outcome score and arm-dominance subgroup analysis. In the remaining patients, there were significant improvements in all PROMs at the final follow-up. At minimum 5 years of follow-up, mean pain as measured by the pain VAS decreased, while shoulder function, as measured by the SANE and ASES, increased (P value < .0001, respectively). There was no significant change in ROM (Table II). A majority of patients met the MCID and achieved the PASS as measured by the pain VAS, SANE, and ASES scores (Table III). Furthermore, a majority of patients achieved SCB as determined by pain VAS and ASES scores. In

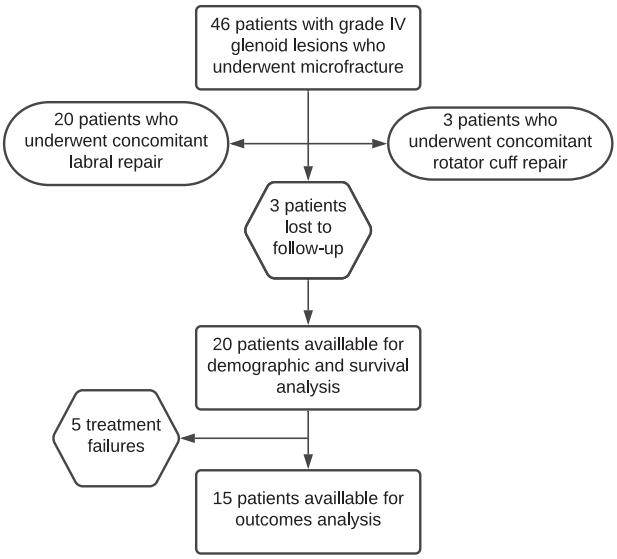

Figure 4 Flowchart of patient inclusion.

the patients who achieved survival, MOI was reached by 66.67% of patients as determined by the SANE and 53.33% as determined by the ASES score. Although patients who underwent surgery on their nondominant shoulder had lower pain and higher outcome scores at final follow-up, these differences did not vary significantly (Table IV).

All patients underwent concomitant arthroscopic subacromial decompression (ASAD). Concomitant procedures included ABT, arthroscopic-assisted sub-pectoral biceps tenodesis, arthroscopic subacromial bursectomy, and arthroscopic débridement of the humeral head (ADHH). As a whole, concomitant procedures were not significantly related to net changes in pain VAS, SANE, and ASES scores as well as forward flexion (FF), ER, and IR measurements (VAS: $R^2 = 0.2454$, $F(4,10) = 0.8130$, $P = .5449$; SANE: $R^2 = 0.1287$, $F(4,10) = 0.3693$, $P = .8253$; ASES: $R^2 = 0.1245$, $F(4,10) = 0.3555$, $P = .8346$; FF: $R^2 = 0.3152$, $F(4,10) = 1.151$, $P = .3880$; ER: $R^2 = 0.04396$, $F(4,10) = 0.1149$, $P = .9743$; IR: $R^2 = 0.1718$, $F(4,10) = 0.5185$, $P = .7244$). Similarly, concomitant procedures were not significantly related to final pain VAS, SANE, and ASES scores or ER and IR measurements (VAS: $R^2 = 0.4104$, $F(4,10) = 1.740$, $P = .2174$; SANE: $R^2 = 0.4810$, $F(4,10) = 2.317$, $P = .1282$; ASES: $R^2 = 0.4565$, $F(4,10) = 2.100$, $P = .1557$; ER: $R^2 = 0.2661$, $F(4,10) = 0.9064$, $P = .4962$; IR: $R^2 = 0.1718$, $F(4,10) = 0.5185$, $P = .7244$). The overall regression for FF was statistically significant ($R^2 = 0.8902$, $F(4,10) = 20.27$, $P < .001$) with the presence of ABT and ADHH predicting significantly lower FF (ABT: $\beta = -6.560$, CI $= -9.096$ to -4.025, $P = .0002$; ADHH: $\beta = -4.769$, CI $= -7.715$ to -1.824, $P = .0048$).

There was no instance of postoperative infection or nerve injury. Survivorship was 100% at 1 year postoperative, 85% at 3 years postoperative, and 75% at 5 years postoperative follow-up (Table V). The average time to treatment failure was 45.6 ± 13.15 months postoperative. All 5 (25%) patients who failed went on to undergo additional surgery: 4 underwent comprehensive arthroscopic management (CAM), and 1 underwent an anatomic total shoulder arthroplasty.[34] At most recent follow-up, 13/20 (65%) of patients remained on active-duty with no limitations or permanent profile required to substantiate continuous occupational limitations. Of the 7 who could not remain on active duty, 5 experienced treatment failure, and 2 had persistent activity-limiting pain inconsistent with continued active-duty service.

Discussion

Glenoid microfracture offers a potentially attractive treatment option for symptomatic Grade IV chondral lesions not responding to physical therapy in a young, active-duty military population as it enables patients to remain on unrestricted active-duty. The primary conclusion of our study is that outcomes and survivorship following microfracture in military patients is consistent with published reports of this procedure in civilian patients; that is, a majority of patients who did not fail treatment experienced statistically and clinically significant improvements in PROMs, decreases in pain, and high rates of return to unrestricted active-duty military service.[16,35,56] In addition, it does not appear that dominant arm involvement is associated with worse PROMs. In line with civilian patient survivorship data, however, 5 (25%) patients experienced treatment failure at mean 45.6 ± 13.15 months postoperatively.[56]

While the exact incidence of glenohumeral chondral lesions is unknown, they are not uncommon findings during diagnostic arthroscopy, with a variety of etiologies implicated in the pathogenesis of these lesions.[16,35,52] Although classically associated as sequalae of concomitant glenohumeral pathology, that is, instability or rotator cuff injury, glenohumeral chondral lesions can also occur secondary to trauma or systemic illness.[10,13,20,33,49] Management of full-thickness glenohumeral cartilage lesions in young, active patients represents a challenging clinical scenario, as these injuries lack inherent regenerative capability and, if symptomatic, often necessitate surgical intervention.[8] The optimal surgical treatment, however, for these young patients is poorly defined. Arthroplasty remains a suboptimal treatment option, both due to the increased risk for early revision in young patients in addition to the strict postoperative lifting restrictions that are typically incongruent with many active patients' goals and expectations.[12,29,32] Whereas osteochondral transplantation or chondrocyte implantation has gained acceptance in other joints, outcomes data for these procedures, especially with respect to glenoid lesions, is limited.[10,33,49] As a result, the minimally invasive approach and straightforward technique characteristic of microfracture distinguish it as an attractive potential treatment for glenohumeral chondral lesions.[54] While short-term outcomes following glenohumeral microfracture were promising, longer-term outcome studies report a 21.4% conversion rate to arthroplasty and a clinical failure rate of 33% to 42%.[16,35,46,52,56]

The active-duty patient represents a challenging demographic to treat. These often young, high-demand patients place incredible load on their shoulders and experience shoulder injury at a rate that far outpaces the civilian population.[15,26,39,55] While limited duty and protective profiles are possible for some service men and women, patients in combat arms specialties are often unable or unwilling to accept duty limitations, as full use of their shoulder is required for their warfighting tasks and physical readiness training. Additionally, maintaining active-duty status is especially important for patients who may be nearing retirement and hoping to avoid premature medical separation. During our study period, we encountered 46 patients with full-thickness (Outerbridge IV) glenoid cartilage lesions.[38] While 50% of these patients had concomitant glenohumeral instability or a full-thickness rotator cuff tear, the other 50% had no subjective or objective evidence consistent with the presence of these pathologies.[13,25] Furthermore, of the 20 patients with no evidence of instability or rotator cuff injury, only half could recall a specific inciting traumatic event which preceded the development of their pain. As a result, 50% of our patients with symptomatic, full-thickness glenoid chondral lesions had no evidence of instability, rotator cuff injury, or trauma. Given an incidental incidence of approximately 5%-15% on diagnostic

Table II
Comparison of preoperative and postoperative outcome measures for patients who did not fail treatment (n = 15).

Outcome	Preoperative, mean (95% CI)	Postoperative, mean (95% CI)	Difference	*P* value
VAS	5.40 (4.74, 6.06)	1.37 (0.48, 2.25)	−4.17 (−3.43, −4.90)	<.0001
SANE	45.00 (36.23, 53.77)	86.33 (80.48, 92.19)	41.33 (30.24, 52.42)	<.0001
ASES	57.20 (52.83, 61.57)	88.27 (82.35, 94.18)	31.07 (24.39, 37.74)	<.0001
Forward elevation	156.00 (153.62, 158.38)	156.33 (153.90, 158.77)	0.33 (−0.82, 1.49)	.3225
External rotation	66.33 (63.90, 68.77)	67.33 (64.83, 69.84)	1.00 (−1.74, 3.74)	.4486
Internal rotation	T10.67 (9.51, 11.82)	T9.80 (8.78, 10.82)	T0.87 (−0.48, 2.22)	.1919

VAS, visual analog scale; *SANE*, Single Assessment Numeric Evaluation; *ASES*, American Shoulder and Elbow Surgeons; *CI*, confidence interval.

Table III
Achievement of clinical significance.[4,19,50,51]

Clinical outcome measure	Pain VAS		SANE		ASES	
	N (%)	Threshold	N (%)	Threshold	N (%)	Threshold
Minimum clinically important difference	14 (93.33)	1.6	10 (66.67)	28.8	14 (93.33)	13.6
Substantial clinical benefit	11 (73.33)	3.2	3 (20)	50.2	9 (60)	31.5
Patient acceptable symptomatic state	11 (73.33)	1.5	13/15 (86.67)	75.5	13 (86.67)	76.0
Maximum orthopaedic improvement	N/A	N/A	10 (66.67)	>75%	8 (53.33)	>69.5%

VAS, visual analog scale; *SANE*, Single Assessment Numeric Evaluation; *ASES*, American Shoulder and Elbow Surgeons.

Table IV
Comparison of final outcome scores between shoulder dominance.

	Dominant (n = 9)	Nondominant (n = 6)	*P* value
VAS, mean (95% CI)	2.75 (1.70, 3.80)	1.38 (−0.05, 2.81)	.1389
SANE, mean (95% CI)	77.50 (69.73, 85.27)	83.13 (69.28, 96.98)	.4635
ASES, mean (95% CI)	79.17 (71.44, 86.90)	86.75 (79.42)	.2850
Forward elevation, mean (95% CI)	155.67 (152.89, 158.45)	154.38 (150.94, 157.82)	.3225
External rotation, mean (95% CI)	65.00 (60.48, 69.52)	67.50 (63.79, 71.21)	.4486
Internal rotation, mean (95% CI)	T10.58 (9.46, 11.70)	T9 (7.72, 10.28)	.0888

VAS, visual analog scale; *SANE*, Single Assessment Numeric Evaluation; *ASES*, American Shoulder and Elbow Surgeons; *CI*, confidence interval.

Table V
Preoperative patient characteristics for patients who experienced treatment failure.

	Total (N = 5)
Age, y, mean ± SD (range)	42.40 ± 5.77 (34-50)
Male, N (%)	4 (80.00%)
Combat arms, N (%)*	4 (80.00%)
Dominant shoulder involvement, N (%)	3 (60.00%)
History of a traumatic event, N (%)	2 (40.00%)
MRI evidence of chondral injury, N (%)	1 (20.00%)
Time to surgery from symptom onset, mo, mean ± SD	35.40 ± 67.49
Surgical time, min, mean ± SD	73.60 ± 26.34
Glenoid lesion area, cm^2, mean ± SD	2.52 ± 1.50
Concomitant procedures	
ASAD, N (%)	5 (100.00%)
ABT, N (%)	1 (20.00%)
AASPBT, N (%)	3 (60.00%)
Débridement of humeral head osteochondral defect, N (%) (average size 1.00 cm^2)	1 (20.00%)

ASAD, arthroscopic subacromial decompression; *ABT*, arthroscopic biceps tenodesis; *AASPBT*, arthroscopic-assisted sub-pectoral biceps tenodesis; *SD*, standard deviation; *MRI*, magnetic resonance imaging.

*Defined as patients whose military duties require regular high-demand physical readiness training, manipulation of firearms, moving across uneven terrain and obstacles with heavy loads, hand to hand combat training and other warfighting tasks (ie, infantry, artillery, military police).

arthroscopy, it follows that this population appears to be at a markedly increased risk for either the development or the symptomatic progression of glenoid chondral injury.[6,18,36]

Although this increased incidence of glenoid chondral lesions among active-duty service members is likely multifactorial, we believe that there are a few critical factors that may explain its presence. First, active-duty service men and women place exceptionally high demand on their shoulders, be it through daily physical training or as a result of jobs which frequently involve lifting, carrying, pushing, pulling and, in the case of warfighters, shooting.[5,22,31] Second, it is well-described that active-duty military patients often experience a substantial delay between symptom onset and eventual appropriate treatment.[40,47,48,55] This, coupled with continued physical readiness training and bi-annual physical fitness tests, greatly increases the risk of injury progression. Finally, it is unknown what effect sub-clinical instability or scapular dyskinesia, pathologies frequently encountered in active-duty patients, has on the pathogenesis of chondral injury.[1,58] Subsequently, active-duty patients' predisposition to developing concomitant pathologies may implicate or exacerbate the development of glenoid chondral lesions.

Our findings are comparable to much of the published literature on microfracture for glenohumeral cartilage lesions in civilian patients. In their cohort of 16 patients (17 shoulders) with an average 10-year follow-up, Wang et al reported an overall success rate of 66.7%, comparable to our maintenance of active-duty rate of 65%.[56] These results are promising, especially when considering that, on average, our patients had larger lesions. Of patients who did not fail treatment, the improvements in PROMs are consistent with previously published values.[16,35,56]

Determination of the clinical significance of these outcomes, however, is obfuscated by a paucity of data on these metrics following glenoid microfracture. Given that distribution-based methods for determining MCID, SCB, and PASS carry not only a risk of underapproximation of the true value but also lack concrete

ties to patient satisfaction, we elected to use the previously published values for these metrics following shoulder arthroplasty.[4,19,27,50,51] Similarly, we chose to utilize previously published MOI thresholds following arthroscopic rotator cuff repair for the SANE and ASES. Promisingly, a majority of patients had improvements in PROMs which exceeded the MCID and reached the PASS as determined by the pain VAS, SANE, and ASES. Two-thirds of patients achieved MOI on the SANE, while only 53.33% of patients did so on the ASES. Achievement of SCB was not as ubiquitous: while 73.33% and 60% of patients surpassed this threshold on the Pain VAS and ASES, respectively, only 20% of patients did so on the SANE. SCB as measured by the SANE following shoulder arthroplasty (50.2), however, is far higher than that following rotator cuff repair (29.8) or biceps tenodesis (5.8).[9,19,43] Given that 86.7% of our patients who did not experience treatment failure remained on unrestricted active-duty, we postulate that identification of appropriate clinical significance metrics will further increase achievement of these thresholds in our cohort.

In much of the published literature on microfracture, the presence of concomitant procedures introduces the possibility that a portion of the observed benefit is secondary to additional procedures.[16,52,56] Our analysis demonstrates no significant differences between relevant concomitant procedures and both final outcome scores as well as net changes in outcome scores. The only model achieving statistical significance involved the relationship between ABT and ADHH on final FF measurement; however, the discrepancy in FF rates was estimated at only 6.56 and 4.77 degrees less for each procedure, respectively. With only minor FF disparities of less than seven degrees in FF associated with two procedures in the setting of similar outcome scores and other ROM measurements, these differences are unlikely to be clinically significant. Given the young, active military patient population unique to this study and frequently prolonged time to treatment, the treating surgeon elected to perform ASAD for all patients eligible for inclusion. Subsequently, future research involving patients with and without ASAD is needed to isolate the effects of ASAD on glenoid microfracture outcomes.

Although a majority of our patients were able to remain on active-duty and avoid the need for further surgery, 5 (25%) of patients required a secondary surgical procedure. While 1 patient was treated with an anatomic total shoulder arthroplasty, 4 patients were reluctant to undergo the same. As a result, these 4 patients were treated with a CAM procedure.[34,36] Described originally by Millett et al, the CAM procedure involves the combination of glenohumeral chondroplasty, loose body removal, humeral head osteoplasty and osteophyte resection, thorough capsular release, axillary neurolysis, subacromial decompression, and biceps tenodesis.[34] An attractive alternative to shoulder arthroplasty, CAM has a reported 10-year survivorship of 63.2%.[3] Risk factors for early conversion to shoulder arthroplasty following CAM include humeral head collapse and marked joint space narrowing and/or incongruity.[3,34] Promisingly, none of the 4 patients in our cohort who underwent CAM required additional surgical procedures.

Limitations

Although our results at midterm follow-up are promising, there are limitations to this study. Multiple concomitant procedures were performed, which have the potential to obfuscate the results of the microfracture procedure. The cohort is overwhelming male and fully comprised of active-duty soldiers who can go on restricted duty during rehabilitation, so the generalizability of our findings to non-military patients may be limited. All procedures were performed by a single shoulder-elbow fellowship-trained surgeon, which may limit the generalizability of these findings while also maintaining reliability regarding operative intervention. The clinical significance measures (PASS, SCB, and MCID) are not yet fully defined for shoulder stabilization procedures, so the values for shoulder arthroplasty and/or rotator cuff repair were used as a stand-in.[4,19,50,51] Finally, the results are a retrospective review of prospectively collected data, thereby introducing the risk for selection bias inherent to a case series.

Conclusion

Glenoid microfracture can result in pain relief and symptomatic improvement for a select group of active-duty military patients, with 75% survivorship at 5 years. Approximately one in three (35%) patients, however, were unable to remain on active-duty military service.

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