Predictive Factors and the Duration to Pre-Injury Work Status Following Biceps Tenodesis

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Purpose: To determine when patients return to work after biceps tenodesis stratified by the preinjury level of work-intensity and to identify predictive measures of return to work. **Methods:** Patients undergoing biceps tenodesis between 2014 and 2017 were reviewed. Patients receiving concomitant rotator cuff repair or arthroplasty, revision biceps tenodesis, or unemployment before the procedure were excluded. Patient-acceptable symptom state (PASS), substantial clinical benefit, and minimal clinically important difference were calculated for the American Shoulder Elbow Society (ASES) score, subjective Constant-Murley score (CMS), and Single Assessment Numerical Evaluation (SANE) using the anchor-based and distribution-based approach. Preoperative outcome scores were analyzed to determine their predictive power of return to work using receiver operator curve area under the curve (AUC) analysis. Multivariate logistical analysis assessed predictive variables of return to work. **Results:** Seventy-nine percent of patients were able to return to work without permanent restrictions at an average of 5.4 ± 2.8 months after biceps tenodesis. Return to work status for sedentary, light, moderate, and heavy duties were 100%, 85%, 71%, and 69%, respectively. Return to work was associated with achieving PASS for the ASES and SANE questionnaires ($P = .006$, .003, respectively) but not for the CMS ($P = .768$). On multivariate analysis, there were no preoperative or intraoperative variables that were predictive of return to work in full capacity. The preoperative Short Form-12 mental component score (>59.4, AUC = 71.2%) was predictive of returning to work. **Conclusions:** After biceps tenodesis, most patients were able to return to work at an average of 5.4 ± 2.8 months. Furthermore, there were no demographic or intraoperative variables that were predictive of return to work. Work intensity was not correlated with an increased duration of return to work. Achieving PASS on the ASES and SANE questionnaires was predictive of return to work. **Level of Evidence:** Level IV, case series.

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Lesions to the long head of the biceps tendon is often treated via a tenotomy or tenodesis procedure. The incidence of isolated biceps tenodesis procedures increased by 1.8-fold from 2008 to 2011, and the incidence of biceps tenodesis increased by 1.8-fold over the same period.[1] Biceps tenodesis is more commonly performed in younger, active patients, as well as laborers, and results in a lower incidence of residual pain, cramping, and cosmetic deformity.[2,3] The increase in the incidence of biceps tenodesis may be owing to improved understanding of concurrent tendon and labral pathology, patient or surgeon preference to eliminate all potential sources of pain, and improved instrumentation and techniques that facilitate minimally invasive approaches.[4]

The increase in biceps tenodesis procedures predominantly occurred in the patient population that comprises most of the workforce population.[1,4] After operative management, patients are limited in their ability to perform activities of daily living and work-related tasks. Although functional changes are captured by patient-reported outcome measures (PROMs), the duration from operative intervention until reintegration to the previous level of occupational functioning is not well understood, and its relationship to PROMs remains undefined.

Outcomes after tenodesis of the long head of the biceps tendon are favorable regardless of fixation site or technique.[5,6] Although patients report satisfactory improvements after biceps tenodesis, improvements in PROMs should be interpreted in a clinically meaningful manner. The minimal clinically important difference (MCID), which is the minimum change in outcome score that the patient perceives,[7] patient-acceptable symptom state (PASS), which is the outcome score at which patients deem their condition as satisfactory,[8] and substantial clinical benefit (SCB), which describes the value for substantial clinical improvement,[9] are common metrics to assess clinically important changes in PROMs.

Notwithstanding, the ability to return to work is an important factor for patients after operative intervention.[10] It is imperative to counsel patients on their timeline to return to work in light of their work-intensity status to manage postoperative patient expectations effectively. Establishing return to work as an outcome metric enables patients and physicians to evaluate the success of the biceps tenodesis procedure. It is beneficial to establish whether a relationship exists between return to work and PROMs.

The purpose of this investigation is to determine when patients return to work after biceps tenodesis stratified by the preinjury level of work intensity and to identify predictive measures of return to work. Because PROMs summarize pain, function, and quality of life, it is hypothesized that these metrics can predict return to work after biceps tenodesis.

Methods

Data Collection

Our institution maintains a registry of all patients undergoing an biceps tenodesis and collects PROMs prospectively from 2014 until 2017. All PROMs are collected and retrieved electronically using a data collection service (Outcome Based Electronic Research Database; Universal Research Solutions, Columbia, Missouri). In addition to PROMs, anchor questions were also collected at the same timepoints to report the change in the patient's overall function.

From 2014 to 2017, patients undergoing biceps tenodesis without concomitant rotator cuff repair or shoulder arthroplasty from 1 of 6 fellowship-trained sports medicine or fellowship trained shoulder and elbow physicians at our institution were identified. Patients undergoing biceps tenodesis or with concomitant rotator cuff debridement, SLAP repair, labral or SLAP debridement, subacromial decompression, distal clavicle excision, capsular release, or coracohumeral ligament release were included in the investigation. Patients were excluded if they were undergoing revision biceps tenodesis or were unemployed at the time of surgery.

Open Subpectoral Biceps Tenodesis Surgical Technique

A 3-cm longitudinal incision is made lateral to the axillary fold. After blunt dissection, the surgeon follows the pectoralis major tendon to the intertubercular groove and manually retrieves the long head of the biceps tendon from the bicipital tunnel.

If a PEEK (polyether ether ketone) tenodesis screw (Arthrex, Naples, FL) was used for fixation, the surgeon placed 5-7 Krackow whipstitches in the long head of the biceps tendon (No. 2 FiberWire; Arthrex) beginning at the musculotendinous junction. A guidewire is placed in line with the bicipital tunnel 1.5 cm below the inferior border of the pectoralis major tendon. A 6.5-, 7-, or 8-mm-diameter tunnel is drilled through the cortex to accommodate the tendon and screw. A suture is passed through the PEEK screw and the tendon is inserted into the drill hole and is fixated with the interference screw. Last, the suture tails are tied to one to provide additional fixation strength. If a SutureFix suture anchor (Smith & Nephew, Andover, MA) was used, a 1.7- or 1.9-mm drill bit was used to create a unicortical tunnel. A 1.7- or 1.9-mm suture anchor is inserted into the humeral cortex. Sutures were passed through the biceps tendon at the musculotendinous junction for 10-15 mm in a Krackow fashion. The remainder of the tendon was removed, and the sutures were then tied to reapproximate the biceps in a normal position.

Arthroscopic Suprapectoral Biceps Tenodesis Surgical Technique

The arthroscope is placed in the lateral portal to view the humerus distally. The long head of the biceps tendon is then mobilized from any adhesions, and the transverse humeral ligament. Through an accessory anterosuperolateral portal, a spinal needle is positioned perpendicular to the bicipital groove, approximately 1.5 cm proximal to the superior border of the pectoralis major tendon. The long head of the biceps tendon is removed from the subdeltoid space through an arthroscopic portal. Final fixation occurred approximately 1.5 cm above the pectoralis major tendon within the bicipital groove. Fixation with an interference screw or suture anchor occurred as described earlier.

Postoperative Protocol

After operative management, patients were placed in a sling for 2 weeks for comfort purposes. After 2-4 weeks, the sling was discontinued. For the first 4 weeks after surgery, patients are instructed to exercise passive range of motion as tolerated with a focus on deltoid isometrics. From 4 to 8 weeks after surgery, patients are instructed to increase active range of motion as tolerated until full range of motion is achieved, as well as advance isometrics to the deltoid and rotator cuff. From 8 to 12 weeks after surgery, patients are instructed to progress to full range of motion without discomfort and advanced strength training as tolerated. To return to overhead work and sport activities, patients must have no complaints of pain and have adequate range of motion, strength, as well as endurance of the rotator cuff and scapular musculature.

Patient-Reported Outcome Measures

Patients completed shoulder-specific patient-reported questionnaires, including the American Shoulder and Elbow Society (ASES) score, the subjective Constant-Murley score (CMS),[11,12] and the Single Assessment Numerical Evaluation (SANE), as well as general health questionnaires, including the mental and physical component of the 12-item Veterans-RAND Health Survey, the Veterans-Rand 6-Dimensions, as well as the mental and physical components of the 12-item Short Form (SF-12) survey. Clinical improvement was assessed through patients reaching MCID, SCB, and PASS on PROMs. These metrics have previously been calculated for patients with a variety of shoulder pathologies, such as shoulder instability, rotator cuff injuries, and glenohumeral arthritis.[13] However, as described by Harris et al.,[13] these values are unique to each body part, system, and disease, and they have not been calculated for biceps tenodesis. MCID, PASS, and SCB were calculated for patients undergoing biceps tenodesis using an anchor-based and distribution-based approach using the question: "Since your surgery, has there been any change in the overall function of your shoulder?" This item is assessed on a 15-point scale ranging from "A very great deal worse" to "A very great deal better."[14] A receiver operator curve area under the curve (AUC) analysis was performed to determine MCID, SCB, and PASS thresholds. AUC values >70% were acceptable, and values >80% were excellent.[15] Threshold values for the MCID, SCB, and PASS were determined using a Youden index that maximizes sensitivity and specificity in a given relationship. Calculated MCID, SCB, and PASS for the ASES questionnaire was 16.3, 16.8, and 59.6, respectively, whereas the MCID, SCB, and PASS for the subjective CMS questionnaire was 6.8, 11.0, and 29.5. Last, the MCID, SCB, and PASS for the SANE questionnaire was 3.5, 5.8, and 65.5, respectively. These values were correlated with returning to work.

Physicians at this institution counsel patients that return to work and sport-related activity occur approximately 4-6 months after surgery. Patients were followed up until 6 months after surgery and were instructed to return on an as-needed basis. Patients were asked to complete PROMs at 6 months after surgery.

Data Analysis

Questionnaires were completed in a time-sensitive manner at the 6-month clinical visit to prevent heterogeneity of patient outcomes being recorded before or after this time point. Medical records were then reviewed to determine whether patients reached 100% functional capability as assessed by the treating physician or an independent examiner. It was also recorded if patients were able to return to work and in what capacity, whether permanent work restrictions were imposed, as well as any complications in the postoperative period. Last, duration of symptoms and previous surgical history were also recorded. The patient's occupation and level of intensity was recorded as described by the U.S. Department of Labor.[14] Duration of symptoms and the time to return to full activity were measured in months. Baseline characteristics, such as PROMs, age, sex, body mass index, comorbidities, smoking status, Workers' Compensation status were also collected for regression analysis and compared with those patients who did not have work status recorded in their medical record.

Statistical Analysis

Statistical analysis was performed using RStudio software version 1.0.143 (R Foundation for Statistical Computing, Vienna, Austria). The rate of return to work was analyzed for the overall population and then for each occupational level of intensity (sedentary, light, moderate, and heavy-duty populations). Differences in the rate of return to work based on

occupational level of intensity were calculated using the χ^2 test. Univariate analysis on all recorded variables was performed using the χ^2 test and Student's *t*-test. All variables that demonstrated a relationship with return to work with $P < .20$ were included in a multivariate logistical regression model. Final significance of each variable was considered with $P < .05$.

From the regression analysis, an odds ratio was calculated for each variable. A nonparametric receiver operating characteristic was created for each preoperative PROM to determine the future ability of a patient to return to work in full capacity without any permanent restrictions. AUC analysis was subsequently performed to determine if this association was predictive of return to work. The predictive power of PROM was considered acceptable with an AUC >0.7 and excellent with an AUC >0.8.[16] Optimal thresholds for each score were obtained using the Youden index to maximize sensitivity and specificity. A χ^2 test was performed to determine whether there was a correlation between return to work at full duty and achieving MCID, SCB, and PASS.

Results

Demographics

From 2014 to 2017, 342 consecutive patients underwent biceps tenodesis without concomitant rotator cuff repair or shoulder arthroplasty. Of this patient population undergoing biceps tenodesis, 120 patients completed all PROMs and anchor-based questions at 6 months after surgery. A total of 76 patients were documented to have held an occupation before undergoing biceps tenodesis. Sixty-seven patients (88.2%) had preoperative and postoperative work-intensity status documented in their medical record. There was no statistical difference between patient demographics in the group that reported work status than the group that did not report work status; however, there was a difference in gender distribution between both groups ($P = .04$; Table 1). A larger proportion of patients insured by Workers' Compensation were present in this population than in the group where work status was not reported ($P < .001$). Baseline ASES, SANE, and subjective CMS were not significantly different between either group ($P = .5$, $P = .9$, $P = .2$, respectively).

Operative Data

Operative data were collected and assessed in their ability to affect a patient's ability to return to work in full capacity. Concomitant procedures include subacromial decompression (n = 63, 82.9%), distal clavicle excision (n = 18, 24%), rotator cuff debridement (n = 10, 13%), labral debridement (n = 29, 38%), and SLAP repair (n = 7, 9%). Fixation technique included subpectoral fixation (n = 72, 95%) with a PEEK screw (n = 21, 28%) or suture anchor (n = 55, 72%). A single patient returned to the operating room after their index surgery, where the patient received a subacromial decompression and capsular release 4 months after the initial surgery.

Work Outcomes

After operative intervention, 78.9% of patients returned to the previous level of work intensity at an average time of 5.4 ± 2.8 months after operative intervention (Table 2). Patients who were insured by Workers' Compensation returned to work 5.5 ± 3.5 months after surgery, whereas those not insured by Workers' Compensation returned to work 6.5 ± 4.7 months after surgery ($P = .3$).The time to maximal medical improvement coincided with the time that patients were able to return to full work status. There was also no statistical difference between the time necessary to return to full duty and the level of work intensity ($P = .8$). No concomitant procedure, fixation site, or fixation modality (PEEK screw or suture anchor) was associated with return to work ($P > .05$).

In the entire population, the ASES, subjective CMS, SANE, and SF-12 mental and physical component

Table 1. Baseline Characteristics

	Return to Work Reported	No Return to Work Reported	*P* Value
No.	76	44	
Age, SD, yrs	43.1	38.9	.9
Male:Female (% male)	49:27 (64.5)	20:24 (45.5)	.04
BMI	29.7	27.8	>.99
Tobacco use, n	13	4	.2
History of diabetes, n	1	4	.05
History of thyroid problem, n	1	0	.3
Symptom duration ± SD, months	11.2 ± 12.1	10.8 ± 10.3	.8
Workers' Compensation, n (%)	56 (73.7)	7 (15.9)	<.001
Baseline ASES ± SD	47.5 ± 17.6	51.4 ± 21.1	.4
Baseline SANE ± SD	36.5 ± 22.0	36.1 ± 24.3	.9
Baseline constant ± SD	13.1 ± 6.7	15.5 ± 8.0	.2

ASES, American Shoulder Elbow Society score; BMI, body mass index; SANE, Single Assessment Numeric Evaluation; SD, standard deviation.

Table 2. Rate and Average Time of Return to Work After BT

	Working Before BT (n)	Working After BT (n)	Rate of RTW	Average Time to RTW (months)
Sedentary	8	8	100%	3.4 ± 2.6
Light	13	11	84.6%	4.4 ± 1.7
Moderate	17	12	70.6%	5.6 ± 2.8
Heavy	29	20	69.0%	5.6 ± 2.0
Total*	76	60	78.9%	5.4 ± 2.8

NOTE. No correlation between work intensity and rate of RTW ($P = .8$).

BT, biceps tenodesis; RTW, return to work.

*Total patients are greater than the sum of patients with work intensity status because there were several patients in whom work-intensity status was not provided.

scores significantly increased from the preoperative to 6-month time point (Fig 1). ASES improved from 47.5 ± 17.6 to 74.8 ± 17.9 ($P < .001$), SANE improved from 36.5 ± 22.9 to 57.0 ± 31.8 ($P < .001$), and the subjective CMS improved from 13.1 ± 6.7 to 17.0 ± 7.7 ($P = .006$). The quality of life metrics also improved from the preoperative to 6-month timepoints (Fig 1), the SF-12 physical component improved from 32.3 ± 3.7 to 40.8 ± 10.6 ($P = .006$), and the SF-12 mental component improved from 44.1 ± 14.3 to 51.8 ± 13.9 ($P = .03$). Achieving a PASS for ASES and SANE was associated with returning to work at full duty in comparison to those who did not return to work at their previous level of function ($P = .006$, $P = .003$, respectively; Table 3). However, achieving PASS for the subjective CMS score was not associated with the ability to return to work in full capacity ($P = .8$).

Univariate analysis of 25 preoperative and intraoperative variables demonstrated that Workers' Compensation status was the only variable to be associated with the inability to return to work ($P = .04$). Subsequent multivariate analysis of significant variables and those that were trending toward significance (duration of symptoms and previous surgery) revealed that no variable was associated with the inability to return to work (Table 4).

Predictive Metrics of Return to Work

A score >59.4 on the SF-12 mental component had a specificity of 46.7% and a sensitivity of 100% in predicting return to work the overall population (AUC = 71.2%; Fig 2). Within the moderate-duty subgroup, an outcome score with the SF-12 mental component of 50.6, respectively, was predictive of return to work (AUC = 71.4%; Table 5).

Discussion

In this investigation, it was demonstrated that 79% of patients returned to their previous level of work duty at an average of 5.4 ± 2.8 months after biceps tenodesis. As the level of work intensity increased, the proportion of patients who returned to their previous work level decreased; however, this finding was not statistically significant. Achieving a PASS on the ASES and SANE questionnaires was predictive of return to work, although it was not predictive of return to work for the subjective CMS survey. The preoperative SF-12 mental component score was predictive of return to full level of duty in the overall population, specifically within the heavy-duty group. However, disease-specific PROMs were not predictive metrics for the ability to return to work in the full capacity.

Return to sport is a commonly reported outcome metric after orthopaedic procedures because it serves as an identifiable milestone after operative management, and it functions to help outline patient expectations in the postoperative period. Similarly, return to work at the preinjury functional status can serve as a marker to help manage patient expectations. After biceps tenodesis for SLAP tears or tenosynovitis, 73%-85% of patients returned to sport by 2 years after surgery.[17,18] Although biceps tenodesis demonstrates a high rate of return to sport, no previous investigation has established a timeline or factors that may predict return to the previous level of work intensity. Bhatia et al.[19] demonstrated that 89% of Workers' Compensation status patients returned to work 7.6 ± 2.6 months after rotator cuff repair. Seventy-five percent of patients who

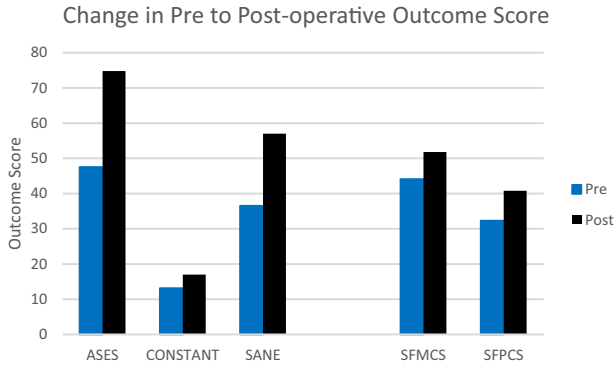

Fig 1. Change in outcome score 6 months after surgery from baseline following biceps tenodesis. (ASES, American Shoulder Elbow Society score; SANE, Single Assessment Numeric Evaluation; SFMCS, Short-Form 12 mental component score; SFPCS, Short-Form 12 physical component score.)

Table 3. Relationship Between Achieving MCID, SCB, and PASS from ASES, SANE, and Constant Scores to Return to Work

Metric	Light Duty (*P*)	Moderate Duty (*P*)	Heavy Duty (*P*)	Overall (*P*)
ASES				
Achieving MCID	.070	.620	.096	.020
Achieving SCB	.231	>.999	.194	.035
Achieving PASS	>.999	<.001	.311	.006
SANE				
Achieving MCID	.070	>.999	.088	.356
Achieving SCB	>.999	>.999	.231	.356
Achieving PASS	.559	.029	.209	.003
Constant				
Achieving MCID	>.999	>.999	.231	.548
Achieving SCB	N/A	N/A	N/A	N/A
Achieving PASS	>.999	.338	.231	.768

MCID, minimally clinically important difference; PASS, patient- acceptable symptom state; SCB, substantial clinical benefit.

underwent concomitant biceps tenodesis with rotator cuff repair demonstrated a delay in achieving maximal medical improvement and return to previous level of work intensity, because they returned to work between 7 and 12 months after surgery. Although rotator cuff repair is a major operative procedure that limits patients in their ability to perform work-related activities, the findings of this previous investigation establish that biceps tenodesis is an impediment in a patient's ability to achieve their full previous level of functioning. The results of this investigation establish a timeline for patients to return to work after biceps tenodesis and that the ability to return to work is dependent on the level of physical intensity of a patient's occupation.

Although patients demonstrated an improvement in all PROMs 6 months after surgery, achieving PASS on the ASES and SANE questionnaires were significantly associated with the ability to return to work in full capacity. PASS is a PROM-based methodology of establishing patient satisfaction.[20] Because achieving PASS for several disease-specific outcome metrics was significantly associated with the ability to return to work, this illustrates that return to work is a prominent factor in determining patient satisfaction. Achieving PASS on the subjective CMS was not associated with the ability to return to work in this group. Although the subjective CMS is an efficient outcome metric because of its brevity, it is not comprehensive enough to truly recapitulate a patient's symptom state.[21,22] The CMS provides physicians an opportunity to efficiently implement its use into the clinical setting; however, the addition of the objective component is time-consuming and lacks the responsiveness to changes in the patient condition.[23] Instead, other outcome metrics, such as ASES, have been shown to be more effective in responding to changes in patient function owing to its methodologic strength.[21,23] In this investigation, the ASES questionnaire was the only outcome measure where achieving MCID and SCB was predictive of return to work, demonstrating that the questionnaire is more responsive and reflective of functional status required for return to work.

It was also demonstrated that the preoperative SF-12 mental component score was predictive of patients' ability to return to work in a full capacity, especially in the heavy-duty group. This result exemplifies the relationship that exists between mental health and musculoskeletal function and its subsequent impact on a patient's livelihood. The SF-12 survey assesses for depression, anxiety, as well as functional impairment that occurs secondary to psychological distress.[24] Analogous to anterior cruciate ligament reconstruction, where psychological factors may play a role in determining return to play after ligament reconstruction,[15,25] fear of reinjury may delay a patient's return to work in full capacity after biceps tenodesis. This perception is likely magnified when a patient's livelihood depends specifically on their shoulder function and strength, both of which may be compromised after surgery. Regardless of age, gender, or socioeconomic status, a score >50 on the SF-12 mental component score demonstrates that it is less likely that a patient has depression, anxiety, or any other common mental disorder.[26] Thus patients with higher preoperative SF-12

Table 4. Multivariate Analysis of Variables Associated With Return to Work

	Univariate Regression (*P*)	Multivariate Regression (*P*)	Odds Ratio (95% CI)
Workers' Compensation	.041	.886	1.139 (0.191-6.795)
Previous surgery	.070	.176	3.552 (0.567-22.260)
Duration of symptoms	.051	.206	0.958 (0.896-1.024)

CI, confidence interval.

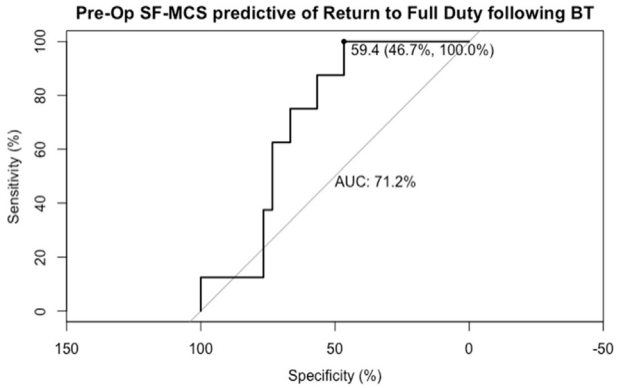

Fig 2. ROC AUC analysis of the Short Form-12 mental component demonstrating its predictive power of return to work in full capacity. (ROC, receiver operator curve; AUC, area under the curve.)

mental component scores may demonstrate increased resilience with the recovery process, more confidence in their shoulder function, and may return to work earlier than those with lower preoperative scores. The preoperative SF-12 mental component scores may recapitulate resilience and may be used as a surrogate measure of psychological factors that influence return to work and subjective clinical outcomes, as demonstrated with anterior cruciate ligament reconstruction.[27] Although the definition of resilience revolves around the concept of mental fortitude, other socioeconomic factors may influence resilience and may contribute to one's ability to return to work in full capacity. As such, higher SF-12 mental component scores may also be reflective of social and emotional factors that are also influential in the recovery process.

Table 5. Predictive Value of Preoperative Scores Toward Return to Work

	Threshold	Specificity (%)	Sensitivity (%)	AUC (%)
Moderate Duty				
ASES	35.6	55.6	80.0	56.7
Constant	11.5	80.0	40.0	42.0
SF-MCS	50.6	57.1	100.0	71.4
SF-PCS	32.7	57.1	100.0	57.1
Heavy Duty				
ASES	61.7	35.3	100.0	71.1
Constant	10.2	100.0	85.7	87.9
SF-MCS	52.4	50.0	75.0	58.2
SF-PCS	35.6	66.7	100.0	66.7
Overall Population				
ASES	47.4	58.5	71.4	62.2
Constant	8.5	87.5	60.0	74.0
SF-MCS	59.4	46.7	100.0	71.2
SF-PCS	33.0	56.7	87.5	58.8

ASES, American Shoulder Elbow Society Score; AUC, area under the curve; SANE, Single Assessment Numeric Evaluation; SF-MCS, Short Form-12 mental component score; SF-PCS, Short Form-12 physical component score.

Limitations

Although the data for this investigation were collected prospectively, this study was conducted in a retrospective manner, which carries its intrinsic limitations such as an inability to control baseline characteristics or operative techniques. The largest limitation of this study is the heterogeneity of the selected study group, because the included patients received various combinations of concomitant procedures. However, most of the biceps tenodesis literature involves patients who received a rotator cuff repair, which is a procedure that involves a longer recovery period than biceps tenodesis.[28] The authors contend that biceps tenodesis is rarely performed in isolation and that it is frequently accompanied by concomitant procedures such as subacromial decompression, tissue debridement, and distal clavicle excision. Furthermore, the authors believe that among the concomitant procedures included in this study, biceps tenodesis represents the rate-limiting procedure in terms of recovery period. Varying indications by physicians included in this investigation may contribute to the heterogeneity of the patient population. Owing to poor outcomes after combined SLAP repair and biceps tenodesis, there is a trend toward performing fewer of these procedures at this institution.[29,30] In this investigation, indications for performing combined SLAP repair and biceps tenodesis includes high demand patients, such as athletes or overhead laborers, with type II or IV SLAP tears who were perceived to be at an elevated risk for glenohumeral instability.[29] An additional limitation is that the primary outcome metric of this investigation was the patient's ability to return to work. However, the patient's functionality on reintegration into the workforce was not assessed and may present a discordance with the treating physician releasing the patient to full duty. This study would benefit from a longer duration of follow-up to capture the patient's ability to maintain their level of function as their ability to perform work activities may be influenced by nonpatient factors, such as job performance, economy, personal matters, or other socioeconomic factors. Finally, the subgroup analysis that attempted to correlate time to return to work and work intensity may have been underpowered for patients with light and sedentary occupations.

Conclusions

After biceps tenodesis, most patients were able to return to work at an average of 5.4 ± 2.8 months. Furthermore, there were no demographic or intraoperative variables that were predictive of return to work. Work intensity was not correlated with an increased duration of return to work. Achieving PASS on the ASES and SANE questionnaires was predictive of return to work.

References

1. Werner BC, Brockmeier SF, Gwathmey FW. Trends in long head biceps tenodesis. *Am J Sports Med* 2015;43:570-578.
2. Shang X, Chen J, Chen S. A meta-analysis comparing tenotomy and tenodesis for treating rotator cuff tears combined with long head of the biceps tendon lesions. *PLoS One* 2017;12:e0185788.
3. Boileau P, Neyton L. Arthroscopic tenodesis for lesions of the long head of the biceps. *Oper Orthop Traumatol* 2005;17:601-623.
4. Vellios EE, Nazemi AK, Yeranosian MG, et al. Demographic trends in arthroscopic and open biceps tenodesis across the United States. *J Shoulder Elbow Surg* 2015;24:e279-e285.
5. AlQahtani SM, Bicknell RT. Outcomes following long head of biceps tendon tenodesis. *Curr Rev Musculoskelet Med* 2016;9:378-387.
6. Abraham VT, Tan BH, Kumar VP. Systematic review of biceps tenodesis: Arthroscopic versus open. *Arthroscopy* 2016;32:365-371.
7. Nwachukwu BU, Runyon RS, Kahlenberg CA, Gausden EB, Schairer WW, Allen AA. How are we measuring clinically important outcome for operative treatments in sports medicine? *Phys Sportsmed* 2017;45:159-164.
8. Maksymowych WP, Richardson R, Mallon C, van der Heijde D, Boonen A. Evaluation and validation of the patient acceptable symptom state (PASS) in patients with ankylosing spondylitis. *Arthritis Rheum* 2007;57:133-139.
9. Glassman SD, Copay AG, Berven SH, Polly DW, Subach BR, Carreon LY. Defining substantial clinical benefit following lumbar spine arthrodesis. *J Bone Joint Surg Am* 2008;90:1839-1847.
10. Mihata T, Lee TQ, Fukunishi K, et al. Return to sports and physical work after arthroscopic superior capsule reconstruction among patients with irreparable rotator cuff tears. *Am J Sports Med* 2018:363546517753387.
11. Levy O, Haddo O, Massoud S, Mullett H, Atoun E. A patient-derived Constant-Murley score is comparable to a clinician-derived score. *Clin Orthop Relat Res* 2014;472:294-303.
12. Ebert JR, Wang A, Smith A, et al. A midterm evaluation of postoperative platelet-rich plasma injections on arthroscopic supraspinatus repair: A randomized controlled trial. *Am J Sports Med* 2017;45:2965-2974.
13. Harris JD, Brand JC, Cote MP, Faucett SC, Dhawan A. Research pearls: The significance of statistics and perils of pooling. Part 1: Clinical versus statistical significance. *Arthroscopy* 2017;33:1102-1112.
14. Juniper EF, Guyatt GH, Willan A, Griffith LE. Determining a minimal important change in a disease-specific Quality of Life Questionnaire. *J Clin Epidemiol* 1994;47:81-87.
15. Nwachukwu BU, Chang B, Voleti PB, et al. Preoperative short form health survey score is predictive of return to play and minimal clinically important difference at a minimum 2-year follow-up after anterior cruciate ligament reconstruction. *Am J Sports Med* 2017;45:2784-2790.
16. Berliner JL, Brodke DJ, Chan V, SooHoo NF, Bozic KJ. John Charnley Award: Preoperative patient-reported outcome measures predict clinically meaningful improvement in function after THA. *Clin Orthop Relat Res* 2016;474:321-329.
17. Tahal DS, Katthagen JC, Vap AR, Horan MP, Millett PJ. Subpectoral biceps tenodesis for tenosynovitis of the long head of the biceps in active patients younger than 45 years old. *Arthroscopy* 2017;33:1124-1130.
18. Pogorzelski J, Horan MP, Hussain ZB, Vap A, Fritz EM, Millett PJ. Subpectoral biceps tenodesis for treatment of isolated type II SLAP lesions in a young and active population. *Arthroscopy* 2018;34:371-376.
19. Bhatia S, Piasecki DP, Nho SJ, et al. Early return to work in Workers' Compensation patients after arthroscopic full-thickness rotator cuff repair. *Arthroscopy* 2010;26:1027-1034.
20. Kocher MS, Steadman JR, Briggs K, Zurakowski D, Sterett WI, Hawkins RJ. Determinants of patient satisfaction with outcome after anterior cruciate ligament reconstruction. *J Bone Joint Surg Am* 2002;84-A:1560-1572.
21. Makhni EC, Hamamoto JT, Higgins JD, et al. How comprehensive and efficient are patient-reported outcomes for rotator cuff tears? *Orthop J Sports Med* 2017;5:2325967117693223.
22. Huang H, Grant JA, Miller BS, Mirza FM, Gagnier JJ. A systematic review of the psychometric properties of patient-reported outcome instruments for use in patients with rotator cuff disease. *Am J Sports Med* 2015;43:2572-2582.
23. Unger RZ, Burnham JM, Gammon L, Malempati CS, Jacobs CA, Makhni EC. The responsiveness of patient-reported outcome tools in shoulder surgery is dependent on the underlying pathological condition. *Am J Sports Med* 2018:363546517749213.
24. Vilagut G, Forero CG, Pinto-Meza A, et al. The mental component of the short-form 12 health survey (SF-12) as a measure of depressive disorders in the general population: Results with three alternative scoring methods. *Value Health* 2013;16:564-573.
25. Ellman MB, Sherman SL, Forsythe B, LaPrade RF, Cole BJ, Bach BR Jr. Return to play following anterior cruciate ligament reconstruction. *J Am Acad Orthop Surg* 2015;23:283-296.
26. Gill SC, Butterworth P, Rodgers B, Mackinnon A. Validity of the mental health component scale of the 12-item Short-Form Health Survey (MCS-12) as measure of common mental disorders in the general population. *Psychiatry Res* 2007;152:63-71.
27. Nwachukwu BU, Voleti PB, Berkanish P, et al. Return to play and patient satisfaction after ACL reconstruction: Study with minimum 2-year follow-up. *J Bone Joint Surg Am* 2017;99:720-725.
28. Zuke WA, Leroux TS, Gregory BP, et al. Establishing maximal medical improvement after arthroscopic rotator cuff repair. *Am J Sports Med* 2018;46:1000-1007.
29. Chalmers PN, Monson B, Frank RM, et al. Combined SLAP repair and biceps tenodesis for superior labral anterior-posterior tears. *Knee Surg Sports Traumatol Arthrosc* 2016;24:3870-3876.
30. Hurley ET, Fat DL, Duigenan CM, Miller JC, Mullett H, Moran CJ. Biceps tenodesis versus labral repair for superior labrum anterior-to-posterior tears: A systematic review and meta-analysis. *J Shoulder Elbow Surg* 2018;27:1913-1919.