Arthroscopic treatment and subacromial decompression of calcific tendinitis without removal of the calcific deposit results in rapid resolution of symptoms and excellent clinical outcomes in commercial airline pilots and cabin crew.

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Informed Consent

Informed consent was obtained from all individual participants included in the study."

Abstract

Purpose:

The purpose of this study was to report the results of subacromial arthroscopic decompression (SAD) without removal of the calcific deposits in patients with calcifying tendinitis.

Methods:

All patients between 2016-2019 were included if they were aged between 18-60 years and had an isolated calcific deposit. The Constant-Murley score (CMS), Disabilities of the Arm, Shoulder and Hand (Quick DASH) score, the Shoulder Pain and Disability Index (SPADI), the simple shoulder test (SST), and the single assessment numeric evaluation (SANE) were used for assessment. Time to return to work was recorded.

Results:

24 patients (13 pilots, 11 cabin crew) with a mean age of 47.1±7.8 years were included. Quick Dash improved from 68.8 preoperative, to 8.4 at 3 months, and .1 at 24 months. CMS improved from 37.4 preoperative, to 83 at 3 months, and 94 at 24 months. SPADI improved from 73.8

preoperative, to 5.4 at 3 months, and 1 at 24 months. SST improved from 22.5 preoperative, to 94.2 at 3 months, and 100 at 24 months. SANE improved from 33.5 preoperative, to 78.7 at 3 months, and 95.6 at 24 months. MCID, SCB, and PASS reached values above 83% at 3 months and 100% at 6 months, with the exception of SANE which reached 29 at 3 months and plateaued to 96 at 6 months. The mean time to return to work was 7.1±2.1 weeks. Pilots returned at a mean of 6.9±1.8 weeks; cabin crew returned to work at a mean of 7.8±2.5 weeks.

Conclusions:

The results of this study suggest excellent short- and mid-term clinical outcomes can be achieved in patients with calcific tendinitis undergoing arthroscopic debridement and subacromial decompression without removal of calcific deposits. In this patient population, early surgical intervention was a potentially viable alternative to nonoperative treatment, and allowed early return to work.

Key words:

Calcific tendinitis; arthroscopic subacromial decompression; shoulder arthroscopy

Introduction

Calcific tendinitis of the shoulder is a painful shoulder condition, characterised by single or multiple deposits of calcium within the rotator cuff [1]. The deposit is most commonly located in the mid-substance or insertion of the supraspinatus tendon [2,3]. The calcium deposits are composed of calcium hydroxyapatite in its crystalline or amorphous form [4]. The condition typically affects patients aged between 30 to 60 years, and women are more commonly affected than men [5]. Uhthoff and Loehr have described three clinical stages of the condition: pre-calcific, calcific, and post-calcific [6]. In the pre-calcific stage, fibrocartilaginous metaplasia occurs and matrix vesicles unite to become calcific deposits [6]. In the resting (calcific) stage

the condition is dormant. When resorption eventually occurs, fibroblasts and granulation tissue replace the bulk of the calcific deposit [5,6]. The main clinical manifestation is acute pain with the onset of the disease, and may be associated with restricted motion and muscle spasm [1]. However, episodes of acute pain are also observed in the chronic stage, with episodic flare-ups of tendinopathy [1,7].

Several treatment options have been described, but there appears to be consensus that conservative treatment should be the first choice [1,3,5]. Non-surgical interventions focus on pain mitigation, and include rest, NSAID's, steroid injections, and physical therapy [8] Minimally invasive techniques include ultrasound guided lavage and extracorporeal shockwave therapy [9]. Ultrasound guided lavage and needling can be performed under local anaesthetic, and satisfactory results have been reported at 3 months [10]. However, a recent meta-analysis concluded that the current evidence for ultrasound guided lavage is of low quality, and that further trials could modify the conclusions [11]. Extracorporeal shockwave therapy (ESWT) induces analgesic and anti-inflammatory effects through mechano-transduction, and has been proven to be effective in calcific tendinopathy [12]. A recent systematic review revealed only moderate evidence for ESWT over placebo, and reported substantial concerns regarding the methodological quality of the included studies [8].

Surgical intervention is still controversial, and should only be offered for those patients not responding to conservative treatment [1]. Whether the calcific deposit should be removed is also controversial [13-16]. Similarly, the role of acromioplasty remains undefined. Tillander et al. [17] demonstrated acromioplasty had no benefits; others have suggested that acromioplasty should only be considered in the presence of visible mechanical impingement [13-16].

However, for specific population groups who, in the course of their normal work activities, perform safety critical tasks in which impaired awareness, lack of concentration, imbalance, and lack of joint mobility or strength could result in disastrous consequences, complete recovery is an absolute requirement prior to return to work. For example, construction workers and aviation personnel cannot perform light duties, and must be able to fulfill certain safety critical medical standards [18-20]. Aviation staff, namely cabin crew and pilots, are required to safely perform functional tasks such as assisting in emergency situations [emergency door opening by hand, and flying an aircraft without hydraulic or electronic support] [19,20] Non-operative treatment, therefore, is often not a feasible or attractive option for this group, and early operative intervention may allow them to safely return to work earlier.

The purpose of this study was to therefore report the results of subacromial arthroscopic decompression (SAD) in a select cohort of patients with calcifying tendinitis, specifically commercial airline pilots and cabin crew. It was hypothesized that SAD would result in resolution of symptoms, with good functional outcomes and high patient reported satisfaction.

Methods

This research was conducted as an observational longitudinal cohort study of prospectively collected data. Patients who were treated for calcifying tendinitis between 2016-2019 were identified from the departmental database at a tertiary orthopaedic speciality hospital. Patients were referred directly to this hospital and specific surgeon by the treating aviation medical examiner on behalf of the airline. The Civil Aviation Authority (CAA) mandates that aviation personnel should be treated by a registered aviation medical specialist, and the treating surgeon is currently one of the three locally registered orthapedic surgeons with the CAA, and the only

orthopaedic surgeon with fellowship training in orthopaedic sports medicine. This was a single surgeon case series by a fellowship trained surgeon treating patients from the aviation industry, and included flying personnel only. The rationale for this selection criteria was to reduce inherent heterogeneity and variability, and to include patients who are operating in a high stress environment, requiring full use of the shoulder with considerable pressure for early return to work. It is acknowledged that these criteria may have resulted in selection bias. The return to flying duties was assessed and acknowledged by an independent aeromedical examiner, according to regulations established by the Civil Aviation Authority.

The following inclusion criteria were applied: patients aged between 18-60 years, isolated calcific deposit in the supraspinatus tendon with an intact rotator cuff, and minimum follow-up of two years. Patients were excluded if other shoulder pathology such as long head biceps pathology, shoulder instability, or osteoarthritis in both the glenohumeral and acromioclavicular joint was identified on radiographs, MR imaging, or during surgery. Patients with previous shoulder surgery, trauma, or symptoms exceeding 12 months were also excluded.

Outcome Measures

The Constant-Murley score (CMS) assesses four aspects related to shoulder pathology: pain, activities of daily living, range of motion, and strength [21]; the subjective component ranges up to 35 points, and the objective score up to 65 [21]. Although the CMS score has been widely used it has never been properly validated, but its use for subacromial conditions is considered reliable and reproducible [21]. The subjective outcome measures consisted of the upper extremity specific Disabilities of the Arm, Shoulder and Hand (Quick DASH) score [22]. The Quick DASH questionnaire is an 11 item scoring system; a total score of 100 indicates severe disability, while a score of zero signifies no disability. The Shoulder Pain and Disability Index

(SPADI) is a self-administered questionnaire designed to measure pain and disability associated with shoulder pathology [23]. It consists of 13 items in 2 domains; pain (5 items) and disability (8 items), scored on visual analogue scales, ranging from 0 to 10 (0 = no pain/no difficulty and 10 = worst pain imaginable/so difficult it requires help) [23]. Each item score is equally weighted, then added for a total ranging score from 0 to 100 [0 = best and 100=worst outcome] [23]. The simple shoulder test (SST) is a self-reported shoulder-specific questionnaire that measures functional limitations of the affected side in patients with shoulder dysfunction; it consists of 12 questions with dichotomous (yes/ no) response options. For each question, the patients indicate that they are able or are not able to perform the activity. The scores range from 0 (worst) to 12 (best) [24,25]. The single assessment numeric evaluation (SANE) is a simple one-question patient reported outcome measure (PROM): How would you rate your shoulder today as a percentage of normal (0-100%, with 100% being normal) [26]. The score correlates closely with common shoulder scores and is associated with patient satisfaction, and is validated for common shoulder conditions [26-29]. The minimal clinically important difference (MCID), substantial clinical benefit (SCB), and patient acceptable symptomatic state (PASS) were calculated where available, and reported as the percentage of patients who satisfied these criteria.

For the Constant-Murley score (CMS) and SANE score, the results by Cvetanovich et al. were used [30]. For the CMS MCID was 5.5, for SCB 20, and PASS 23 [30]. For the SANE score, the MCID was 29.4, for SCB 29.87, and PASS 82.5 [30]. For the DASH score the MCID was 10.83 [31], for SCB 19.6 [32], and PASS [33]. For the SPADI score the MCID was [34], for SCB 45.4 [32], and PASS 41[33]. For the SST score the MCID was 17% [35], for SCB 28% [34], and PASS 76% [33]. It is acknowledged that the reported values from Franchignoni et al [31], Christie et al [33], Simovitch et al [34], Tashjian et al [35], and Chamberlain et al [36]

were not specifically evaluated for rotator cuff disease or calcific tendinitis and may introduce bias, although these criteria have satisfied prior peer review.

All outcome measures were obtained by an independent research associate to reduce bias. The time to return to work was defined as the reinstatement of the aviation licence. This interval was selected as there were requirements for additional simulator checks for some patients, whereas others were able to return to flying duties without additional checks.

Statistical analysis

Descriptive statistics were used for outcome measures and return to duty intervals. Normal data distribution was assessed with the Shapiro-Wilks Test, and homogeneity of variance verified with Levene's test. If the data was normally distributed, the mean was used as a measure of central tendency, and standard deviation, range, and 95% confidence intervals were calculated as measures of dispersion. To analyse clinical improvement over the 24 months time interval, repeated measures of ANOVA and within group post hoc multiple comparisons with Tukey's honest significant difference test was used for each outcome score. All analyses were conducted using STATA SE for Windows (version 12.0; StataCorp, College Station, Texas, USA).

Results

From June 2016 to March 2019, 24 patients with shoulder pain and calcific tendinitis were treated. The mean age was 47.1±7.8 years; there were 10 males (mean age 53.7±3.9 years), and 14 females (mean age 42.4±6.2 years). There were 13 pilots (10 male, 3 female) and 11 cabin crew (11 female; 6 purser and 5 cabin crew). The mean duration of symptoms was 7.9±5.4

months. For males the mean duration of symptoms was 8.9±5.4 months; for females the mean duration was 7.1±4.4 months.

	Pre-operative	6 weeks	3 months	6 months	12 months	24 months
Quick Dash	68.8	22.2	8.4	3.2	1.8	1.1
Constant Score	37.4	70.9	83	88.6	92.6	94.1
SPADI	73.8	18.4	5.4	2.3	1.2	1
SST	22.5	80.1	94.2	100	100	100
SANE	33.5	65.6	78.7	91.1	96.3	95.6

Table 1: Clinical Outcomes

Outcome Measures

The results for the clinical outcome scores are summarized in table 1. All patients improved significantly over the 24 months follow-up period. For the DASH, the improvements were significant between pre-op and 6 weeks, 3,6,12, and 24 months, as well as between 6 weeks and 3,6,12, and 24 months [F=163.65; p=0.001]. Further significant improvement between 3 months and the later time intervals were not observed. For the CMS, the improvements were significant between pre-op and 6 weeks, 3,6,12, and 24 months, as well as between 6 weeks and 6,12, and 24 months [F=242.17; p=0.001]. Further significant improvement between 3 months and the later time intervals were not observed. For the SPADI, the improvements were significant between pre-op and 6 weeks, 3,6,12, and 24 months, as well as between 6 weeks and 3,6,12, and 24 months [F=439.36; p=0.001]. Further significant improvement between 3 months and the later time intervals were not observed. For the SST, the improvements were significant between pre-op and 6 weeks, 3,6,12, and 24 months, as well as between 6 weeks and 3,6,12, and 24 months [F=170.98; p=0.001]. Further significant improvement between 3

months and the later time intervals were not observed. For the SANE score, the improvements were significant between pre-op and 6 weeks, 3,6,12, and 24 months, as well as between 6 weeks and 3,6,12, and 24 months, and between 3 months and 6,12, and 24 months [F=166.35; p=0.001]. Further significant improvement between 6 months and the later time intervals were not observed.

		6 weeks	3 months	6 months	12 months	24 months
Dash	MCID [11]*	100	100	100	100	100
	SCB [20]	91	96	100	100	100
	PASS [23]	58	96	100	100	100
Constant Score	MCID [5.5]	100	100	100	100	100
	SCB [20]	83	96	100	100	100
	PASS [19.5]	100	100	100	100	100
SPADI	MCID [13]	100	100	100	100	100
	SCB [45]	71	96	100	100	100
	PASS [41]	100	100	100	100	100
				100	100	100
SST	MCID [17]	100	96	100	100	100
	SCB [28]	92	92	100	100	100
	PASS [76]	58	92	100	100	100
SANE	MCID [29]	67	83	100	100	100
	SCB [30]	67	83	100	100	100
	PASS [82.5]	0	29	96	96	96

*the respective values for MCID, SCB and PASS for each scoring system included is shown in square brackets

Table 2: Percentages of patients reaching MCID, SCB and PASS

MCID, SCB, PASS

The results for MCID, SCB, and PASS are summarized in table 2. MCID for the DASH, Constant, SPADI, and SST score reached 100% at 6 weeks; the SANE score reached 100% at the 6 months follow-up interval. The SCB for the DASH, Constant, SPADI, and SST score

was above 90% by 3 months, and reached 100% at 6 months; the SANE score reached 100% by 6 months. PASS was achieved in all patients (100%) for the Constant and SPADI score by 6 weeks, while for the DASH and SST this was achieved in over 90% of all patients by 3 months, and reached 100% for the DASH, Constant, SPADI, and SST scores by 6 months. The SANE score was not achieved by any patient at 6 weeks, and needed 6 months to achieve PASS in 96% from 6 months onwards.

Return to work

The mean time to return to work was 7.1±2.1 weeks. Pilots returned at a mean of 6.9±1.8 weeks, and cabin crew returned to work at a mean of 7.8±2.5 weeks. There were two female patients (both pursers) who had ongoing symptoms with overhead movements and loading the shoulder in the elevated forward position. They did not reach PASS for the SANE score, and these two patients rated their involved shoulder as 75% and 80% of normal at 24 months. Their DASH and SPADI scores were still above 10, and the Constant score was 86 at final follow-up. Prior to surgery they were both treated for 12 months, including physical therapy, extracorporeal shockwave, steroid injections, and NSAID's. Despite ongoing dedicated physical therapy and several courses of NSAIDs and steroid injections, post-operative recovery was slow and remained static from 6 months onward with no further improvements. Both patients also had workers compensation/industrial injury claims, and returned to work 12 weeks after surgery. They left the airline industry 6 and 12 months after surgery respectively, as they found they were unable to satisfy the physical requirements of their profession. These two patients were considered to be treatment failures, resulting in an overall success rate following surgery of 92%.

Discussion

The results of this study demonstrate that subacromial decompression without removal of the calcific deposit can result in good and reliable clinical outcomes, and is a reasonable treatment alternative in selected patients. The mean maximal improvement was reached at 3 months, with no further significant improvement for the DASH, Constant, SPADI, and SST scores. The SANE score reached maximum improvement at 6 months. The SANE score utilizes a simple one question approach, where patients are asked to subjectively rate the shoulder as a percentage of normal. Previous studies have validated SANE for different shoulder conditions [26-29]. Williams et al [29] reported correlation coefficients between 0.46 to 0.69 compared with the ASES score. Thigpen et al [27] demonstrated the ASES had an operator characteristic under the curve area of 0.79. O'Connor et al [26] reported a correlation coefficient of 0.59 between other common shoulder scores and SANE. Wickham et al [28] found a strong correlation [r=0.78] between the ASES and WORC compared to SANE one year after rotator cuff repair. Obviously, these relationships are not perfect and when using the highest correlation coefficient of the above studies by Thigpen et al [27], only 61% of the variation of SANE was explained by the other shoulder scores [37]. This leaves considerable room for interpretation, and uncertainty may still explain the discrepancy between SANE and the other shoulder scores. Another more plausible explanation is that the SANE score forces patients to compare their operated or involved extremity to the uninvolved arm. In contrast, the other shoulder scores specifically assess the clinical outcome or function of the involved extremity, and patients may perceive clinical improvements differently when comparison to the contralateral extremity is not a component of the scoring system.

Minimal clinically important difference (MCID), substantial clinical benefit (SCB), and patient acceptable symptomatic state (PASS) are becoming increasingly important for orthopaedic

outcome measures. They define minimum degrees of quantifiable outcome improvement (MCID), minimum quantifiable outcome improvement for a patient to feel substantially better (SCB), and the highest level of symptom beyond which patients consider themselves well (PASS) [38]. These PROMs are reported in percentages of the group at interest. Similar to the clinical outcomes, MCID was reached in 100% for all scores but SANE at 6 weeks; SCB and PASS was achieved in over 96% for all scores but SANE, confirming that the overwhelming majority of patients achieved maximal improvement by 3 months.

The mean time to return to work was 7.1 weeks for the entire study cohort. This compares favourably to Nicholson [39], who reported that patients returned to full duties at an average of 9.1 weeks following arthroscopic subacromial decompression. McClelland et al [40] also investigated return to work after arthroscopic subacromial decompression in manual workers, and reported 85% of manual workers returned to work by 3 months postoperatively, with a median time for return to work of 9.1 weeks. Charalambous et al [41] reported a mean of 4.1 weeks for return to work in a mixed group of 70 patients. However, 28% of workers returned to lighter duties initially, and their inclusion has most likely skewed this data favourably [41]. Unfortunately, their study cohort also included 19 unemployed patients, further reducing the validity of their data substantially. Jayasekara et al. [42] reported a 62% return to work at 6 months following arthroscopic calcific deposit debridement, and was associated with significantly better return to full duties when compared to SLAP repair and was more effective than arthroscopic acromioplasty. Marder et al [43] compared return to unrestricted activity in patients with and without decompression, and reported faster returns in patients following debridement only at 11 weeks versus 18 weeks in patients with subacromial decompression. The time to return to work for pilots is considerably shorter when compared to the studies by Nicholson [39], McClelland et al [40], and Jayasekara et al [42], but longer than the time reported by Charalambous et al [41] who included return to light duties. Obviously, regulatory

bodies such as the European Union Aviation Safety Agency (EASA) and the Federal Aviation Authority (FAA) have issued explicit functional criteria for pilots and cabin crew, and return to light duties is not an option for this population. For example, EASA [19] requires pilots pass a satisfactory simulator and flight check, including all tasks required for the type of flight and aircraft intended. These mandates require personnel achieve competency in all emergency and evacuation procedures [19]. The FAA specifically guides aviation medical examiners, and clearly states that any musculoskeletal condition that makes someone unable to safely perform the duties or exercise the privileges of their licence must not be granted medical clearance, resulting in either suspension or cancellation of the licence [19]. Any impairment of joint mobility or muscle strength, regardless of whether flight personnel is applying for licence renewal or reinstatement of a suspended licence, automatically disqualifies any licence holder from active duties. In fact, the major airline of the country (UAE) has established fitness tests to resume flying duties, and those include objective mobility and strength assessments that simulate the tasks typically experienced on board [44]. Despite these strict regulations for aircrew personnel, the outcomes reported here are encouraging and suggest that arthroscopic treatment of calcific tendinitis is a feasible option, allowing pilots and cabin crew to return to work faster when compared to nonoperative treatment [45-47].

The treatment of calcific tendinitis remains controversial, but current evidence suggests conservative treatment is still the first line of treatment [48]. Interestingly, several studies have reported failure rates between 27-40% for non-operative management [45-47]. Ogon et al [47] assessed the efficacy of 3 months of conservative treatment, and reported persistence of symptoms in 27% of patients. Cho et al [45] demonstrated improvement of Constant and UCLA scores at the final follow-up, but confirmed the failure rate of 28%. Contreras et al [46] followed 49 patients over a mean of 22 months, and 16 patients (40%) ultimately underwent

surgery for failed conservative treatment during the follow-up period. Surgery is commonly considered only when symptoms persist [3,48], but the published failure rates between 28-40% brings into question this approach in specific patient populations who cannot afford prolonged conservative treatment or who require full functional use of their shoulder and upper extremity.

Sabeti et al [49] performed an arthroscopic debridement in 20 patients with calcific rotator cuff tendinitis, and reported significant improvement of the Constant score, from 45 preoperative to 75 at 2 weeks and 90 at 9 months. Clement et al [50] compared a group of patients undergoing bursectomy and debridement to a group who also underwent arthroscopic subacromial decompression, but did were unable to identify any meaningful differences at 1 year. However, patients in both groups improved significantly from a pre-operative DASH score of 34 and a Constant score of 46 to a DASH score of 14 and Constant score ranging from 77 to 82 one year after surgery [50]. Ark et al [13] treated 22 patients with arthroscopic bursectomy and needling of the calcific deposit where possible, and noticed that 7 patients had almost complete pain relief within 3 weeks, 4 patients within 3-6 months, and 9 patients had occasional episodes of discomfort with full use of the upper extremity at the final follow up of 26 months. These results are very similar to the results of our cohort, suggesting arthroscopic debridement combined with subacromial decompression is a reasonable treatment option. Surgical treatment is also supported by Wittenberg et al [51], who matched 100 patients comparing surgical to non-operative treatment. The surgical group demonstrated higher subjective satisfaction rates and graded their functional activities of daily living as not severely limited at 5 months, compared to 20 months in the conservative group [51]. In contrast, other studies have indicated removal of the calcific deposit is required, and reported clinical outcomes are inversely related to the number and size of the residual deposits [14,15].

Limitations

This study has several limitations, and most importantly the location/size of the calcific deposit and the severity of symptoms was different for each case, and this may have influenced clinical outcomes in a manner that is difficult to control. Radiographic resolution of the calcific deposit was not checked at the final follow-up, and could have also influenced clinical outcomes at 12 and 24 months. However, Cho et al [45] demonstrated that there was no correlation between these variables, and these factors did not affect clinical outcomes. This study cohort was limited to aircrew only, limiting the external validity of the study. The procedures were performed by a single fellowship trained sports medicine surgeon with expertise in shoulder arthroscopy, further limiting the external validity of the results. However, given the stringent regulations for return to work imposed by the civil aviation regulatory bodies, the results of this study may also reflect the worst case scenario. Finally, the study was designed as a retrospective analysis of prospectively collected data with no control group, and is therefore susceptible to measurement and recall bias.

Conclusions

The results of this study suggest excellent short- and mid-term clinical outcomes can be achieved in patients with calcific tendinitis undergoing debridement and arthroscopic subacromial decompression without removal of calcific deposits. In this selected patient population, early surgical intervention is potentially a viable alternative to non-operative treatment, and may facilitate earlier return to work in this demanding cohort.

Author Contributions

EH: Conceptualisation, protocol, design interpretation, writing, final approval of manuscript

KT: Conceptualisation, protocol, writing, final approval of manuscript

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Compliance with ethical standards

Conflicts of Interest

The authors declare that they have no competing interested

Ethical Approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards." Informed consent was obtained from all individual participants included in the study."

Consent to participate

All authors agreed to participate

Consent for publication

All authors are in agreement with the manuscript

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