

Research Article

Risk Factors for Unexpected Hospital Admission Following Achilles Tendon Repair: A National Database Study

John M. Tarazi, MD^{1,2}^a, Matthew J. Partan, DO^{1,2b}, Areil Aminov, BS^{1c}, Alain E. Sherman, MD^{1,3d}, Adam D. Bitterman, DO^{1,2e}, Randy M. Cohn, MD^{1,2,4f}

¹ Donald & Barbara Zucker School of Medicine at Hofstra/Northwell, ² Department of Orthopaedic Surgery, Northwell Health—Huntington Hospital, ³ NYC Health + Hospitals Lincoln, ⁴ Department of Orthopaedic Surgery, Northwell Health—Long Island Jewish Valley Stream

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INTRODUCTION

Achilles tendon rupture (ATR) repair is one of the most common orthopaedic surgeries performed in the United States, however there is a paucity of literature on predisposing risk factors for hospital readmissions. The purpose of this study is to identify risk factors

a Dr. Tarazi is a research fellow for Northwell Health—Huntington Hospital for the Department of Orthopaedic Surgery.

[Visit Dr. Tarazi's Website](#)

[Conflicts of Interest Statement for Dr. Tarazi](#)

b Matthew Partan is a PGY-5 chief resident at the Northwell Health Orthopedic Surgery Residency Program at Huntington Hospital. He will be attending the University of Connecticut for a sports medicine fellowship next year for continued training.

[Conflicts of Interest Statement for Dr. Partan](#)

c [Conflicts of Interest Statement for Ariel Aminov](#)

d Alain Sherman is currently a resident physician at NYC Health + Hospitals Lincoln. He will begin residency in diagnostic radiology later this year.

[Conflicts of Interest Statement for Dr. Sherman](#)

e Adam D. Bitterman, DO is a board certified orthopaedic surgeon and an Assistant Professor of Orthopaedic Surgery at the Donald and Barbara Zucker School of Medicine at Hofstra/Northwell. He is the Chairman of Orthopaedic Surgery at Huntington Hospital. He is a foot and ankle specialist and has a focus in treating conditions of the lower leg. His clinical interests include arthritis of the foot and ankle, deformity correction, Achilles tendon disorders, and sports-related injuries to the ankle and foot. He is highly skilled in arthroscopic, minimally invasive, and open approaches for various conditions surrounding the lower foot and ankle.

[Visit Dr. Bitterman's Website](#)

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[Conflicts of Interest Statement for Dr. Bitterman](#)

f Dr. Cohn is a board certified orthopaedic surgeon and sports medicine specialist with a clinical focus on arthroscopic treatment of the knee, shoulder, hip, ankle, and elbow. Dr. Cohn also specializes in anterior cruciate ligament reconstruction, hip labral injury and impingement, and shoulder arthroscopy and shoulder replacement surgery.

After graduating from Mount Sinai School of Medicine with distinction in research, Dr. Cohn performed his orthopaedic surgery residency at NYU Hospital for Joint Diseases where he was recognized for his leadership and clinical teaching. He completed his sports medicine fellowship training at Massachusetts General Hospital and Harvard Medical School. As a fellow in sports medicine and shoulder surgery at Massachusetts General Hospital, Dr. Cohn served as an assistant team physician for the New England Patriots, Boston Red Sox, Boston Bruins, New England Revolution, and numerous colleges and high schools, gaining experience in treating athletes at all levels.

Currently, Dr. Cohn is the team orthopaedic surgeon for Hofstra University and several Long Island high schools. He also serves as the director of Northwell Health's Dance Medicine and Performing Arts Program, Young Adult Hip Preservation Program, and as the medical director of the Hofstra University Athletic Training Program. Dr. Cohn's academic titles include Assistant Professor of Orthopaedic Surgery at the Zucker School of Medicine and the Associate Program Director of the Northwell Health Plainview Hospital Orthopaedic Residency Program.

[Visit Dr. Cohn's Website](#)

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for 30-day readmission in patients undergoing ATR repair with emphasis on procedures performed in the outpatient setting. Specifically, we examine: 1) 30-day post-operative hospital readmission rates; 2) the medical comorbidities and patient characteristics that predisposed this cohort to post-operative complications; and 3) the complications leading to readmission.

METHODS

The ACS-NSQIP was queried for patients who underwent ATR from 2015 to 2019 using CPT code 27650 in all fields yielding a sample size of 3,887 cases. The following demographic, lifestyle, and comorbidity variables were recorded: age, sex, race, BMI, morbid obesity ($\text{BMI} \geq 40.00 \text{ kg/m}^2$), bleeding disorders, chronic obstructive pulmonary disease (COPD), diabetes mellitus, hypertension, tobacco use, and chronic steroid use. The primary outcome of 30-day readmission was defined as unplanned hospital readmission likely related to the principal procedure. Independent samples Student's t-tests, chi-squared, and, where appropriate, Fisher's exact tests were used in univariate analyses to identify demographic, lifestyle, and peri-operative variables related to 30-day readmission following ATR. Multivariate logistic regression modeling was subsequently performed. Odds ratios (ORs) with 95% confidence intervals (CIs) were calculated and reported.

RESULTS

Of the 3,887 patients included in our sample, 28 were readmitted within the 30-day post-operative period, corresponding to a readmission rate of 0.73%. Significant relationships with univariate analyses between readmission status and the following patient variables included: mean patient age ($p = 0.02$); hypertension ($p < 0.001$); BMI ($p = 0.01$); morbid obesity ($p = 0.002$); ASA Classification ($p = 0.006$); and bleeding disorders ($p = 0.03$). Multivariate logistic regression modeling confirmed that the following patient variables were associated with statistically significantly increased odds of readmission: age, $p = 0.02$, OR = 1.03, 95% CI [1.01, 1.06]; hypertension, $p < 0.001$, OR = 3.82, 95% CI [1.81, 8.06]; BMI, $p = 0.01$, OR = 1.06, 95% CI [1.01, 1.11]; morbid obesity, $p = 0.004$, OR = 3.53, 95% CI [1.49, 8.36].

CONCLUSION

Our study indicated that only 0.73% of patients were readmitted after their outpatient procedure. Patients who: 1) have BMIs greater than 40; 2) are older in age 3) have hypertension; and 4) a higher ASA Classification were at increased risk for readmission.

INTRODUCTION

The Achilles tendon is the largest, strongest, and most commonly injured tendon in the human body (Dams et al. 2019; Oda et al. 2016). The incidence of an Achilles tendon rupture (ATR) is increasing and currently stands at 11-37 cases per 100,000 persons per year (Ganestam et al. 2015). Although most ATR repairs are performed in an ambulatory setting, surgical repair of these injuries may result in complications requiring readmission to the hospital.

The importance for physicians to identify which patients are at increased risk for post-operative complications can hopefully address unexpected readmissions after ATR repair. While previous studies have postulated that risk factors such as diabetes, hypertension, and drug abuse increase the risk of post-operative complications, the data is limited (Amendola 2014; Pean et al. 2018; Stavenuiter et al. 2019). Therefore, the purpose of this study is to identify risk factors for unexpected admission following ATR repair. Specifically, we examine: 1) 30-day post-operative hospital readmission rates; 2) the specific characteristics that pre-

disposed this cohort to readmission; and 3) the complications leading to readmission.

METHODS

DATABASE

This study utilized the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) database (Improvement Q and Data Q 2014–2015). Data was collected by trained clinical reviewers from over 700 participating hospitals and include patient demographics, comorbidities, surgery in Current Procedural Terminology (CPT) codes, diagnoses in International Classification of Disease 9th and 10th (ICD-9, ICD-10, respectively) revision codes, and 30-day post-operative surgical outcomes. Readmissions were defined as patients who were admitted to a hospital within 30 days of the index procedure.

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PATIENT POPULATION

The ACS-NSQIP was queried for patients who underwent ATR from 2015 to 2019 using CPT code 27650 in all fields yielding 5,121 cases. Patients with incomplete data were excluded (n = 1,234), resulting in a study population of 3,887 cases of ATR.

VARIABLES COLLECTED

The following demographic, lifestyle, and comorbidity variables were recorded: age, sex, race, BMI, morbid obesity (BMI ≥ 40.00 kg/m²), American Society of Anesthesiologists (ASA) Classification bleeding disorders, chronic obstructive pulmonary disease (COPD), diabetes mellitus, hypertension, tobacco use, and chronic steroid use. Peri-operative variables that were collected included anesthesia type (general versus regional) and operative time. The primary outcome of 30-day readmission was defined as unplanned hospital readmission likely related to the principal procedure. Reasons for readmission were recorded.

STATISTICAL ANALYSES

All data were analyzed using the Statistical Package for the Social Sciences (SPSS) version 23.0 (IBM Corp., Armonk, NY). Independent samples Student's *t*-tests, chi-squared, and, where appropriate, Fisher's exact tests were used in univariate analyses to identify demographic, lifestyle, and perioperative variables related to 30-day readmission following ATR. Multivariate logistic regression modeling was subsequently performed. Odds ratios (ORs) with 95% confidence intervals (CIs) were calculated and reported.

RESULTS

Of the 3,887 patients included in our sample, 28 were readmitted within the 30-day post-operative period, corresponding to a readmission rate of 0.73%. The complications leading to readmissions are included in [Table 1](#). Demographic, lifestyle, comorbidity, and peri-operative factors are presented in [Table 2](#).

Results of univariate analysis revealed statistically significant relationships between readmission status and the following patient variables: mean patient age, $t(3,885) = 2.35$, $p = 0.02$; hypertension, $\chi^2(1, 3,887) = 14.38$, $p < 0.001$; BMI, $t(3,885) = 2.55$, $p = 0.01$; morbid obesity, $\chi^2(1, 3,887) = 9.33$, $p = 0.002$; ASA, $\chi^2(4, 3,887) = 14.50$, $p = 0.006$; and bleeding disorders $\chi^2(1, 2,991) = 4.70$, $p = 0.03$. Patient sex, race, ethnicity, COPD, diabetes, tobacco use, chronic

Table 1. Complications Leading to Readmission

Complication	Frequency N (%)
Pulmonary Embolism or Deep Vein Thrombosis	8 (28.6)
Infection (Deep or Superficial Incisional) or Wound Disruption	6 (21.4)
Sepsis/Septic Shock	2 (7.1)
Acute Pulmonary Edema, Acute Congestive Heart Failure	2 (7.1)
Pneumonia	2 (7.1)
Hematoma	1 (3.6)
Myocardial Infarction	1 (3.6)
Other	6 (21.4)
Total	28 (100)

steroid use, anesthesia type, and operative time were not significantly associated with readmission.

Multivariate logistic regression modeling confirmed that the following patient variables were associated with statistically significantly increased odds of readmission: age, $p = 0.02$, OR = 1.03, 95% CI [1.01, 1.06]; hypertension, $p < 0.001$, OR = 3.82, 95% CI [1.81, 8.06]; BMI, $p = 0.01$, OR = 1.06, 95% CI [1.01, 1.11]; morbid obesity, $p = 0.004$, OR = 3.53, 95% CI [1.49, 8.36]. The relationship between bleeding disorders and readmission trended toward, but did not achieve, statistical significance in the multivariate model, $p = 0.06$, OR = 7.02, 95% CI [0.90, 54.75].

DISCUSSION

The data addressing predisposing risk factors for complications after ATR repairs is currently limited. The goal of this study was to explore the patient characteristics that increased the risk of hospital readmission within 30 days of an outpatient ATR and to define the causes for readmission. During the study period, the 30-day admission rate was 0.73%. Following our analysis, patients with a history of hypertension, bleeding disorders, a BMI greater than 40 or patients 49 years-old and older. Furthermore, pulmonary emboli or deep vein thrombi along with infection (deep or superficial incisional) or wound disruption served as the major causes for readmission. These findings can provide surgeons with the knowledge of modifiable and non-modifiable risk factors when counseling their patients and discussing treatment options.

Table 2. The Relationship Between Demographic, Lifestyle, Comorbidity, and Peri-operative Factors and Readmission following Achilles Tendon Repair

Outcome	Not Admitted (N = 3,859)		Admitted (N = 28)		p-Value
	N	Percent (%)	N	Percent (%)	
Mean Age, year (SD)		42.96 ± 13.9		49.1 ± 17.1	0.02
Sex					0.155
Female	932	24.15	10	34.48	
Male	2,927	75.85	18	62.1	
Mean BMI, kg/m2 (mean ± SD)		30.5 ± 6.2		33.6 ± 9.2	0.01
BMI < 40	3,526	99.4	21	0.6	0.002
BMI ≥ 40 (Obesity Class III)	333	97.9	7	2.1	0.002
ASA Classification					0.006
Class I	1510	39.1	6	21.4	
Class II	1778	46.1	11	39.3	
Class III	554	14.4	11	39.3	
Class IV	15	0.4	0	0.0	
Race					0.26
Hispanic					0.87
Bleeding Disorder	21	0.71	1	4.8	0.03
Dyspnea/COPD	35	0.91	0	0.0	0.613
Diabetes					0.663
Non-Insulin Dependent	174	4.51	2	7.1	
Insulin Dependent	77	2.0	1	3.6	
No Diabetes	3,608	93.49	25	89.3	
Hypertension	800	20.7	14	50.0	< 0.001
Current Smoker	468	12.1	2	7.1	0.569
Steroid Use	46	1.2	1	3.6	0.29
Anesthesia Type					0.871
General	3,304	97.4	26	92.9	
Regional	87	2.6	1	3.6	
Op Time					0.973

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There is a paucity of literature on unanticipated hospital admissions after ATR repair. In a retrospective study in 2016, Rensing *et al.* studied 1,626 patients who underwent an ATR repair and found that there was a total of 28 (1.7%) patients who recorded complications during the 30-day post-operative period (Rensing *et al.* 2016). Twenty-one local complications (1.3%) accounted for most of these complications with the most common being superficial wound

infections (0.7%) or wound disruption (0.4%). Furthermore, this study demonstrated that readmissions were scarce and included five total patients (0.3%). In a 2017 retrospective study, Hussein *et al.* identified 4,040 patients who had an Achilles tendon repair and determined that during the 30-day post-operative period, 1.16%, 0.4%, and 0.02% of those patients returned with a surgical infection, DVT requiring therapy, or sepsis, respectively (Hussien *et al.*

2021). Specifically, Hussein *et al.* determined that patients who had open wounds or pre-operative wound infections had higher odds to return during the 30-day post-operative period due to surgical infection, $p < 0.001$, OR = 25.96, 95% CI [6.45, 104.47]. Although limited in literature, these studies support our findings and attribute the types of complications that led to unplanned readmissions in ATR repair.

The findings of previous studies exploring the association between obesity and adverse post-operative outcomes are varied. A database analysis of 18,948 patients, Burrus *et al.* determined that obese patients had significantly higher rates of post-operative wound complications (OR = 2.1; $p < 0.0001$), infection (OR = 1.8; $p < 0.0001$), venous thromboembolism (VTE) (OR = 1.8; $p < 0.0001$), and medical complications (OR = 3.9. $p < 0.0001$) (Burrus *et al.* 2015). Conversely, a review by Pean *et al.* did not find any correlation between obesity and increased risk of adverse post-operative outcomes (Pean *et al.* 2018). However, a limitation of that study was that the sample analyzed was small (N = 1164) and patients were only followed up within 30 days of their operation. In contrast, Dombrowski *et al.* analyzed over 24,000 patient records and found that obesity was associated with a significantly elevated risk for post-operative surgical site infection (SSI), $p < 0.001$; OR = 3.23, 95% CI [2.9, 3.6] (Dombrowski *et al.* 2019). Our study found that patients with severe obesity (BMI ≥ 40) had a significantly increased chance for hospital admission within 30 days of their outpatient ATR. Of note, our study did not find a statistically significant increase in hospital readmissions in obese patients whose BMI was less than 40. This contrasts with the cited studies which did not stratify obese patients by BMI class. The specific nature of our findings allows for cleaner physician application when assessing risk factors for their patients. Thus, a BMI ≥ 40 should be considered a significant risk factor for post-operative complications and hospital readmissions within 30 days of an outpatient ATR.

Previous studies have attempted to relate the risk of increased age with post-operative complications. Studies by Pean *et al.* and Burgmenn *et al.* did not find that increased age (greater than 50 years) was a significant risk factor for post-operative complications (Bruggeman *et al.* 2004; Pean *et al.* 2018). Conversely, Hussain *et al.* determined that each additional year of age increased the likelihood of a post-operative infection by a factor of 1.0303 ($p = 0.03$) (Hussien *et al.* 2021). Our analysis found that older age was associated with increased post-operative complications requiring hospitalization. The discrepancy between these findings may be explained by the fact that ATRs typically occur in younger patients who are generally healthier and have less comorbidities. Furthermore, the studies that found no association between increased age and post-operative complications limited their follow-up period to 30 days post-operatively and do not encompass long-term complications.

Vasculopathies such as hypertension and bleeding disorders have also been postulated to increase the risk of post-operative complications such as DVTs and wound in-

fections. There is a paucity of studies exploring these comorbidities in the setting of an ATR. An analysis by Hussain *et al.* did not find an increase of post-operative complications in patients with hypertension or bleeding disorders (Hussien *et al.* 2021). An analysis performed by Dombrowski *et al.* found that patients with uncomplicated hypertension had higher rates of surgical irrigation and debridement in Achilles tendon patients who had an SSI, $p < 0.001$, OR 2.4, 95% CI [1.5, 3.9] (Dombrowski *et al.* 2019). Our study determined that patients with hypertension or bleeding disorders, although a small number of patients, had an increased risk of post-operative complications requiring hospitalizations. The difference in findings may be due the high prevalence of hypertension with other comorbidities and further studies are necessary to establish uncomplicated hypertension as a risk factor.

This study benefited from a large patient cohort, however there are several limitations. First, there are inherent limitations to the ACS-NSQIP database. Multiple institutions contribute their data to this database, but their data might only represent their patient populations and not be representative of the general population. However, the number of contributing institutions is continuously growing which increases the generalizability of our findings. Like any database study, the data is limited by the accuracy and completeness of data entry. However, interrater reliability disagreement within ACS-NSQIP has previously been shown to be less than 1.8% (Improvement Q and Data Q 2014–2015). Since ACS-NSQIP only captures admission within 30 days of the index procedure, this is not a comprehensive measurement of all complications after ATR repair. This is important to note as other complications such as re-rupture could occur after 30 days and are not included in this dataset. Lastly, ACS-NSQIP serves as an inpatient hospital database which excludes independent ambulatory surgery centers, thus impacting the generalizability of the study. Despite these limitations, we have identified specific risk factors that increase the chances of post-operative complications in outpatient ATR repair, and may provide guidance to surgeons regarding pre-operative optimization to avoid readmission and other surgical complications.

CONCLUSION

The authors identified a low 30-day readmission rate after Achilles tendon repair of 0.73%. The results of our analysis determined that patients who: 1) have BMIs greater than 40; 2) have hypertension; 3) a higher ASA Classification; and 4) are older in age, have a higher risk of unexpected admission following Achilles tendon rupture repair.

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