Factors associated with Achilles tendon re-rupture following operative fixation

a cohort study of 43,287 patients

From Seoul National University Bundang Hospital, Seongnam-Si, South Korea

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Correspondence should be sent to Kyoung Min Lee
oasis100@empal.com

Y. H. Choi,[1] T. H. Kwon,[1] J. H. Choi,[2] H. S. Han,[1] K. M. Lee[1]

[1]Department of Orthopedic Surgery, Seoul National University Bundang Hospital, Seongnam-si, South Korea
[2]Department of Orthopedic Surgery, Korea University Anam Hospital, Seoul, South Korea

Aims

Achilles tendon re-rupture (ATRR) poses a significant risk of postoperative complication, even after a successful initial surgical repair. This study aimed to identify risk factors associated with Achilles tendon re-rupture following operative fixation.

Methods

This retrospective cohort study analyzed a total of 43,287 patients from national health claims data spanning 2008 to 2018, focusing on patients who underwent surgical treatment for primary Achilles tendon rupture. Short-term ATRR was defined as cases that required revision surgery occurring between six weeks and one year after the initial surgical repair, while omitting cases with simultaneous infection or skin necrosis. Variables such as age, sex, the presence of Achilles tendinopathy, and comorbidities were systematically collected for the analysis. We employed multivariate stepwise logistic regression to identify potential risk factors associated with short-term ATRR.

Results

From 2009 to 2018, the short-term re-rupture rate for Achilles tendon surgeries was 2.14%. Risk factors included male sex, younger age, and the presence of Achilles tendinopathy.

Conclusion

This large-scale, big-data study reaffirmed known risk factors for short-term Achilles tendon re-rupture, specifically identifying male sex and younger age. Moreover, this study discovered that a prior history of Achilles tendinopathy emerges as an independent risk factor for re-rupture, even following initial operative fixation.

Article focus

- Utilize big-data analysis to extensively explore the risk factors for surgical revision due to mechanical re-rupture in primarily surgically repaired Achilles tendons.
- Report the surgical outcomes of primary repair of Achilles tendon ruptures in cases with chronic tendinopathy, and investigate the risk factors for surgical revision.

Key messages

- A 2.14% rate of short-term postoperative Achilles tendon re-rupture requiring surgical revision was observed.
- Identified risk factors for short-term ATRR include male sex, younger age, and a history of Achilles tendinopathy.

Strengths and limitations

- This was a large population cohort specifically focused on surgical cases of primary Achilles tendon rupture.

- Our study contributes meaningfully to the expanding research body on the re-rupture of Achilles tendons.
- Due to the absence of specific diagnostic codes for re-rupture and contralateral Achilles tendon rupture, we defined Achilles tendon re-rupture as cases requiring surgical revision within one year post-initial surgery.
- Additionally, specific patient characteristics and anatomical details of the ruptured tendons could not be assessed.
- The post-surgical rehabilitation process was not observed in our study.

Introduction

Achilles tendon rupture (ATR) is the most common tendon injury in the lower limbs, with its incidence climbing annually due to an expanding sports population.[1,2] While a past study suggested a decline in operative repair rates when compared to nonoperative treatments,[3] the frequency of surgical intervention for ATR continues to grow yearly in South Korea.[1]

Achilles tendon re-rupture (ATRR), a significant post-treatment complication, is similarly increasing.[4] Patients with ATRR often necessitate more complex surgical procedures than standard end-to-end repair, and are at risk for long-term disability.[5,6] Re-ruptures occurring post-surgery inherently necessitate more challenging approaches compared to those occurring after nonoperative management of ATR.[7] This leads to additional surgical procedures and hospitalization followed by vigorous rehabilitation treatment,[5] which probably increases the medical expenses.

Prior research has proposed various risk factors for ATRR, such as male sex, younger age, prolonged traditional immobilization, and seasonal variability of injury mechanism; however, these studies were constrained by small, heterogeneous samples rather than focusing solely on surgically treated cases.[8-10]

Thus, this study aimed to explore the incidence and risk factors for postoperative ATRR that necessitated surgical revision, leveraging national population-based health insurance data in South Korea.

Methods

We conducted a retrospective cohort study using the Health Insurance Review and Assessment (HIRA) claims data, which covers 98% of the overall South Korean population.[1] This dataset enabled us to collect a wide range of health insurance claims data, including diagnostic codes, procedural codes, medical costs, and the dates or duration of medical service usage. Due to South Korea's national insurance system, which operates under a government-mandated fee-for-service model, instances of missing data are exceptionally rare, primarily occurring in unusual situations where medical professionals do not record data.

The current study was approved by our hospital's Institutional Review Board (IRB no. X-2110-714-901) and also received approval from HIRA.

Defining the cohort and short-term ATRR criteria

The inclusion and exclusion criteria for this study are outlined in Figure 1. Utilizing the S86.0 diagnostic code for Achilles tendon injury from the Korean classification of diseases,[11] we identified patients who were newly diagnosed with ATR between January 2008 and December 2018. These patients were part of a larger cohort identified from January 2007 to September 2020. We included adult participants aged 18 years and older who were diagnosed with ATR and underwent surgical repair within two weeks of diagnosis. Surgical repair was identified by performance codes for Achilles tendon repair or reconstruction (N0920) and repair or reconstruction of tendons or ligaments (N0931, N0932, N0933, N0934). Patients who received treatment more than two weeks after their initial diagnosis were excluded to minimize the confounding effects associated with chronic ruptures.[12]

Short-term ATRR is defined as revision surgery assigned a diagnostic code of S86.0, occurring between six weeks and one year after the initial surgical repair (Figure 2).[13] This definition is based on the assumption that non-concurrent contralateral ruptures are unlikely within this timeframe.[14] Further, to discern and exclude cases of reoperation due to skin necrosis or deep infection, we conducted a thorough review process. After identifying the group of patients with revision surgery, we pinpointed those diagnosed with wound complications (T813) or surgical site infections (T793, T814). A total of 186 patients who underwent relevant procedures, such as wound debridement (N0844), partial-thickness skin graft (N0173, N0176, N0178), full-thickness skin graft (S0173, S0175), or flap surgery (S0161, S0164, S0168), were subsequently excluded from the final inclusion (Figure 1).

Data compilation and potential risk factors for short-term ATRR

Data were obtained from the HIRA database, which included demographic variables such as age and sex. Comorbidities that patients had prior to the initial Achilles tendon rupture were cataloged using specific diagnostic codes. These comorbidities included Achilles tendinopathy, osteoporosis, dyslipidemia, hypertension, diabetes mellitus, chronic kidney disease, and peripheral vascular disease.

Statistical analysis

Descriptive statistics were employed to display means, standard deviations (SDs), and relative frequencies. Data normality was tested using the Kolmogorov-Smirnov test. For assessing temporal trends in the incidence of ATR per 100,000 per year and re-rupture rates, the Mann-Kendall trend test was applied, which highlighted a significant increasing trend in ATR incidence rates, while re-rupture rates remained constant over the study period. For comparing continuous variables between groups with and without short-term ATRR, we used the independent-samples *t*-test. Nominal variables were assessed using chi-squared tests. Multivariate stepwise logistic regression served to identify significant risk factors contributing to short-term ATRR. Data extraction was performed using SAS Enterprise Guide 7.15 (SAS Institute, USA), and statistical analysis was carried out using both SAS and R 3.5.1 (R Foundation for Statistical Computing, Austria). A p-value of less than 0.05 was considered statistically significant.

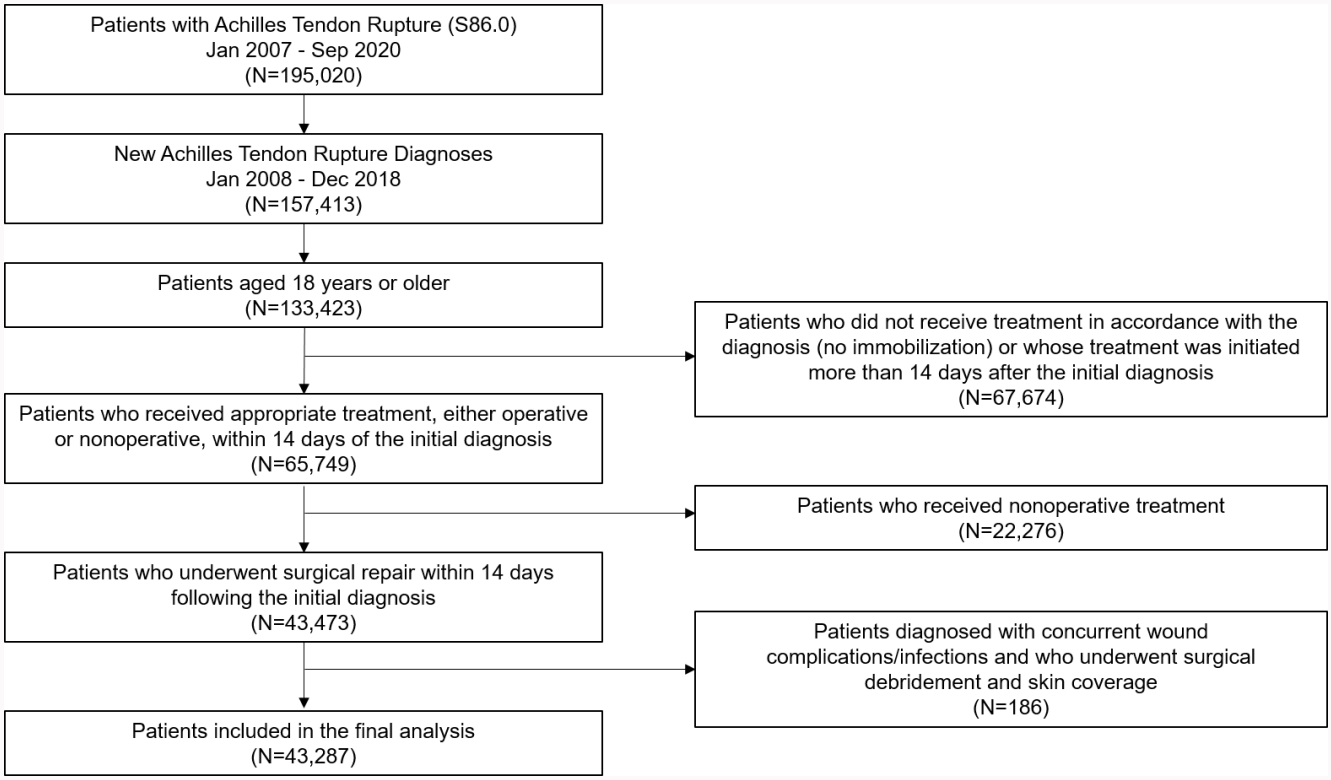

Fig. 1
Cohort identification: inclusion and exclusion criteria.

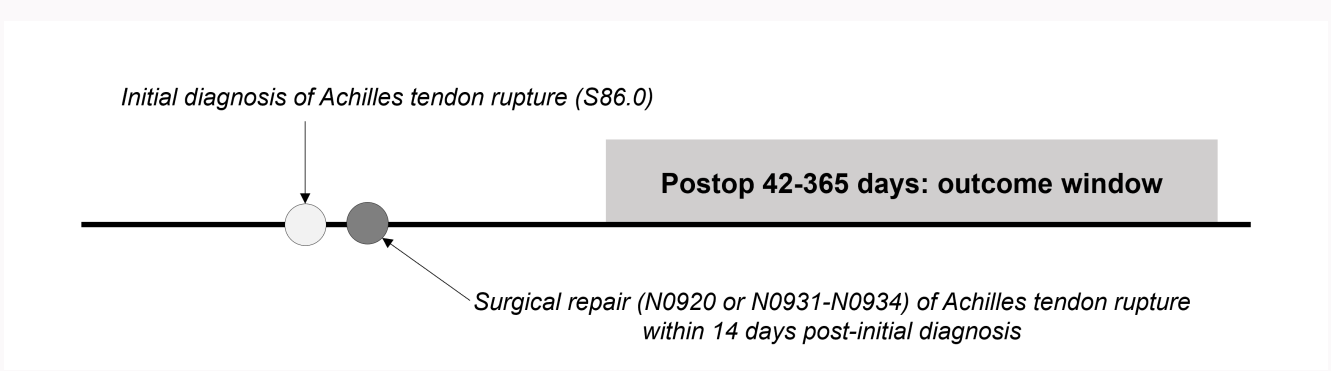

Fig. 2
Study design. Short-term re-rupture was defined in our study as the need for revision surgery, and was monitored from six weeks to one year following the initial Achilles tendon repair.

Results

Characteristics of patients based on short-term re-rupture status

Upon adhering to the study's inclusion and exclusion criteria, a final sample size of 43,287 patients who underwent surgical treatment for ATR was established, as depicted in Figure 1. A total of 926 patients, representing 2.14% of the cohort, experienced a short-term ATRR, which necessitated revision surgery. The mean annual incidence of surgically treated primary ATR was 9.91 per 100,000 person-years (SD 0.97). During the study period, the annual incidence of surgically treated primary ATR significantly increased ($p < 0.001$, Mann-Kendall trend test), while the re-rupture rate did not ($p = 0.954$, Mann-Kendall trend test) (Figure 3). The subset of patients with ATRR demonstrated a statistically significant preponderance of males ($p = 0.014$, Mann-Kendall trend test) and was more likely to have comorbidities such as Achilles tendinopathy, hypertension, and diabetes mellitus (Table I).

Multivariate analysis of short-term ATRR risk factors

The multivariate stepwise logistic regression revealed key risk factors for short-term ATRR. Specifically, male patients had an adjusted odds ratio (aOR) of 1.31, indicating a statistically significant risk (95% confidence interval (CI) 1.08 to 1.58). Furthermore, an inverse relationship was observed with age, suggesting that younger patients are at a higher risk (aOR = 0.98, 95% CI 0.98 to 0.99), and Achilles tendinopathy (aOR = 2.51, 95% CI 2.09 to 3.01) was significantly associated with an increased risk of ATRR (Table II). Comorbidities did not show statistically significant results in this analysis.

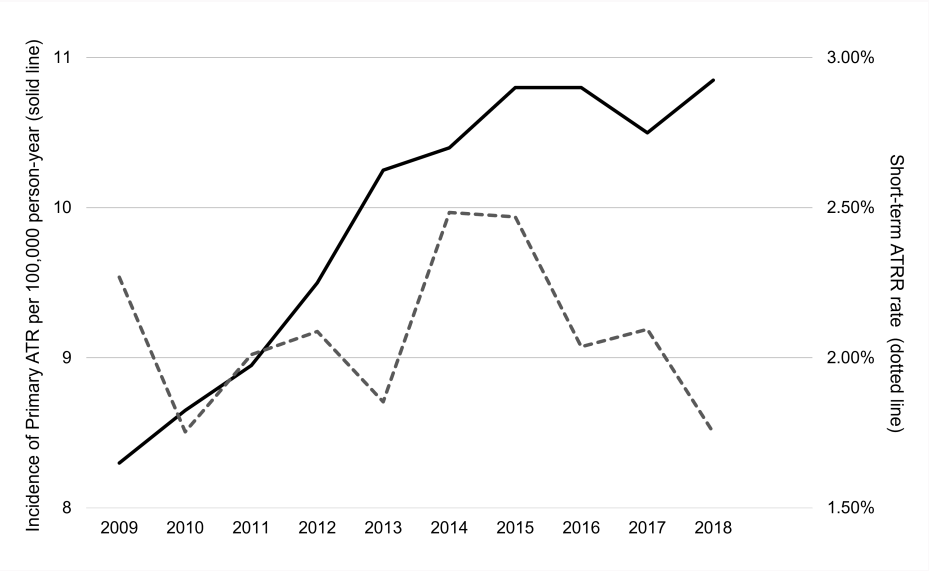

Fig. 3
There was an increase in the annual incidence of Achilles tendon rupture (ATR) between 2009 and 2018 (solid line), but not in the short-term Achilles tendon re-rupture rate (dotted line).

Table I. Demographic and clinical characteristics stratified by postoperative short-term re-rupture status.

Characteristic	ATR without re-rupture (n = 42,361)	ATRR (n = 926)	p-value
Male, n (%)	33,276 (78.6)	759 (82.0)	0.014*
Mean age, yrs (SD)	42.2 (11.8)	41.5 (12.4)	0.075†
Mean delay of treatment, days (SD)	0.9 (1.9)	1.0 (1.9)	0.281†
Underlying disease, n (%)			
Achilles tendinopathy	4,518 (10.7)	241 (26.0)	< 0.001*
Osteoporosis	2,181 (5.1)	59 (6.4)	0.113*
Dyslipidemia	14,032 (33.1)	324 (35.0)	0.247*
Hypertension	8,035 (19.0)	204 (22.0)	0.021*
Diabetes mellitus	6,113 (14.4)	177 (19.1)	< 0.001*
Chronic kidney disease	260 (0.6)	7 (0.8)	0.738*
Peripheral vascular disease	4,016 (9.5)	92 (9.9)	0.681*

*Chi-squared test.
†Independent-samples *t*-test.
ATR, Achilles tendon rupture; ATRR, Achilles tendon re-rupture; SD, standard deviation.

Table II. Multivariate stepwise logistic regression analysis.

Variable	Estimate	Standard error	Odds ratio	95% CI	p-value
Male	0.2681	0.0974	1.31	1.08 to 1.58	0.006
Age (years)	-0.0178	0.0036	0.98	0.98 to 0.99	< 0.001
Achilles tendinopathy	0.9192	0.0933	2.51	2.09 to 3.01	< 0.001

CI, confidence interval.

Discussion

We conducted a nationwide population-based study in South Korea to investigate the risk factors for short-term Achilles tendon re-rupture following operative fixation. Our results revealed that, in addition to well-known risk factors such as male sex and younger age, Achilles tendinopathy also significantly increased the risk of postoperative short-term ATRR.

A previous epidemiological study in South Korea reported that about 39% of primary ATR cases underwent surgical repair, with a yearly uptick in such surgeries.[1] Our findings align with this, showing an increasing trend in surgically treated ATR cases. In our study, re-ruptures were defined as those necessitating reoperation between six weeks and one year following the initial surgery, while cases involving infection or skin necrosis were excluded. The rate of postoperative ATRR in our cohort was 2.14%, consistent with previously reported rates ranging from 1.7% to 5.6%.[9] Interestingly, the rate of postoperative re-rupture remained relatively stable over the study period. This observation suggests an important inference: despite advancements in surgical techniques and rehabilitation methods, the unchanged revision rate for re-ruptures underscores the need to enhance awareness and understanding of the risks associated with ATRR.

Earlier research on risk factors for ATR has largely centred on treatment methods – ranging from conservative

management to minimally invasive and open surgery – as well as protocols for immobilization and rehabilitation.[15–18] Large-scale studies specifically investigating re-rupture are limited, although one major study did identify male sex and younger age as key predisposing factors for ATRR.[9] Many of these studies, however, relied on small, heterogeneous samples and did not focus specifically on patients who had undergone surgical treatment for ATR. Our study fills this gap by being the first nationwide research effort to exclusively examine surgically treated ATR cases. By leveraging the large sample size inherent in a big data study, our research enhances the statistical power of our findings, identifying male sex, younger age, and a history of Achilles tendinopathy as significant risk factors for postoperative ATRR.

Achilles tendinopathy and rupture are known to share pathological features, with tendinopathy recognized as a precursor to rupture.[19,20] Previous studies have shown that 10% of patients with Achilles ruptures had pre-existing tendinopathy,[21] and 4% of those with tendinopathy go on to experience acute ruptures.[20] Our study uniquely reveals that Achilles tendinopathy persists as a risk factor for re-rupture even after an initial surgical intervention. This enduring risk may be attributed to persistent pathological changes within the tendons, such as diminished microvascularity and ongoing intratendinous degeneration.[6,22] Consequently, achieving a durable surgical repair for Achilles tendon ruptures with underlying tendinopathy presents a significant clinical challenge, despite seemingly successful initial surgical efforts.

Diabetes mellitus was not a statistically significant factor in the multivariate logistic regression analysis, although it showed a significant difference between the ATRR group and patients with ATR who did not experience re-rupture. This finding aligns with previous studies suggesting that Achilles tendon repair surgery remains a viable option for patients with diabetes,[23] despite the potential impact of their disease on other complications, such as infections and wound problems.[24] Therefore, it can be inferred that if surgical wound management is conducted effectively, the presence of diabetes may not significantly increase the risk of mechanical re-rupture.

This study has several limitations worth noting. First, the retrospective, big data nature of our research required extensive statistical programming, involving multiple inclusion and exclusion criteria, to obtain the intended results. This approach could potentially introduce unintended biases or reduce the size of the final cohort. Nonetheless, we believe that our refined cohort, subjected to detailed criteria, would yield more robust and statistically meaningful outcomes than an uncontrolled dataset. Second, a potential point of contention is our definition of short-term ATRR, which we confined to reoperations occurring between six weeks and one year post-surgery. This specific timeframe was selected to minimize the inclusion of non-concurrent contralateral ATR cases, which previous literature indicates occur at a rate of 0.4% within the first year,[14] as well as to reduce the likelihood of capturing early postoperative complications. As a result, the exclusion of rare nonoperatively treated ATRR cases and patients who experienced complications within the first six weeks post-surgery was unavoidable. Third, the HIRA database lacked data on specific patient characteristics such as BMI, the mechanism of injury, surgical techniques employed, or subsequent immobilization and rehabilitation protocols. Since only the procedural codes are available in the database, and specific details about rehabilitation methods are not recorded, it was not feasible to compare re-rupture rates between recent functional versus traditional rehabilitation approaches.[25] This absence of detailed information limited our ability to analyze their potential association with the risk of re-rupture. Likewise, we could not assess specific anatomical characteristics of the ruptured tendons, such as location, extent, length, or thickness, which could affect the risk of re-rupture. Given these limitations, further studies that delve into these variables, perhaps with larger sample sizes, would be valuable for providing a more comprehensive understanding of the risk factors associated with ATRR.

In conclusion, our nationwide, population-based study in South Korea revealed a 2.14% rate of short-term postoperative ATRR that necessitated surgical revision. Risk factors for this outcome included male sex, younger age, and a history of Achilles tendinopathy.

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Author information

Y. H. Choi, MD, Orthopaedic Surgeon
T. H. Kwon, MD, Orthopaedic Surgeon
H. S. Han, MD, Orthopaedic Surgeon
K. M. Lee, MD, PhD, Orthopaedic Surgeon
Department of Orthopedic Surgery, Seoul National University Bundang Hospital, Seongnam-si, South Korea.

J. H. Choi, MD, Orthopaedic Surgeon, Department of Orthopedic Surgery, Korea University Anam Hospital, Seoul, South Korea.

Author contributions

Y. H. Choi: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Writing – original draft.
T. H. Kwon: Writing – review & editing, Data curation, Formal analysis, Methodology.
J. H. Choi: Writing – review & editing, Conceptualization, Supervision.
H. S. Han: Writing – review & editing, Data curation, Formal analysis, Methodology.
K. M. Lee: Writing – review & editing, Conceptualization, Project administration, Supervision.

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Data sharing

The data that support the findings for this study are available to other researchers from the corresponding author upon reasonable request. The data supporting the findings of this study are stored in a national database and are accessible to designated users. Other researchers can obtain the data from the Health Insurance Review & Assessment Service (HIRA) and the corresponding author upon reasonable request.

Ethical review statement

This study was approved by our hospital's Institutional Review Board (IRB No: X-2110-714-901) and also received approval from HIRA.

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