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Predicting Pain and Disability after Shoulder Arthroscopy: Rotator Cuff Tear Severity and Concomitant Arthroscopic Procedures

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Abstract

Objectives—Study the influence of concomitant arthroscopic procedures and rotator cuff tear (RCT) severity on daily pain intensity and disability following shoulder arthroscopy.

Methods—145 patients (mean age: 42.66 ± 17.6; n of males=96) completed daily pain intensity and disability measures prior to shoulder arthroscopy. RCT severity was assessed on a 7-point scale based on operative report. Operative procedures were categorized based on anatomical location and invasiveness to calculate a weighted concomitant procedure estimate. Postoperative daily pain and disability were assessed 3 months, 6 months, and 1 year status-post surgery.

Results—Only concomitant procedures was associated with 3 month daily pain intensity after adjusting for age, sex, pain duration, and baseline daily pain intensity ($R^2=.03$; St. Beta=.203; $p=.036$). Moreover, post-hoc analysis revealed concomitant procedures remained predictive of 3 month daily pain intensity when the estimate was calculated independent of RCT procedures ($R^2=.05$; St. Beta=.233; $p=.007$), and when accounting for post-operative factors of physical therapy and analgesic medication ($R^2=.05$; St. Beta=.237; $p=.007$). Neither RCT severity nor concomitant procedures were predictive of daily pain intensity at 6 months and 1 year, or disability at any time point, in the adjusted models ($p>.05$).

Discussion—This study introduces a novel means for estimating concurrent procedures for use as a prognostic factor. Our findings are similar to previous research of RCT severity which was found to have limited influence on postoperative outcomes. In contrast, this study highlights the

potential importance of accounting for concomitant arthroscopic procedures as a predictor of early postoperative pain intensity outcomes.

Keywords

Shoulder; post-operative; pain; disability; concomitant

INTRODUCTION

Shoulder pain and disability are highly prevalent symptoms among the general population and primary indicators for shoulder arthroscopy.¹⁻⁴ While both generally improve with surgery,⁵⁻⁷ there is a lack of identifiable prognostic factors which put individuals at risk for persistent postoperative pain and disability. For example, preoperative shoulder pain and disability have been traditionally attributed to intrinsic conditions like rotator cuff tear (RCT).^{8,9} RCT severity would, therefore, appear to be a prognostic factor of poor postoperative recovery, since large tears are intuitively more injurious and also require more invasive surgery compared to smaller tears. However, no link exists between RCT severity and postoperative shoulder pain, and only a handful of studies have shown a relationship with postoperative shoulder disability.¹⁰ Moreover, research has suggested shoulder pain and disability can improve independent of changes in RCT integrity after surgery.^{11,12}

The role of concomitant surgical procedures in the development of postoperative persistent pain and disability is also under-investigated. Concomitant procedures are commonly performed during shoulder arthroscopy,^{7,13} and individuals undergoing concomitant procedures have reported similar or even better outcomes compared to individual arthroscopic procedures.¹⁴⁻¹⁷ However, other studies have reported concomitant procedures to put individuals at risk for higher postoperative disability or longer recovery time.¹⁷⁻¹⁹ In addition, most studies on concomitant procedures have been modeled for treatment effects (e.g. comparison to standard of care), which elucidate group differences in outcome, but does not necessarily quantify the magnitude of influence concomitant procedures themselves have on outcome. Two recent studies examined the post-operative influence of concomitant biceps and acromioclavicular procedures with RCT repair, and both concomitant procedures were found to predict long-term radiographic tendon defects.^{20,21} While the influence on postoperative pain or disability was not reported, this study highlights the potential for concomitant procedures to be a prognostic factor of postoperative recovery.

Therefore, the purpose of this study was to assess the prognostic influence of concomitant arthroscopic procedures on short-term (up to 1 year) postoperative pain and disability. To our knowledge, previous studies have not quantified concomitant procedures by procedure number and invasiveness, both of which were performed in this study. In addition, we assessed the prognostic value of concomitant procedures after adjusting for other established preoperative predictors like demographics and pain acuity. Finally, we aimed to compare the influence of concomitant procedures to that of RCT severity, which has inconsistent support as a prognostic factor of recovery.¹⁰ We hypothesized that study results would introduce a novel quantification of concomitant arthroscopic procedures and further elucidate whether intraoperative procedures were a prognostic factor of post-operative pain and disability.

MATERIALS & METHODS

Sample

Individuals with musculoskeletal complaints related to the shoulder were seen at university outpatient practice in Gainesville, Florida between 2009 and 2011. Surgical candidacy was determined by poor response to conservative treatment (e.g. physical therapy, cortisone injection) and/or diagnostic imaging (e.g. radiograph, MRI). Individuals were then screened by one of the authors (WHG) for study eligibility. Individuals were considered if they had complaints of pain limited to anterior, lateral, or posterior shoulder and were scheduled for the arthroscopic procedure. Individuals were excluded if they had pain greater than 3 months in another anatomical region; received surgery on either shoulder within 1 year of screening; were diagnosed with systemic conditions affecting the shoulder (tumor, infection); had a fracture diagnosis in the involved shoulder; were previously diagnosed with a chronic pain disorder (e.g. fibromyalgia); were undergoing psychiatric management; or had gastrointestinal or renal illness. Eligible participants were consented and scheduled for a baseline study session within 1 week prior to surgery. Participants then underwent shoulder arthroscopy, and returned for study sessions at 3 months, 6 months and 1 year postoperatively. This study was approved by the University of Florida Institutional Review Board.

Outcome Measures

The proposed prediction model of postoperative shoulder pain and disability used in this study is illustrated in Figure 1. Patients provided daily pain intensity and disability report preoperatively (baseline) and 3 months, 6 months, and 1 year postoperatively. For daily pain intensity, patients completed the Brief Pain Inventory Short Form (BPI). The BPI measures items on an 11 point numerical scale, 0 equal to “no pain” and 10 equal to “worst pain intensity imaginable”. Present pain intensity and best and worst pain intensity over a 24-hour period were then averaged to calculate daily pain intensity. The BPI is considered a valid and reliable measure of musculoskeletal pain^{22,23} and has been used previously in surgical shoulder studies.^{24,25} Next, patients indicated shoulder disability using the Disability of Arm, Shoulder, and Hand Quick Form Outcome Measure (QuickDASH). The QuickDASH is an 11-item patient-reported measure which rates the ability to perform personal, home, work and community tasks. The QuickDASH also assesses pain severity, pain interference, and sleep interruption related to the shoulder. Scores range from 0 to 100, with higher values indicative of greater disability. The QuickDASH is deemed a responsive disability measure for orthopaedic rehabilitation settings.^{26,27}

Prognostic factors

In addition to the BPI and QuickDASH, patients provided demographic information at baseline. This included age, sex and shoulder pain duration, which was the number of weeks of shoulder pain from onset to the baseline. At follow-up, RCT severity was also included as a baseline predictor, however, was operationally defined using the intraoperative diagnosis outlined in the operative report. Although the diagnostic accuracy of preoperative imaging (i.e. MRI, ultrasound) is well established, we opted for intraoperative diagnosis to maximize detection and classification of all levels of RCTs, including partial tears.^{28,29} Operative

reports were examined by two separate raters (RAC, WHG), and RCT severity was classified anatomically based on the following criteria: partial thickness <50%, partial thickness >50%, small (<1 cm), medium (1–3 cm), large (3–5 cm), or massive full thickness tear (>5 cm). If conflict arose, the operating surgeon (TWW, MWM, KWF) was consulted to resolve the conflict. Seven categories (e.g. 0 = no tear, 6= massive full thickness tear) were established to arrive at a RCT severity score for each individual. To our knowledge, use of two raters to ensure tear size agreement has not been reported previously. However, previous prognostic shoulder surgery studies have used surgeon operative report to record data pertaining to tear size.²¹

Similar to RCT severity, concomitant procedures were determined using the operative report assessed by two separate raters (RAC, WHG). Participants underwent one or more procedures involving the acromion or clavicle (acromioplasty, distal clavicle resection), biceps (tenodesis, tenotomy), bursa (bursectomy), capsule (manipulation, release), chondral tissue (chondroplasty), labrum (debridement, repair, capsulorrhaphy), and/or RCT (debridement, repair). If disagreement arose, the operating surgeon (TWW, MWM, FWF) was consulted to resolve the disagreement. For each anatomical region, participants were either dichotomously coded (yes/no), or for conditions with greater than 2 levels, dummy coded. Next, a concomitant procedure estimate was computed based on number and invasiveness of surgical procedures performed. Surgical procedures with 2 levels (i.e. acromion, biceps, bursa, capsule, chondral) were given a score of 1 if in the affirmative. Procedures with more than 2 levels based on predetermined surgical invasiveness (e.g. labral, RCT), were scored based on their dummy coded value (0=no procedure; 1=debridement; 2=repair). Scores were then added to arrive at the concomitant procedure estimate for each individual. The minimum possible estimate was 1, indicating only one procedure performed. The maximum possible estimate was 9, indicating all 2-level procedures and both labral and RCT repair were performed.

Statistical Analysis

IBM® SPSS® Statistics software, Version 21 (2012, IBM® Corp; Armonk, NY) was used for all analyses. Alpha level was set at $p=.05$. Spearman's rank-order correlation (ρ) was first used to assess inter-correlation between RCT severity and concomitant procedures. Ordinary least squares regression was then used to calculate univariate (unadjusted) influence of RCT severity and concomitant procedures on post-operative daily pain and disability at 3 months, 6 months, and 1 year. If either factor significantly predicted an outcome, it was then entered into the second block of a hierarchical multivariate regression model to calculate the unique (adjusted) influence (R^2 change) after accounting for age, dummy-coded sex, pain duration, and baseline daily pain or disability (first block); as well as to compare strength of predictors in the total model (standardized beta). In the event RCT severity and concurrent procedures both predicted postoperative pain or disability, then both factors were entered into the second block of the model. To avoid multicollinearity within the models, *a priori* cut-off rules were established for inter-correlation ($r=.70$), tolerance ($.20$), and variance inflation (4), as have been reported previously.³⁰

RESULTS

One Hundred forty-five individuals underwent shoulder arthroscopy during the study time frame. Patient intake and outcome characteristics are summarized in Table 1. A majority of participants were male and were experiencing chronic shoulder pain at the time of surgery. Nearly half of individuals had a rotator cuff tear, half of which were full thickness tears (Table 1). Labral repair was the predominant surgery followed by acromioplasty and bursectomy. Frequency of arthroscopic procedures and concomitant procedure estimates are provided in Table 2. Postoperative pain and disability by follow up time point are illustrated in Figure 2.

As expected, RCT severity and concomitant procedure estimate were moderately and positively correlated ($\rho=.635$, $p<.001$). Concomitant procedures ($R^2=.057$, $p=.009$), but not RCT severity ($p>.05$) were associated with daily pain intensity at 3 months (Table 3). The final model explained 27.3% of the variance in 3 month daily pain intensity. After accounting for age, sex, pain duration, and baseline daily pain intensity, concomitant procedures accounted for an additional 3% of the variance in 3 month daily pain intensity. Further, with the exception of baseline daily pain intensity (St. Beta=.465, $p<.001$), concomitant procedures were the only predictor of 3 month daily pain intensity (St. Beta=.203, $p=.036$). (Table 4). Unadjusted estimates of RCT severity and concomitant procedures were not associated with daily pain intensity at 6 months or 1 year. Therefore, adjusted estimates were not calculated at these time points.

Both Concomitant surgical procedures ($R^2=.067$, $p=.005$) and RCT severity ($R^2=.057$, $p=.009$) were associated with disability at 3 months. The final model explained 15.4% of the variance in 3 month disability. After accounting for age, sex, pain duration, and baseline disability, neither factor predicted 3 month disability. Neither unadjusted factor was associated with disability at 6 months or 1 year (Table 3), and therefore, adjusted estimates were not calculated at these time points.

A post-hoc analysis was performed based on the correlation level observed between RCT severity and concomitant procedures, and to confirm direct influence of concomitant procedures on 3 month daily pain intensity above and beyond RCT involvement. First, a modified concomitant procedure estimate was calculated as previously described, with removal of RCT procedures (debridement, repair). Modified concomitant procedure estimate and RCT severity were not correlated ($\rho = -.003$, $p=.974$). Next, the multivariate model for 3 month daily pain intensity was rebuilt with age, sex, pain duration, and baseline daily pain intensity in the first block; dummy-coded RCT procedure (debridement, repair versus no repair) in the second block; and modified concomitant procedure estimate in the third block. Only baseline daily pain intensity (St. Beta=.461, $p<.001$) and concomitant procedures (St. Beta=.233, $p=.007$) were predictive of 3 month daily pain intensity. Concomitant procedures explained 5% of the variance in 3 month daily pain intensity after accounting for the other factors.

Finally, a post-hoc analysis confirmed whether post-operative factors affected the influence of concomitant procedures on 3 month daily pain intensity. Specifically, 113 individuals

reported participating in physical therapy (PT) at 3 months (mean PT weeks=10.40, SD ± 3.7). Further, 26 individuals were still using analgesic medication (opioids, NSAIDs, peripheral analgesics) at 3 months. Using analgesic medication ($r=.182$, $p=.049$) was associated with higher 3 month daily pain intensity, however number of PT weeks was not ($r=-.026$, $p=.781$). Analgesic medication was entered into original 3 month daily pain intensity prediction model, however, did not affect the influence of either the original concomitant procedure estimate ($R^2=.03$; St. Beta=.203, $p=.036$), or the post-hoc modified concomitant procedure estimate ($R^2=.05$; St. Beta=.237, $p=.007$).

DISCUSSION

Shoulder arthroscopy incidence is rising exponentially in the United States,^{31–33} yet we continue to have less than optimum means for predicting postoperative recovery.³⁴ In particular, research has identified few prognostic factors for postoperative shoulder pain intensity and disability. Here, we examined the influence of concomitant procedures and found that higher estimates were associated with higher daily pain at 3 months; even after accounting for age, sex, pain duration, baseline daily pain intensity, and postoperative factors (PT, analgesic medications). Post-hoc analyses confirmed that concomitant procedures independent of RCT involvement were predictive of 3 month daily pain intensity. Collectively, these findings corroborate previous research regarding the limited utility of RCT severity for predicting postoperative pain and disability.^{10,12,34} Finally, it was determined that, with the exception of baseline pain intensity, our models did not predict post-operative pain and disability outcomes beyond 3 months.

Concomitant arthroscopic procedures have not been comprehensively examined for postoperative shoulder influence. This may be due to multiple factors, including variability in the number and type of arthroscopic procedures and/or exclusion of concomitant procedures in clinical trials to control for confounding factors. To our knowledge, only two papers have examined the prognostic value of concomitant procedures, Nho et al's²⁰ 2 year analysis and Gulotta et al's²¹ 5 year analysis of rotator cuff repairs. In both studies, concomitant RCT and biceps procedures, or RCT and acromioclavicular procedures were predictive of tendinous defect.^{20,21} While these findings are novel and relevant, they are not indicative of clinical outcome. In fact, Gulotta et al.²¹ did not find a relationship between tendinous defect and long-term clinical outcomes. Conversely, we found concomitant procedures to predict short-term clinical outcome. More recent investigations have highlighted the propensity for concomitant procedures to be performed during shoulder arthroscopy. This is important since recent investigation suggests frequency of concomitant procedures to be high.^{7,13} Our sample aligns with this notion as nearly all individuals had at least two procedures. Therefore, it's essential for future research to account for the potential influence of such factors when assessing recovery. Introducing a novel means for indexing concomitant procedures is an additional strength of this study, since it's simple and can be further explored in future postoperative prognostic studies.

The strength of influence by concomitant procedures on short-term postoperative pain, while small, was stronger than selected predictors like age, sex and pain duration; as well as associations with post-operative factors like physical therapy and analgesic medication. In

the past, indicators for surgery and postoperative outcomes were commonly attributed to intrinsic pathological shoulder conditions, like RCT.^{1,4} However, RCT integrity may play a negligible role in primary pain complaints. For example, prolonged preoperative shoulder pain duration or impaired shoulder activity level have been previously considered indicators for surgery when rotator cuff tears are present. However, emerging research suggests that neither factor is correlated with the RCT.^{35,36} Fermont et al's¹⁰ recent systematic review of prognostic factors of recovery after RCT repair did not report an association between either preoperative RCT severity or RCT healing and postoperative pain. A similar lack of association has been reported between functional outcome (i.e. disability) and healing of the RCT after surgery.³⁷ In fact, Jost et al's¹² findings are even more perplexing as they report improved pain and disability in the presence of failed RCT repair. If varying levels of postoperative shoulder pain and disability exist (i.e. surgical response), yet are not linked to intrinsic pathological shoulder conditions, then intraoperative factors may be involved. This notion is strengthened by the post-hoc analysis, as variance explained by concomitant procedures was increased once RCT procedures were parsed out.

We note that post-operative pain or disability beyond 3 months was not influenced by concomitant procedures. This may be a result of our sample characteristics, as most individuals had low pain and disability at these time points. In other words, decreased variability in clinical improvement may explain loss of clinical prediction after 3 months. Another possibility is that invasiveness of concomitant procedures resolves by the 6-month postoperative time point. Whatever the reason, this study showed a weak influence of concomitant procedures on long-term postoperative pain and disability. Manaka et al.³⁸ found that nearly three quarters of individuals undergoing RCT repair achieved functional recovery by 6 months, so it's possible the greatest postoperative pain and disability variability occurs before that time. Nevertheless, it's still possible concomitant procedures factor into long-term recovery for individuals with poorer surgical response, and therefore, should be investigated further. In addition, future research should consider influence on postoperative pain and disability beyond a year, much like previous analyses of RCT integrity.

There are limitations to this study that are priorities of future research. Pain assessment at each time point covered approximately 24 hours via a recall measure (BPI), which previous research has determined to be a fairly accurate representation of actual pain intensity.³⁹ However, daily self-report assessed over several days has been found to be more sensitive,⁴⁰ and therefore, should be considered for future prognostic studies of arthroscopic shoulder recovery. Second, while we accounted for number and invasiveness of arthroscopic procedures, we were unable to assess interactions amongst these procedures. Future research may identify the extent to which certain procedure combinations or procedure by intrinsic condition interactions influence postoperative pain and disability. Third, the concomitant procedure estimate was used in a heterogeneous sample of individuals undergoing shoulder arthroscopy, including those with both traumatic and atraumatic intrinsic pathological conditions. As previously described, however, the impact of such conditions is often equivocal. Further, using a heterogeneous sample offers the advantage of increased variability in the concomitant procedure estimate, which theoretically enhances the predictive potential for the index. Nevertheless, future studies may provide insight into the

predictive potential of concomitant procedures in a more homogenous sample of conditions. Fourth, the extent to which pain type (e.g. inflammatory, neuropathic) moderates the influence of concomitant procedures on post-operative pain intensity should be further examined.^{41,42} Finally, the postoperative prognostic models in this study were comprehensive as both preoperative, intraoperative, and postoperative factors were accounted for. However, future research should also account for preoperative psychosocial factors (e.g. pain catastrophizing, anxiety, depression) which have also shown influence on postoperative recovery.^{43–45} Similarly, post-operative factors like occupation or patient satisfaction may influence post-operative pain and disability either directly or through interaction with other factors.

CONCLUSION

Findings of this study support previous research suggesting RCT severity is not a prognostic factor of postoperative shoulder pain or disability. In contrast, concomitant arthroscopic procedures may negatively influence short-term postoperative pain intensity outcomes. Future research will elucidate the extent to which concomitant procedures influence postoperative recovery through pathological and procedural interactions, influence long term (>1 year) recovery, and account for additional preoperative (e.g. psychosocial) and postoperative (e.g. occupational) factors.

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CITED REFERENCES

1. Iannotti. Full-Thickness Rotator Cuff Tears: Factors Affecting Surgical Outcome. *J Am Acad Orthop Surg.* 1994; 2(2):87–95. [PubMed: 10708996]
2. Walker-Bone K, Palmer KT, Reading I, Coggon D, Cooper C. Prevalence and impact of musculoskeletal disorders of the upper limb in the general population. *Arthritis Care Res.* 2004; 51(4):642–651.
3. Wofford JL, Mansfield RJ, Watkins RS. Patient characteristics and clinical management of patients with shoulder pain in U.S. primary care settings: Secondary data analysis of the National Ambulatory Medical Care Survey. *BMC Musculoskelet Disord.* 2005; 6(1):4. [PubMed: 15691370]
4. Marx RG, Koulouvaris P, Chu SK, Levy BA. Indications for Surgery in Clinical Outcome Studies of Rotator Cuff Repair. *Clin Orthop.* 2009; 467(2):450–456. [PubMed: 18949526]
5. Gartsman GM, Brinker MR, Khan M. Early effectiveness of arthroscopic repair for full-thickness tears of the rotator cuff - An outcome analysis. *J Bone Jt Surg-Am Vol.* 1998; 80A(1):33–40.
6. Nho SJ, Shindle MK, Sherman SL, Freedman KB, Lyman S, MacGillivray JD. Systematic review of arthroscopic rotator cuff repair and mini-open rotator cuff repair. *J Bone Joint Surg Am.* 2007; 89 (Suppl 3):127–136. [PubMed: 17908878]
7. Mall NA, Chahal J, Heard WM, et al. Outcomes of Arthroscopic and Open Surgical Repair of Isolated Subscapularis Tendon Tears. *Arthroscopy.* 2012; 28(9):1306–1314. [PubMed: 22607828]
8. Itoi E. Rotator cuff tear: physical examination and conservative treatment. *J Orthop Sci.* 2013; 18(2): 197–204. [PubMed: 23306597]
9. Mitchell C, Adebajo A, Hay E, Carr A. Shoulder pain: diagnosis and management in primary care. *BMJ.* 2005; 331(7525):1124–1128. [PubMed: 16282408]

10. Fermont AJM, Wolterbeek N, Wessel RN, Baeyens J-P, de Bie RA. Prognostic Factors for Successful Recovery After Arthroscopic Rotator Cuff Repair: A Systematic Literature Review. *J Orthop Sports Phys Ther.* 2014; 44(3):153–163. [PubMed: 24450368]
11. Boileau P, Brassart N, Watkinson DJ, Carles M, Hatzidakis AM, Krishnan SG. Arthroscopic repair of full-thickness tears of the supraspinatus: does the tendon really heal? *J Bone Joint Surg Am.* 2005; 87(6):1229–1240. [PubMed: 15930531]
12. Jost B, Pfirrmann CW, Gerber C, Switzerland Z. Clinical outcome after structural failure of rotator cuff repairs. *J Bone Joint Surg Am.* 2000; 82(3):304–314. [PubMed: 10724223]
13. Lin EC, Mall NA, Dhawan A, et al. Arthroscopic primary rotator cuff repairs in patients aged younger than 45 years. *Arthroscopy.* 2013; 29(5):811–817. [PubMed: 23510942]
14. Gartsman GM, O'Connor DP. Arthroscopic rotator cuff repair with and without arthroscopic subacromial decompression: A prospective, randomized study of one-year outcomes. *J Shoulder Elbow Surg.* 2004; 13(4):424–426. [PubMed: 15220883]
15. Krishnan SG, Harkins DC, Schiffern SC, Pennington SD, Burkhead WZ. Arthroscopic repair of full-thickness tears of the rotator cuff in patients younger than 40 years. *Arthrosc- J Arthrosc Relat Surg.* 2008; 24(3):324–328.
16. Forsythe B, Guss D, Anthony SG, Martin SD. Concomitant arthroscopic SLAP and rotator cuff repair. *J Bone Joint Surg Am.* 2010; 92(6):1362–1369. [PubMed: 20516311]
17. Huberty DP, Schoolfield JD, Brady PC, Vadala AP, Arrigoni P, Burkhart SS. Incidence and Treatment of Postoperative Stiffness Following Arthroscopic Rotator Cuff Repair. *Arthroscopy.* 2009; 25(8):880–890. [PubMed: 19664508]
18. Kanatli U, Ozturk BY, Bolukbasi S. Arthroscopic repair of type II superior labrum anterior posterior (SLAP) lesions in patients over the age of 45 years: a prospective study. *Arch Orthop Trauma Surg.* 2011; 131(8):1107–1113. [PubMed: 21706304]
19. Cho NS, Rhee YG. Functional outcome of arthroscopic repair with concomitant manipulation in rotator cuff tears with stiff shoulder. *Am J Sports Med.* 2008; 36(7):1323–1329. [PubMed: 18539948]
20. Nho SJ, Brown BS, Lyman S, Adler RS, Altchek DW, MacGillivray JD. Prospective analysis of arthroscopic rotator cuff repair: prognostic factors affecting clinical and ultrasound outcome. *J Shoulder Elb Surg Am Shoulder Elb Surg Al.* 2009; 18(1):13–20.
21. Gulotta LV, Nho SJ, Dodson CC, et al. Prospective evaluation of arthroscopic rotator cuff repairs at 5 years: part II--prognostic factors for clinical and radiographic outcomes. *J Shoulder Elb Surg Am Shoulder Elb Surg Al.* 2011; 20(6):941–946.
22. Mendoza T, Mayne T, Rublee D, Cleeland C. Reliability and validity of a modified Brief Pain Inventory short form in patients with osteoarthritis. *Eur J Pain.* 2006; 10(4):353–361. [PubMed: 16051509]
23. Daut RL, Cleeland CS, Flanery RC. Development of the Wisconsin Brief Pain Questionnaire to assess pain in cancer and other diseases. *Pain.* 1983; 17(2):197–210. [PubMed: 6646795]
24. George SZ, Wallace MR, Wright TW, et al. Evidence for a biopsychosocial influence on shoulder pain: pain catastrophizing and catechol-O-methyltransferase (COMT) diplotype predict clinical pain ratings. *Pain.* 2008; 136(1–2):53–61. [PubMed: 17686583]
25. Valencia C, Kindler LL, Fillingim RB, George SZ. Stability of conditioned pain modulation in two musculoskeletal pain models: investigating the influence of shoulder pain intensity and gender. *BMC Musculoskelet Disord.* 2013; 14(1):182. [PubMed: 23758907]
26. Beaton DE, Wright JG, Katz JN. Development of the QuickDASH: comparison of three item-reduction approaches. *J Bone Joint Surg Am.* 2005; 87(5):1038–1046. [PubMed: 15866967]
27. Aasheim T, Finsen V. The DASH and the QuickDASH instruments. Normative values in the general population in Norway. *J Hand Surg Eur Vol.* Mar.2013
28. Smith TO, Daniell H, Geere J-A, Toms AP, Hing CB. The diagnostic accuracy of MRI for the detection of partial- and full-thickness rotator cuff tears in adults. *Magn Reson Imaging.* 2012; 30(3):336–346. [PubMed: 22260933]
29. De Jesus JO, Parker L, Frangos AJ, Nazarian LN. Accuracy of MRI, MR arthrography, and ultrasound in the diagnosis of rotator cuff tears: a meta-analysis. *AJR Am J Roentgenol.* 2009; 192(6):1701–1707. [PubMed: 19457838]

30. Menard, SW. Applied Logistic Regression Analysis. Thousand Oaks, Calif: Sage Publications; 1995.
31. Colvin AC, Egorova N, Harrison AK, Moskowitz A, Flatow EL. National trends in rotator cuff repair. *J Bone Joint Surg Am*. 2012; 94(3):227–233. [PubMed: 22298054]
32. Ensor KL, Kwon YW, Dibeneditto MR, Zuckerman JD, Rokito AS. The rising incidence of rotator cuff repairs. *J Shoulder Elb Surg Am Shoulder Elb Surg Al*. 2013; 22(12):1628–1632.
33. Onyekwelu I, Khatib O, Zuckerman JD, Rokito AS, Kwon YW. The rising incidence of arthroscopic superior labrum anterior and posterior (SLAP) repairs. *J Shoulder Elbow Surg*. 2012; 21(6):728–731. [PubMed: 22608836]
34. Oh LS, Wolf BR, Hall MP, Levy BA, Marx RG. Indications for rotator cuff repair: a systematic review. *Clin Orthop*. 2007; 455:52–63. [PubMed: 17179786]
35. Brophy RH, Dunn WR, Kuhn JE. MOON Shoulder Group. Shoulder activity level is not associated with the severity of symptomatic, atraumatic rotator cuff tears in patients electing nonoperative treatment. *Am J Sports Med*. 2014; 42(5):1150–1154. [PubMed: 24658346]
36. Unruh KP, Kuhn JE, et al. The MOON Shoulder Group. The duration of symptoms does not correlate with rotator cuff tear severity or other patient-related features: a cross-sectional study of patients with atraumatic, full-thickness rotator cuff tears. *J Shoulder Elbow Surg*. 2014; 23(7):1052–1058. [PubMed: 24411924]
37. Oh JH, Kim SH, Ji HM, Jo KH, Bin SW, Gong HS. Prognostic factors affecting anatomic outcome of rotator cuff repair and correlation with functional outcome. *Arthrosc J Arthrosc Relat Surg Off Publ Arthrosc Assoc N Am Int Arthrosc Assoc*. 2009; 25(1):30–39.
38. Manaka T, Ito Y, Matsumoto I, Takaoka K, Nakamura H. Functional recovery period after arthroscopic rotator cuff repair: is it predictable before surgery? *Clin Orthop*. 2011; 469(6):1660–1666. [PubMed: 21107925]
39. Jensen MP, Mardekian J, Lakshminarayanan M, Boye ME. Validity of 24-h recall ratings of pain severity: biasing effects of “Peak” and “End” pain. *Pain*. 2008; 137(2):422–427. [PubMed: 18035495]
40. Heapy A, Dziura J, Buta E, Goulet J, Kulas JF, Kerns RD. Using multiple daily pain ratings to improve reliability and assay sensitivity: how many is enough? *J Pain Off J Am Pain Soc*. 2014; 15(12):1360–1365.
41. Haroutiunian S, Nikolajsen L, Finnerup NB, Jensen TS. The neuropathic component in persistent postsurgical pain: a systematic literature review. *Pain*. 2013; 154(1):95–102. [PubMed: 23273105]
42. Dualé C, Ouchchane L, Schoeffler P, Dubray C. EDONIS Investigating Group. Neuropathic aspects of persistent postsurgical pain: a French multicenter survey with a 6-month prospective follow-up. *J Pain Off J Am Pain Soc*. 2014; 15(1):24.e1–e24.e20.
43. Granot M, Ferber SG. The roles of pain catastrophizing and anxiety in the prediction of postoperative pain intensity: a prospective study. *Clin J Pain*. 2005; 21(5):439–445. [PubMed: 16093750]
44. Pavlin DJ, Sullivan MJL, Freund PR, Roesen K. Catastrophizing: a risk factor for postsurgical pain. *Clin J Pain*. 2005; 21(1):83–90. [PubMed: 15599135]
45. De Cosmo G, Congedo E, Lai C, Primieri P, Dottarelli A, Aceto P. Preoperative psychologic and demographic predictors of pain perception and tramadol consumption using intravenous patient-controlled analgesia. *Clin J Pain*. 2008; 24(5):399–405. [PubMed: 18496304]

FIGURE 1. Postoperative Shoulder Pain and Disability Predictive Model

Outline of baseline (pre-operative), surgical (intra-operative), and outcome (postoperative) factors in pain and disability predictive models; Sex dummy coded (e.g. 0=male); Pain duration=number of weeks of shoulder pain from onset to the baseline; Daily Pain intensity=Brief Pain Inventory; Disability=QuickDASH.

FIGURE 2. Postoperative Daily Pain Intensity and Disability

A) Daily pain intensity (Brief Pain Inventory) and B) Disability (QuickDASH) at baseline, 3 months, 6 months, and 1 year. Error bars indicate 95% confidence interval of the mean.

TABLE 1

Patient Intake Characteristics

Female (%)	33.8
Age	42.6 (17.6)
Pain Duration, Weeks	66.88 (91.7)
RC Tear Severity n (%)	
No Tear	74 (51.0)
Partial, <50%	26 (17.9)
Partial, >50%	7 (4.8)
Small	10 (6.9)
Medium	11 (7.6)
Large	6 (4.1)
Massive	11 (7.6)
Baseline Daily Pain Intensity	3.21 (2.3)
Baseline Pain-Related Disability	34.26 (17.9)

Values for Age, Pain Duration, Daily Pain Intensity and Pain-Related Disability presented in mean value (parentheses represent standard deviation). Pain Duration = number of weeks of shoulder pain from onset to the baseline; Daily Pain intensity=Brief Pain Inventory Short Form; Pain-Related Disability=QuickDASH.

TABLE 2

Frequency of Intraoperative Procedures and Concomitant Procedure Estimate

<u>Intraoperative Procedure, n (%)</u>	
Acromion	
Acromioplasty	63 (43.4)
Bursa	
Bursectomy	63 (43.4)
Biceps	
Tenodesis/Tenotomy	28 (19.3)
Capsule	
Manipulation/Release	12 (8.3)
Chondral	
Chondroplasty	19 (13.1)
Labral	
Debridement	35 (24.1)
Repair	64 (44.1)
RCT	
Debridement	28 (19.3)
Repair	39 (26.9)
<u>Concomitant Procedure Estimate</u>	
Mean (SD)	3.13 (1.3)
Frequency, n (%)	
1	4 (2.8)
2	59 (40.7)
3	28 (19.3)
4	32 (22.1)
5	12 (8.3)
6	10 (6.9)

Intraoperative procedures with 2 levels (acromion, biceps, bursa, capsule, chondral) were scored as 1 if in the affirmative. Procedures with greater than 2 levels (labral, RCT) were given weighted score (0=no procedure; 1=debridement; 2=repair). Scores then added to calculate concomitant procedure estimate for each individual.

TABLE 3

Univariate Regression of RCT Severity and Concomitant Procedure Estimate on Postoperative Shoulder Pain and Disability

	3 Months		6 Months		1 Year	
	R ²	p	R ²	p	R ²	p
Daily Pain Intensity						
RTC Tear Severity	0.012	0.241	0.007	0.372	0.001	0.822
Concomitant Procedure Estimate	0.057	0.009	0.009	0.313	0.003	0.578
Disability						
RTC Tear Severity	0.057	0.009	0.017	0.152	0.000	0.926
Concomitant Procedure Estimate	0.067	0.005	0.022	0.100	0.017	0.177

Variance explained (R²) and significance (p) for RCT Severity and Concomitant Procedures on Daily Pain Intensity and Disability at 3 months, 6 Months, and 1 Year. Bold representative of significant association; Daily Pain intensity=Brief Pain Inventory; Pain-Related Disability=QuickDASH.

TABLE 4
Multivariate Regression Predicting 3 Month Postoperative Shoulder Pain and Disability

Predictors	3 Month Daily Pain Intensity					3 Month Disability				
	B	St. Beta	p	Tol	VIF	B	St. Beta	p	Tol	VIF
RTC Tear Severity						0.393	0.053	0.455	0.567	1.763
Concomitant Procedure Estimate	0.232	0.203	0.036	0.731	1.368	1.345	0.121	0.254	0.686	1.457
Age	0.000	0.008	0.970	0.678	1.476	0.086	0.104	0.364	0.582	1.719
Sex	-0.342	-0.106	0.214	0.932	1.073	5.401	1.173	0.066	0.877	1.141
Pain Duration	0.001	0.046	0.578	0.990	1.010	-0.003	-0.018	0.842	0.985	1.016
Baseline Daily Pain Intensity	0.304	0.465	<.001	0.855	1.169					
Baseline Disability						0.124	0.147	0.135	0.806	1.241

Prediction magnitude for RCT Severity and Concomitant Procedures after accounting for age, sex, pain duration, baseline daily pain intensity and disability; B=unstandardized beta coefficient; St. Beta=standardized beta coefficient; p=significance of association; Tol=tolerance; VIF=variance inflation factor.