Operative Versus Nonoperative Treatment of Acute Achilles Tendon Rupture

A Propensity Score–Matched Analysis of a Large National Dataset

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Background: No consensus exists regarding the superiority of operative versus nonoperative management for Achilles tendon ruptures, as multiple randomized controlled trials conducted since the advent of early mobilization protocols have found outcomes for these 2 interventions to be more similar than were previously held.

Purpose: To use a large national database to (1) compare reoperation and complication rates between operative and nonoperative treatment of acute Achilles tendon ruptures and (2) evaluate trends in treatment and cost over time.

Study Design: Cohort study; Level of evidence, 3.

Methods: The MarketScan Commercial Claims and Encounters database was used to identify an unmatched cohort of 31,515 patients who sustained primary Achilles tendon ruptures between 2007 and 2015. Patients were stratified into operative and nonoperative treatment groups, and a propensity score—a matching algorithm—was used to establish a matched cohort of 17,996 patients (n = 8993 per treatment group). Reoperation rates, complications, and aggregate treatment costs were compared between groups with an alpha level of .05. A number needed to harm (NNH) was calculated from the absolute risk difference in complications between cohorts.

Results: The operative cohort experienced a significantly larger total number of complications within 30 days of injury (1026 vs 917; $P = .0088$). The absolute increase in cumulative risk was 1.2% with operative treatment, which resulted in an NNH of 83. Neither 1-year (1.1% [operative] vs 1.3% [nonoperative]; $P = .1201$) nor 2-year reoperation rates (1.9% [operative] vs 2% [nonoperative]; $P = .2810$) were significantly different. Operative care was more expensive than nonoperative care at 9 months and 2 years after injury; however, there was no difference in cost between treatments at 5 years. Before matching, the rate of surgical repair for Achilles tendon rupture remained stable, from 69.7% to 71.7% between 2007 and 2015, indicating little change in practice in the United States.

Conclusion: Results indicated no differences in reoperation rates between operative and nonoperative management of Achilles tendon ruptures. Operative management was associated with an increased risk of complications and higher initial costs, which dissipated over time. Between 2007 and 2015 the proportion of Achilles tendon ruptures managed operatively remained similar despite increasing evidence that nonoperative management of Achilles tendon rupture may provide equivalent outcomes.

Keywords: Achilles; ankle; cost; foot

Achilles tendon rupture is a common orthopaedic injury that results in substantial functional limitations throughout a lengthy recovery time. The increasing incidence of Achilles tendon ruptures has been well documented in population-based studies from northern Europe and is thought to be related to increasing activity levels in older individuals.[12,16] Demographic factors associated with the highest risk of Achilles tendon rupture include middle-aged status and male sex.[11,12]

The primary goals of treatment for patients with acute Achilles tendon rupture are to restore functional strength, ensure an expedient return to work or sport, and reduce the chances of re-rupture. Multiple surgical and nonsurgical approaches to treatment exist,[28] and the superiority of one over the other remains controversial and depends on patient factors and preferences.[3,10,13,25] Historically, surgical repair of Achilles tendon rupture was thought to decrease the risk of re-rupture substantially.[2,14,20] This

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finding was believed to outweigh the increased risk of complications secondary to operative management of Achilles tendon rupture, such as wound healing problems given the subcutaneous nature of the tendon, sural nerve injury, and venous thromboembolism (VTE) from postoperative immobilization.[21]

Early literature around Achilles tendon ruptures tended to compare operative fixation with prolonged cast immobilization as the predominant nonoperative treatment option.[33] More recent literature—including multiple small randomized controlled trials (RCTs) and pooled analyses—has compared outcomes between surgical and nonsurgical treatment when early mobilization recovery protocols are employed and has found minimal or conflicting differences.[6,24,25,27,31-33] Improved outcomes with nonoperative treatment using early mobilization protocols may have led to a trend away from operative repair as observed in a European study[12]; however, no similar shift in preferential treatment modality has been demonstrated in the United States (US).[32]

Although multiple RCTs and meta-analyses exist,[24,27,31] adequately powering a study to detect differences in rerupture or reoperation would require a larger sample size than is typically feasible.[33] National database studies are a powerful accompaniment to randomized trials and retrospective reviews given the vast sample sizes available. The primary purpose of this study was to use a large national database to compare the effects of operative and nonoperative treatment of acute Achilles tendon rupture on reoperation and complication rates. The secondary aims were to evaluate trends in treatment over time as well as costs for both treatment approaches. We hypothesized that there would be no difference between operative and nonoperative treatment in terms of reoperation rates but that operative treatment would be associated with an increased risk of complications and increased cost. We further hypothesized that there would be a trend toward increasing nonoperative management for Achilles tendon rupture.

METHODS

Data Source

The present study used data from the MarketScan Commercial Claims and Encounters database (Truven Health Analytics) between January 1, 2007, and December 31, 2015. This database is a collection of commercial inpatient, outpatient, and pharmaceutical claims of more than 75 million employees, retirees, and dependents, representing a substantial portion of the US population covered by employer-sponsored insurance. MarketScan contains 53 million patient inpatient records, 40 million with employer-sponsored insurance, 3.7 million with Medicare Part B, and 6.8 million on Medicaid for a total of over 28 billion patient records. The data are updated quarterly, with all new records becoming available within 15 months of service and 91% of claims available within 5 months. Because of MarketScan's sourcing from large employers, the data provide superior longitudinal tracking of patients. MarketScan data sets are publicly available to researchers for a fee per year of data and have been used in previously published orthopaedic studies.[5,7,29] The MarketScan database contains the following procedure codes: International Classification of Diseases (ICD), 9th Revision, Clinical Modification (ICD-9-CM) and 10th revision, Clinical Modification, Current Procedural Terminology (CPT), Diagnosis-Related Group, and National Drug Codes.

Study Cohort

We identified an unmatched cohort of 31,515 patients who sustained a primary Achilles tendon rupture (ICD–9 code 845.09) between 2007 and 2015. These patients were stratified based on how their rupture was managed in the first 30 days after injury. Patients indicated as having undergone operative management (CPT code 27650) were categorized into the operative treatment cohort, and patients indicated as having nonoperative management (ICD–9 code 727.67) and no operative procedure codes were categorized into the nonoperative treatment cohort. Only patients with confirmed laterality were included in this study. Patients were excluded from the study if they had neither code within the first 30 days and/or were younger than 21 years.

For each included patient, we recorded demographic information and comorbidity status covariates, including age, sex, hyperlipidemia, hypertension, obesity, diabetes, and tobacco use.

Outcomes

The primary outcome measures of this study were early and medium-term reoperation rates. Secondary aims were to compare complication rates, health care resource utilization over time after injury, and treatment trends over time. The follow-up time was calculated as the difference between the date of the initial Achilles rupture and the date of final insurance enrollment in the dataset.

A postoperative complication was defined as a complication (identified by ICD code) that occurred within 30 days of

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the primary Achilles tendon rupture. These included infection (998.5-998.59, 730.0-730.91, 996.66, 996.67), hematoma (998.1, 998.11-998.13), nerve injury (955.0-955.9, 907.4), wound complications (998.3, 998.31, 998.32, 998.81, 998.83, 998.4, 101.40, 101.60, 101.80), heterotopic ossification (728.1, 728.19, 728.13, 726.91), deep vein thrombosis (451.0-453.9), and pulmonary embolism (415.1-415.19). VTE was defined as the presence of either a pulmonary embolism or deep vein thrombosis.

Revision surgery was determined by the presence of the aforementioned Achilles tendon surgery CPT code after the index surgery date and on the ipsilateral leg, although the indication for revision surgery is not available in the MarketScan database. This was determined 1 and 2 years after the index rupture. The data on health care resource utilization via aggregate payments at multiple time points were also collected for comparison. Payment data encompassed the costs of surgery and postoperative and follow-up care as well as the costs associated with physical therapy at 9 months, 2 years, and 5 years, which are standard time points available in the database.

Propensity Score Matching

To minimize the effect of potential confounding on the direct comparison of patients undergoing the 2 management strategies, a propensity score match was utilized. A greedy nearest-neighbor algorithm was employed to match patients in each cohort to their most alike propensity match available with a 1 to 1 operative-to-nonoperative ratio. A caliper of 0.01 was utilized in the match to minimize confounding bias by approximately 99% in the model,[1] and replacement of patients in the algorithm was not allowed. All recorded baseline characteristics were input into the matching algorithm. After matching, the overall cohort size was 17,996 (8993 patients per treatment group).

Statistical Analysis

Student *t* tests and chi-square tests were utilized to assess statistically significant differences in demographic characteristics, baseline comorbidities, postoperative complications, quality outcomes, and payment information between the operative and nonoperative groups at an alpha level of .05. Percentages in this study were a representation of the proportion of the cohort. For example, for the revision rate, the percentage indicates the number of unique patients who underwent revision surgery. $P < .05$ was considered the threshold for statistical significance. A number needed to harm (NNH) was calculated from the absolute risk difference in complications between cohorts.

RESULTS

The baseline characteristics for the operative and nonoperative treatment cohorts are outlined in Table 1. The groups were not significantly different in terms of age, sex, or prevalence of diabetes or obesity. The nonoperative cohort did include a 1.1% higher rate of smokers ($P = .0491$), while the operative cohort averaged 3 months longer follow-up (27 vs 24 months, $P = .0308$).

The 30-day complications are outlined in Table 2. The operative cohort experienced a significantly larger total number of complications within 30 days of injury (1026 vs 917; $P = .0088$). The absolute increase in cumulative risk with operative treatment in our data was 1.2%, which would result in an NNH of 83 for our cohort. There were no differences in rates of VTE, hematoma, or infection between treatment groups; however, the operative group had significantly higher rates of heterotopic ossification (640 vs 562; $P = .0042$) and wound complications (45 vs 18; $P = .0007$). Neither 1-year (1.1% for operative vs 1.3% for nonoperative; $P = .1201$) nor 2-year reoperation rates (1.9% vs 2%; $P = .2810$) were significantly different between cohorts (Table 3).

TABLE 1
Demographic Characteristics of the Matched Cohorts[a]

Variable	Operative (n = 8993)	Nonoperative (n = 8993)	*P*
Age, y	44.5 ± 11.6	44.2 ± 11.9	.1058
Female sex	4710 (52.4)	4710 (52.4)	>.9999
Hypertension	2802 (31.2)	2716 (30.2)	.1643
Hyperlipidemia	2281 (25.4)	2246 (25)	.5475
Diabetes	690 (7.7)	501 (7.8)	.2901
Obesity	1019 (11.3)	981 (10.9)	.3674
Tobacco use	568 (6.3)	665 (7.4)	**.0491**
Follow-up time, mo	27.2 ± 7.3	24.1 ± 6.8	**<.0308**

[a]Data are reported as mean ± SD or n (%). Bold *P* values indicate statistically significant differences between groups ($P < .05$).

TABLE 2
Outcomes Within 30 Days After Treatment[a]

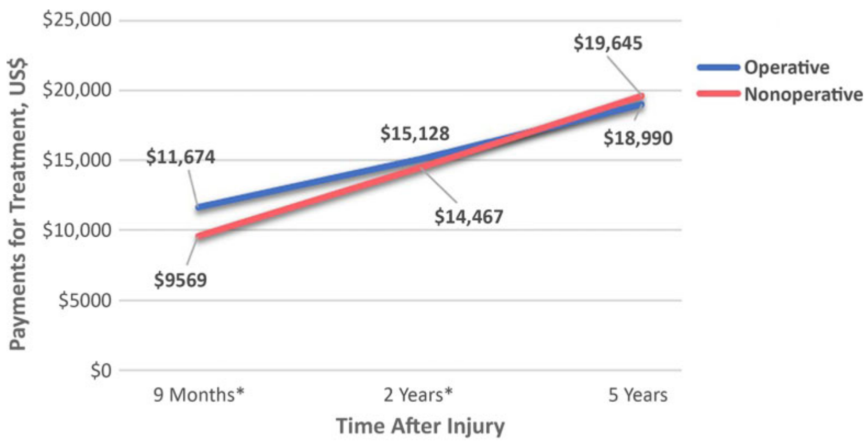
Outcome	Operative (n = 8993)	Nonoperative (n = 8993)	*P*
Any complication	1026 (11.4)	917 (10.2)	**.0088**
VTE	118 (1.3)	133 (1.5)	.3403
Hematoma	13 (0.1)	0 (0)	.3935
Infection	25 (0.3)	17 (0.2)	.2165
Heterotopic ossification	640 (7.1)	562 (6.3)	**.0042**
Stiffness	92 (1)	105 (1.2)	.3517
Wound complication	45 (0.5)	18 (0.2)	**.0007**

[a]Data are reported as n (%). Bold *P* values indicate statistically significant differences between groups ($P < .05$). VTE, thromboembolism.

TABLE 3
Revision Surgery Rate[a]

Revision	Operative (n = 8993)	Nonoperative (n = 8993)	*P*
1-year	101 (1.1)	116 (1.3)	.1201
2-year	172 (1.9)	188 (2)	.281

[a]Data are reported as n (%).



Time After Injury	Operative (n = 8993)	Nonoperative (n = 8993)	*P*
9 months	$11,674 ± $11,443	$9569 ± $12,287	**<.0001***
2 years	$15,128 ± $18,469	$14,467 ± $14,996	**<.0001***
5 years	$18,990 ± $25,276	$19,645 ± $43,345	.2158

Figure 1. Payments made for operative and nonoperative management of Achilles tendon rupture over 3 discrete time points. Data in the table are reported as mean ± SD.

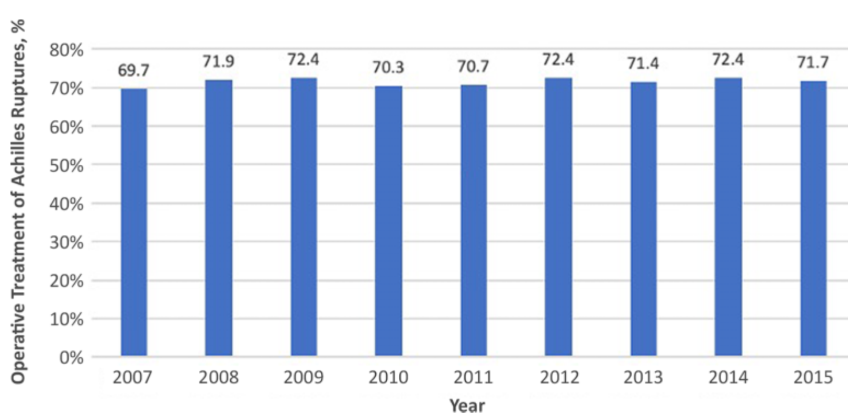


Figure 2. The proportion of Achilles tendon ruptures treated surgically by year.

The mean total care costs are summarized at multiple time points in Figure 1. At 9 months and 2 years, operative care was more expensive than nonoperative management. This cost difference dissipated over time, and at 5 years there was no difference in payments made between operative and nonoperative treatment.

The asterisk denotes a significant difference in cost between nonoperative and operative management at that time point.

Before matching, we found that the rate of surgical repair for Achilles tendon rupture remained stable over the course of this study period (2007-2015). The rates for each particular year are shown in Figure 2.

DISCUSSION

This study presents the largest analysis of patients with Achilles tendon ruptures to date. We found that in this study population spanning between 2007 and 2015, operative management of Achilles tendon rupture did not reduce the risk of subsequent Achilles tendon surgery in all individuals taken together. Unsurprisingly, operative treatment was associated with an increased risk of wound complications and heterotopic ossification compared with nonoperative treatment. Further, while surgical repair of Achilles tendon rupture was associated with a higher initial cost of care compared with nonoperative therapy, these differences diminished over time and were no different at the 5-year follow-up. Finally, despite evidence[24,27,31,33] coming out of Europe and Canada demonstrating nonoperative management as an efficacious option in the management of Achilles tendon ruptures in the early 2010s, our study appears to show little to no change in practice over our study period, demonstrating a continued bias toward surgical management of Achilles tendon ruptures.

The primary goal in treatment of an Achilles tendon rupture is to promote healing of the tendon to facilitate a return to normal activities and prevent subsequent rerupture. Operative repair of the Achilles tendon is performed to allow high-quality tissue healing when bringing the ends of the tendon together. This is thought to prevent re-rupture and expedite healing to allow earlier return to full activity level.[4] While we were not able to directly quantify re-rupture rates from this dataset, given the lack of laterality in the coding of rupture, we were able to analyze rates of subsequent Achilles repair surgery. We found no difference in the 2-year rate of subsequent Achilles tendon repair between patients who underwent operative repair (1.9%) versus nonoperative treatment (2%) of their injury. In accordance with this finding, a recent long-term follow-up study evaluating patient satisfaction outcomes when comparing operative versus nonoperative treatment demonstrated no difference in patient satisfaction.[17] These authors reported that between operative and nonoperative treatment of acute Achilles tendon rupture, there was no significant difference in re-rupture between the groups at 15 years for a small cohort (N = 64 [12.9% nonoperative; 6.1% operative]).[17] Conversely, while a 2022 Norwegian trial demonstrated no difference in clinical outcome score between operative and nonoperative management of Achilles tendon rupture, they did find the incidence of re-rupture to be higher in the nonoperative cohort (6.2%) than either minimally invasive or open repair (0.6%, for both) at 12 months.[23]

As would be expected when comparing surgical and nonsurgical means of treating closed injuries, we observed a higher rate of wound complications and heterotopic ossification in the operative cohort. These findings are similar to those reported in previously published RCTs[24,25,27,31,33] as well as findings obtained from the PearlDiver database.[32] The latter study proposed that the NNH was 51 by treating patients with Achilles rupture operatively. The NNH was 83 for operative treatment in our cohort. These values are similar in magnitude and can be a helpful tool for surgeons to use when helping patients evaluate the risk of surgery against other goals, such as the potentially reduced risk of re-rupture or faster return to work or sport with surgical repair.

Prior studies have shown little difference in long-term range of motion, calf circumference, or strength between operative and nonoperative management of Achilles tendon ruptures.[27,33] Minor differences that have been described include slightly earlier return to work[27] for operative repair and greater plantar flexion strength in the short term after operative repair,[33] which may only be clinically relevant to highly active, younger patients or athletes. With improvements in outcomes after the implementation of early mobilization and functional rehabilitation protocols over the past decade, a concomitant shift away from operative repair of Achilles tendon ruptures has been reported in European database studies.[8,12] Wang et al[32] found a trend toward slightly increased rates of surgical repair in the US, although such trends may have been influenced by their use of a private insurance database. In our study population, the proportion of Achilles tendon ruptures treated surgically appeared to remain relatively stable from 69.7% to 71.7% between 2007 and 2015. These absolute rates are slightly higher than the rate of operative intervention found by Wang et al; however, taken together, these findings indicate that no such shift away from operative repair of Achilles tendon ruptures has yet occurred in the US.

Predictably, we observed a higher upfront cost to undergoing operative repair of Achilles tendon rupture compared with conservative treatment. This finding corroborates other cost analyses of Achilles rupture management.[15,30] Interestingly, while the increased cost of care held up through 2 years after the injury, the differences in cost were no longer present 5 years after surgery. This diminution of cost differences between approaches could be due to the dilution in cost difference as 3 more years of routine care costs are added, or it could indicate that ongoing costs associated with nonoperative treatment are higher and continue beyond 2 years after injury. Truntzer et al[30] reported that nonoperative therapy resulted in an increased number of office visits and increased spending on physical therapy, which may have driven the eventual equalization of costs in our study. In addition to the increased risk of complications seen with surgery, the significantly higher upfront cost of surgery and the opportunity cost of the expected time off associated with the chosen treatment protocol should be discussed with patients preoperatively.

Strengths and Limitations

Common pitfalls of prior investigations on the management of Achilles tendon ruptures are small effect sizes and underpowered analyses. This was rigorously reported on by Parisien et al,[26] who demonstrated fragility to the results of comparative Achilles rupture studies in the literature. A major strength of this study is the use of a large insurance database to power outcomes analyses, resulting in the largest single patient cohort published in the relevant literature. It is also a nationally representative sampling of the US population in that privately insured patients, Medicare patients, and Medicaid patients alike are all included in the database.

There are several limitations to the present study. As with any database study, our results are dependent on the integrity of the ICD and CPT data input into the database and the accuracy of coding by the reporting physicians. Rerupture codes lack laterality, and thus we were unable to directly evaluate nonoperative versus operative management on this specific, common, and costly outcome. In lieu of coding specific to re-rupture, we used revision surgery as a related but nonanalogous proxy for the efficacy of treatment. Furthermore, early restricted mobilization has been demonstrated to improve outcomes in Achilles tendon rupture,[18,22] and minimally invasive surgical techniques have been shown to decrease rates of wound complications.[9] The nature of this dataset without available chart review limited the ability to stratify outcomes based on the nonoperative treatment protocol, surgical technique, surgeon experience, or prior ankle surgery.[19] Similarly, we were unable to eliminate bias in patient selection between treatment cohorts not adjusted for by available variables (ie, we could not match based on activity level), and this dataset is limited to insured individuals. The dataset also makes it difficult to speculate what drives cost washout after 2 years. Finally, key clinical and patient-reported outcome data—such as strength, range of motion, activity level, scar formation, satisfaction, and return to sport—are not available in this dataset although all are critical aspects to any shared decision-making conversation regarding the management of Achilles tendon rupture.

The propensity score matching method used in this study is limited by factors available for input into the algorithm. While a strength is the inclusion of the most common comorbid conditions, such as diabetes and smoking status, we did not have baseline functional or socioeconomic data to build into the model. These additional factors may prove impactful in determining optional management courses for patients with Achilles tendon rupture. Finally, cost analyses are based on the mean total insurer payout per diagnosis at assorted time points, and they may be skewed by particularly complicated cases requiring multiple reoperations or extended recovery.

CONCLUSION

We found no differences between operative and nonoperative management of Achilles tendon ruptures in terms of the need for subsequent surgery in a large cohort of 17,996 patients. As hypothesized, we found that operative management was associated with an increased risk of complications with an NNH of 83 and higher costs of care at 9 months and 2 years. Management trends in the US have not matched the decrease in operative management described in European studies,[8,12] despite increasing evidence of similar outcomes between treatments.[24,27,31,33]

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