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Original Article

# Results of wound complications in Achilles tendon repair at a public service

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## Abstract

**Objective:** To evaluate wound healing outcomes and postoperative complications in patients undergoing surgical treatment of Achilles tendon rupture at a Brazilian university hospital operating exclusively through the public healthcare system and to identify factors associated with worse clinical outcomes.

**Methods:** This retrospective observational study analyzed 64 adult patients with complete Achilles tendon ruptures who underwent surgical treatment between 2019 and 2024. All procedures were performed by orthopedic residents under supervision. Data collected included demographics, comorbidities (smoking, obesity, diabetes), surgical techniques, time to surgery, and wound-related complications. The primary outcome was postoperative complications. Secondary outcomes included time to complete wound healing, rerupture rates, and need for reoperation. Descriptive statistics and inferential analyses were performed with 5% significance ($p < 0.05$).

**Results:** Mean patient age was 45 years, with 73% aged 40-60 years. Overall complication rate was 20.3%, primarily infection (15.6%) and wound dehiscence (12.5%). Nerve injury occurred in 7.8% and deep infection in 4.7%. No reruptures or tendon exposures were observed. Comorbidities significantly increased the risk of complications (OR ≈3.7, $p < 0.05$) and delayed healing. No significant associations were found between outcomes and patient age, time to surgery, or surgical technique.

**Conclusion:** Surgical Achilles tendon repair by supervised residents yielded satisfactory outcomes with complication rates comparable to international literature. Comorbidities were the primary risk factors for adverse events, underscoring the need for preoperative optimization. This study validates the safety and effectiveness of the university hospital model when structured supervision and standardized protocols are implemented.

**Level of evidence III; Retrospective cohort study.**

**Keywords:** Achilles tendon; Rupture; Postoperative complications; Unified Health System; Hospitals, University.

## Introduction

Achilles tendon ruptures (ATR) have emerged as one of the most prevalent tendinous pathologies in contemporary orthopedic practice, demonstrating sustained growth in global incidence over the last few decades[1]. It is estimated that ATR accounts for 10.7% of all tendon injuries[2], totaling approximately 6 to 7 million new episodes annually[3]. Recent national registries in Sweden demonstrate a 45% increase in incidence over the last two decades, reaching 41.7 per 100,000 person-years in 2021, with a sharp upward trend among the population aged 40 and older[1]. In the Brazilian context, prospective studies at university reference centers indicate that the injury predominantly affects men (88.6%) in their productive years (mean age 39.5 years), with soccer practice as the primary traumatic mechanism in more than 53% of cases[4].

The understanding of ATR pathophysiology has evolved to the realization that rupture rarely occurs in healthy tissues. Evidence from 2024 reveals that 46.2% of patients already had a history of previous pain or tendinopathy, suggesting that mechanical failure is the outcome of a chronic and subclinical

Study performed at the Hospital Universitário Ciências Médicas de Minas Gerais, Belo Horizonte, MG, Brazil.

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degenerative process that can present with complete rupture as the first clinical manifestation of tendinopathy[2]. The injury is concentrated between 2 and 6 cm proximal to the insertion into the calcaneus, a region characterized by critical hypovascularity that compromises tissue regenerative capacity[5]. This biological vulnerability is exacerbated by metabolic disorders that alter the collagen microarchitecture and by the chronicity of repetitive mechanical loading[1,4].

The treatment of Achilles tendon ruptures remains a field of intense debate. The most recent position statement from the American Orthopaedic Foot & Ankle Society (AOFAS) emphasizes that the choice between surgical and conservative management should be individualized, considering that both approaches can offer satisfactory results provided that non-surgical treatment is initiated early and reserved for cases without a history of previous tendinopathy, as well as non-delaminating and non-insertional ruptures[5,6]. However, robust meta-analysis evidence indicates that surgical intervention is significantly more effective in reducing the risk of a new rupture, presenting a rerupture rate 3.52% lower compared to conservative treatment (relative risk (RR = 0.44, $p < 0.00001$))[7]. Furthermore, surgery favors a more frequent and rapid return to sports activities, with a success rate 14.44% higher than non-operative management (RR = 1.32; $p = 0.03$)[7].

However, the functional benefits of the surgical procedure are counterbalanced by an elevated risk of tissue complications. While conservative management is associated with low or minimal rates of cutaneous complications, surgical repair is associated with higher rates of superficial and deep infections, as well as a 3.33% higher risk of nerve injury (RR = 3.67)[7]. Among operative options, minimally invasive repair reduces the risk of superficial infection (0.4% vs. 6.0% in open repair) but maintains the risk of temporary sural nerve injury at around 3.4%[8]. Systemic risk factors such as active smoking (OR = 3.20), obesity (OR = 1.7), and diabetes mellitus (OR = 1.7) act as independent predictors of healing failure and postoperative complications[7,9].

In university hospitals, the management of these injuries is aggravated by the high complexity of the patients and the prevalence of neglected ruptures, which require reconstruction techniques with higher morbidity[1,4]. Additionally, there is a perception that procedures performed in a teaching environment, with residents acting as primary surgeons, could be associated with higher complication rates. A recent study reported a 40% complication rate in surgeries performed by residents, with resident status identified as an independent risk factor ($p = 0.042$)[10]. However, this evidence comes from a single center and does not detail the supervision model employed, limiting the interpretation of the role of structured supervision in standardizing outcomes.

In the healthcare context of Belo Horizonte, the local epidemiological profile and specific complication rates at reference centers of the Unified Health System (Sistema Único de Saúde - SUS) require systematic investigation to substantiate prevention protocols informed by regional data. Given the gap in recent national evidence on surgical outcomes in SUS university hospitals, an analysis of healing outcomes after Achilles tendon surgeries is warranted to optimize local orthopedic care and evaluate the safety of surgical training in a supervised environment[4].

## Methods

### Ethical aspects

The study was approved by the Institutional Review Board in accordance with the CNS Resolution No. 466/12, the guidelines of the National Research Ethics Commission (CONEP), and the principles of the Declaration of Helsinki.

All included participants signed an Informed Consent Form (ICF), obtained in digital or physical format, prior to the use of clinical data. The information was kept confidential and stored in a secure environment (REDCap), with access restricted to the involved researchers.

### Study design and setting

This is an observational, retrospective, single-center cohort study based on the analysis of electronic medical records of patients who underwent surgical repair of Achilles tendon rupture at a tertiary care hospital fully dedicated to SUS.

The investigation spanned January 2019 to December 2024 and focused on evaluating healing outcomes following surgical Achilles tendon repair. Due to the institution's nature as a teaching hospital, the surgical interventions were conducted by 3rd-year resident physicians in Orthopedics and Traumatology, or those completing a Fellowship in Foot and Ankle Surgery (4th year of training), assisted and directly supervised by service preceptors, reflecting a setting of tertiary care and specialized professional training.

### Study population and selection criteria

The sample consisted of 64 patients, corresponding to all eligible cases identified during the study period; this strategy is justified by logistical feasibility and the dynamics of a regional university center, in accordance with similar prospective national surveys[4].

**Inclusion criteria:** The study included individuals aged 18 years or older, diagnosed with complete Achilles tendon rupture, who underwent surgical repair at the Hospital Universitário Ciências Médicas between 2019 and 2024, and whose medical records contained complete clinical and surgical data sufficient to evaluate the outcomes of interest.

**Exclusion criteria:** Patients under 18 years of age, those without a minimum postoperative outpatient follow-up of 90 days, cases of partial ruptures or other associated tendon injuries, patients undergoing conservative management, patients who refused to sign the ICF, and medical records with inconsistent or missing data regarding surgical wound progression were excluded.

## Surgical supervision model

All surgeries were performed by Orthopedics and Traumatology resident physicians (PGY-3 and PGY-4 levels) under the direct supervision of the service's orthopedic surgeon preceptors. The adopted supervision model consisted of:

- Mandatory preceptor presence: A preceptor orthopedic surgeon was present in the operating room throughout the entire procedure, scrubbed and ready to intervene when necessary.
- Level of guidance: Supervision included continuous verbal guidance and direct manual intervention during critical stages of the procedure (tendon exposure, end-to-end suture, layered closure), depending on the resident's experience and case complexity.
- Surgical technique selection: The choice of surgical approach (open repair, open repair with tendon transfer, or minimally invasive repair) was made collaboratively between the resident and the preceptor, taking into account factors such as rupture chronicity, tendon tissue quality, the presence of a significant tendon gap, and resident experience.
- Technical standardization: All procedures adhered to standardized institutional protocols, including antibiotic prophylaxis, strict aseptic technique, and uniform postoperative care.

## Data collection and variables

Data collection was conducted over five months through the systematic review of electronic medical records from the orthopedics service of a university hospital, involving manual data extraction by two independent researchers and cross-checking to minimize transcription errors. The data were stored in a standardized electronic database using the Research Electronic Data Capture (REDCap) platform, ensuring anonymization, traceability, and access control.

Demographic and clinical variables: Data collected included sex, age, body mass index (BMI), smoking status (active smoker, former smoker, non-smoker), presence of diabetes mellitus (type 1 or type 2, with glycemic control evaluated when available), presence of obesity (BMI $\geq$ 30 kg/m$^2$), mechanism of injury, and time elapsed between injury and surgery.

Surgical variables: The surgical technique employed (minimally invasive/percutaneous repair, end-to-end open repair, or open repair with tendon transfer), tourniquet use, and procedure duration were recorded

Postoperative protocols: All patients received perioperative antibiotic prophylaxis with a first-generation cephalosporin (cefazolin 2g intravenously 30 minutes prior to incision, with additional doses every 4 hours during the procedure). The immobilization protocol consisted of a short-leg cast in equinus for two weeks, followed by a removable orthosis with gradual release of dorsiflexion. Protected partial weight-bearing in equinus was initiated after 2-3 weeks contingent upon good surgical wound healing, with progression to full weight-bearing in 6-8 weeks. All patients were referred for physical therapy rehabilitation following the removal of rigid immobilization.

**Outcomes:** Healing-related complications included surgical wound dehiscence (separation of wound edges with exposure of deep tissues), edge necrosis (cutaneous or subcutaneous necrosis at the wound margins), tendon exposure (direct visualization of the tendon through the wound), and time to complete healing, categorized as either less than or greater than 60 days. Infections were classified as superficial (cellulitis, local erythema, superficial purulent discharge without deep structure involvement) and deep (paratenon involvement, presence of a deep collection, or need for surgical debridement). Neurological events (sural nerve injury manifested by paresthesia or hypoesthesia in the corresponding dermatome) and vascular events (occurrence of deep vein thrombosis (DVT) confirmed by Doppler ultrasound) were also recorded.

The primary study outcome was the occurrence of surgical wound complications (any complication). Secondary outcomes included time to complete healing, rerupture, and the need for surgical reintervention.

## Statistical analysis

The collected data were logged in the REDCap platform, exported to a Microsoft® Excel spreadsheet, and initially analyzed using descriptive statistics; graphs, tables, and measures such as means, standard deviations, and percentages were constructed to summarize the data[11]. The incidence of postoperative outcomes was calculated using point estimates and 95% confidence intervals[12].

Subsequently, univariate analyses were performed to identify factors associated with both postoperative complications (of any nature) and healing time (less than 2 months vs. equal to or greater than 2 months). Two-tailed hypothesis tests were conducted at the 5% significance level ($\alpha$ = 0.05). Univariate analysis assessed the crude associations between the independent variables of interest and the primary outcome. Categorical variables were evaluated using Pearson's chi-square test or Fisher's exact test (when necessary); quantitative variables were evaluated using the non-parametric Mann-Whitney test[13].

In the final stage, a multivariate analysis was performed using logistic regression to assess postoperative complications (of any type). To identify independent factors associated with the outcome, logistic regression with automatic variable selection, namely Forward Stepwise procedures[14], was applied. Three forward stepwise approaches were used: Forward stepwise (Wald), conditional forward stepwise, and forward stepwise (Likelihood ratio, LR).

The applicability of the logistic regression model for predicting the response variable was evaluated using the Receiver Operating Characteristic (ROC) curve. The ROC curve allows visualization of the model's predictive

performance based on its sensitivity and specificity in relation to the outcome. The area under the ROC curve (AUC) is used to assess model accuracy, that is, the model's ability to correctly identify a given condition. An AUC above 0.9 indicates excellent performance, whereas an AUC between 0.7 and 0.8 is considered acceptable, with good predictive capacity when above 0.8[14].

## Results

Analysis of clinical data from patients undergoing Achilles tendon interventions revealed an epidemiological profile concentrated in the 40-60 age group, which accounted for 73% of the study sample. The mean and median age were 45 years, with a standard deviation of 14 years (a coefficient of variation of 31%, indicating moderate age homogeneity among patients) (Figure 1).

Regarding surgical techniques, end-to-end open repair was the predominant approach, applied in 64% of cases (n = 41). Open repair with tendon transfer was performed in 25% of cases (n = 16), generally for chronic ruptures or significant tendon gaps. Minimally invasive repair was utilized in 11% of cases (n = 7).

The evaluation of postoperative outcomes demonstrated an overall complication rate of 20.3% (95% CI: 11.3-32.2%), with a marked predominance of infectious etiology events (15.6%; 95% CI: 7.8-26.9%) and surgical wound dehiscence episodes (12.5%; 95% CI: 5.6-23.2%) (Figure 2, Table 1).

Among the analyzed factors, the presence of comorbidities (smoking, obesity, and diabetes mellitus) emerged as the primary factor associated with worse postoperative outcomes. Patients with at least one of these comorbidities presented a significantly higher risk of complications (50.0% vs. 13.5%; odds ratio [OR] = 3.7; 95% CI: 1.1-12.4; p = 0.011). This impact extended to recovery time, with a significant increase in the incidence of prolonged healing (42% vs. 12%; p = 0.025) in the presence of such clinical conditions. Conversely, age and the time between injury and surgery showed no statistically significant association with either the occurrence of complications or healing time (Tables 2 and 3).

Among the 64 interventions, isolated open tenoplasty (n = 41) presented dehiscence (n = 6; 14.6%) as the primary complication, along with superficial infection, deep infection, nerve injury, and reapproach (n = 2; 4.9% each), lleaving 80.5% (n = 33) of cases complication-free. In the open technique with transfer (n = 16), the most frequent complications were dehiscence, superficial infection, and nerve injury (n = 2; 12.5% each), followed by deep infection (n = 1; 6.2%) and edge necrosis (n = 1; 6.2%), yielding favorable outcomes in 81.2% (n = 13) of cases. The open percutaneous technique (n = 7) registered superficial infection, DVT, and nerve injury (n = 1; 14.3% each), leaving 71.4% (n = 5) of cases complication-free.

Although descriptive data suggest differences in complication rates across surgical techniques, these differences did not reach statistical significance (p > 0.05), likely due to the limited sample size and subgroup heterogeneity.

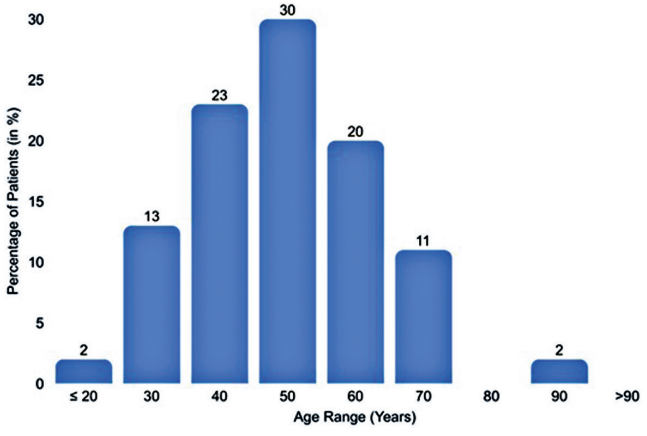


**Figure 1.** Age distribution of the studied sample (n = 64).

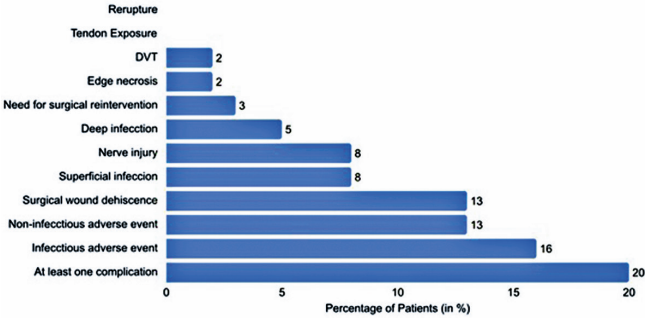


**Figure 2.** Study's outcomes: Infectious adverse events were predominant.

**Table 1.** Outcomes: 20,3% of the patients had any postoperative complication

| Postoperative outcome | Number of cases | Risk | [CI 95%] |
|---|---|---|---|
| At least one complication | 13 | 20.3% | [11.3%; 32.2%] |
| Infectious adverse event | 10 | 15.6% | [ 7.8%; 26.9%] |
| Non-infectious adverse event | 8 | 12.5% | [ 5.6%; 23.2%] |
| Surgical wound dehiscence | 8 | 12.5% | [ 5.6%; 23.2%] |
| Superficial infection | 5 | 7.8% | [ 2.6%; 17.3%] |
| Nerve injury | 5 | 7.8% | [ 2.6%; 17.3%] |
| Deep infection | 3 | 4.7% | [ 1.0%; 13.1%] |
| Need for surgical re-approach | 2 | 3.1% | [ 0.4%; 10.8%] |
| Edge necrosis | 1 | 1.6% | [ 0.0%; 8.4%] |
| DVT | 1 | 1.6% | [ 0.0%; 8.4%] |
| Tendon exposure | 0 | 0.0% | [ 0.0%; 5.6%] |
| Rerupture | 0 | 0.0% | [ 0.0%; 5.6%] |

DVT: Deep vein thrombosis.

**Table 2.** Univariate analysis of factors associated with postoperative complications

| Variable | Categories | Total sample (n = 64) | Complication Yes (n = 13) | Complication risk | Relative risk | p-value |
|---|---|---|---|---|---|---|
| Sex | Female | 6 (9%) | 1 | 16.7% | 0.8 | 1.000 |
| | Male | 58 (91%) | 12 | 20.7% | | |
| Age over 60 years | Yes | 8 (13%) | 2 | 25.0% | 1.3 | 0.660 |
| | No | 56 (88%) | 11 | 19.6% | | |
| Patient with any comorbidity | Yes | 12 (19%) | 6 | 50.0% | 3.7 | 0.011 |
| | No | 52 (81%) | 7 | 13.5% | | |
| Diabetes | Yes | 6 (9%) | 2 | 33.3% | 1.8 | 0.593 |
| | No | 58 (91%) | 11 | 19.0% | | |
| Smoking | Yes | 6 (9%) | 3 | 50.0% | 2.9 | 0.092 |
| | No | 58 (91%) | 10 | 17.2% | | |
| Obesity | Yes | 1 (2%) | 1 | 100.0% | 5.3 | 0.203 |
| | No | 63 (98%) | 12 | 19.0% | | |
| Torniquet use | Yes | 60 (94%) | 13 | 21.7% | - | 0.574 |
| | No | 4 (6%) | 0 | 0.0% | | |
| Surgical technique used | Open with transference | 16 (25%) | 3 | 18.8% | 1.0 | > 0,200 |
| | Minimally invasive | 7 (11%) | 2 | 28.6% | 1.5 | |
| | Isolated open | 41 (64%) | 8 | 19.5% | 1.0 | |

Comorbidity is a significant risk factor ($p < 0.05$)

**Table 3.** Univariate analysis of categorical variables for identifying factors associated with healing time

| Variable | Categories | Total sample (n = 64) | Equal or greater than 2 months (n = 11) | Less than 2 months (n = 53) | p-value |
|---|---|---|---|---|---|
| Sex | Female | 6 (9%) | 1 (17%) | 5 (83%) | 1.000 |
| | Male | 58 (91%) | 10 (17%) | 48 (83%) | |
| Age over 60 years | Yes | 8 (13%) | 2 (25%) | 6 (75%) | 0.617 |
| | No | 56 (88%) | 9 (16%) | 47 (84%) | |
| Patient with any comorbidity | Yes | 12 (19%) | 5 (42%) | 7 (58%) | 0.025 |
| | No | 52 (81%) | 6 (12%) | 46 (88%) | |
| Diabetes | Yes | 6 (9%) | 2 (33%) | 4 (67%) | 0.273 |
| | No | 58 (91%) | 9 (16%) | 49 (84%) | |
| Smoking | Yes | 6 (9%) | 2 (33%) | 4 (67%) | 0.273 |
| | No | 58 (91%) | 9 (16%) | 49 (84%) | |
| Obesity | Yes | 1 (2%) | 1 (100%) | 0 (0%) | 0.172 |
| | No | 63 (98%) | 10 (16%) | 53 (84%) | |
| Torniquet use | Yes | 60 (94%) | 11 (18%) | 49 (82%) | 1.000 |
| | No | 4 (6%) | 0 (0%) | 4 (100%) | |
| Surgical technique used | Open with transference | 16 (25%) | 4 (25%) | 12 (75%) | > 0.200 |
| | Minimally invasive | 7 (11%) | 0 (0%) | 7 (100%) | |
| | Isolated open | 41 (64%) | 7 (17%) | 34 (83%) | |

Therefore, the findings of this study indicate that, within the evaluated context, Achilles tendon surgeries yielded globally satisfactory outcomes, but they reinforce the importance of identifying and appropriately managing comorbidities during the perioperative period to reduce complications and promote faster healing.

Variables identified as statistically significant and clinically relevant in the univariate analysis were included in the multivariate logistic regression model. In this adjusted model, comorbidities remained an important factor associated with postoperative complications. The ROC curve for the logistic regression model predicting postoperative complications demonstrated moderate discriminative capacity, with an area under the curve (AUC) below 0.80 (Figure 3).

## Discussion

The present study reported an overall complication rate of 20.3% after surgical treatment of acute Achilles tendon rupture at a public university hospital. The most frequent adverse events were infectious and wound-healing complications, with infection occurring in 15.6% of cases and wound dehiscence in 12.5%. Although clinically relevant, these findings are consistent with previously reported complication profiles after open Achilles tendon repair. Prior studies have reported wound complication rates ranging from 10% to 25%, with superficial infections in 5% to 10% and deep infections in 2% to 5% of cases[15-17]. In this context, the observed deep infection rate of 4.7% falls within expected ranges.

The overall complication rate is also comparable to prior literature, indicating that complications after Achilles tendon repair are relatively common. A systematic review and network meta-analysis including 2,060 patients reported a major complication rate of 9.13%, with rerupture, deep infection, and DVT as the most clinically significant outcomes[18]. The higher rate observed in this cohort may be attributed to the inclusion of both major and minor complications, the predominance of open surgical techniques, and the characteristics of a real-world population within a public healthcare system. Therefore, these results likely reflect the inherent susceptibility of this procedure to wound-related morbidity rather than suboptimal outcomes.

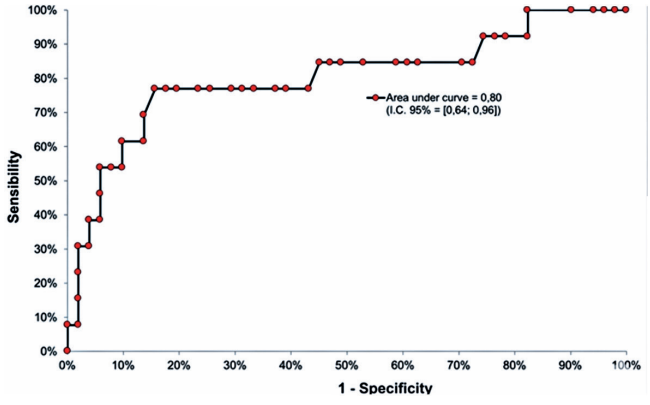


**Figure 3.** ROC curve considering the logistic regression model for predicting postoperative complications.

A key aspect of this study is that all procedures were performed by resident physicians under direct supervision. Teaching hospitals are often perceived as environments with greater surgical variability or a higher risk of complications. However, the findings suggest that, when appropriate supervision, standardized techniques, and institutional protocols are in place, outcomes remain comparable to those reported internationally. This supports the role of university hospitals as both training centers and safe providers of specialized orthopedic care.

The healthcare setting is also relevant. All patients were treated within a hospital integrated into the Brazilian Unified Health System. Public institutions frequently face challenges related to resource availability, operating room logistics, and follow-up limitations, as well as the need to manage patients with greater clinical complexity. Despite these constraints, complication rates remained within the ranges reported in the literature, suggesting that surgical outcomes depend not only on access to advanced technology but also on organization, protocol adherence, and team training[8,9].

Patient-related risk factors played a significant role in the occurrence of complications. Comorbidities such as smoking, obesity, and diabetes mellitus were associated with a significantly increased risk of postoperative complications (OR ≈ 3.7) and delayed healing. These findings are consistent with previous reports. Trivedi et al.[19] identified obesity, diabetes, hyperlipidemia, hypertension, female sex, and older age as predictors of complications and reoperation following Achilles tendon repair. The association between smoking and wound complications has also been well established, as demonstrated by Stavenuiter et al.[17].

Regarding surgical technique, open repair has been associated with higher rates of wound complications, whereas minimally invasive approaches may reduce wound morbidity but carry a higher risk of sural nerve injury[7,10,11]. In this study, no statistically significant differences in complication rates were observed between techniques, possibly due to the limited sample size and reduced statistical power.

The absence of rerupture in this cohort is noteworthy. Rerupture is one of the most concerning complications and is typically reported in 2% to 5% of surgically treated patients, with higher rates in some nonoperative series[12,18]. While this finding may reflect adequate surgical technique and postoperative management, it should be interpreted with caution, as the minimum follow-up of 90 days may not capture late reruptures or long-term functional deficits[20].

Another relevant aspect is the institutional improvement observed during the study period. The implementation of laminar airflow systems and increased involvement of the Hospital Infection Control Committee may have contributed to improved surgical safety. Although causality cannot be established due to the retrospective design, these measures align with established principles of infection prevention. In public teaching hospitals, such interventions are particularly

valuable because they are cost-effective and rely primarily on organizational practices rather than expensive technologies.

This study has several limitations. Its retrospective design introduces potential selection and information bias and limits causal inference. The relatively small sample size, especially for subgroup comparisons, may have reduced statistical power. Although multivariate analysis was performed, residual confounding cannot be excluded. Additionally, the minimum follow-up of 90 days may be insufficient to detect late complications. The absence of a comparator group, such as nonoperatively treated patients or procedures performed exclusively by senior surgeons, further limits conclusions regarding the independent effect of resident participation.

Despite these limitations, the study provides valuable real-world evidence from a resource-constrained public teaching hospital. Achilles tendon repairs performed by supervised residents demonstrated complication rates consistent with international data. The predominance of wound and infectious complications reinforces the importance of patient optimization, careful surgical technique, and infection-prevention strategies. The absence of rerupture or tendon exposure supports the safety of supervised training environments.

## Conclusion

Surgeries for the treatment of Achilles tendon rupture performed in a university hospital serving the public system demonstrated complication rates consistent with the international literature, even when performed by resident physicians in training and using exclusively resources provided by the Unified Health System.

Adverse events were predominantly related to infectious and healing complications, and were heavily influenced by the presence of conditions such as smoking, obesity, and diabetes mellitus. This underscores the importance of preoperative clinical optimization in patients with comorbidities to achieve satisfactory postoperative progress. The results reinforce that the combination of proper supervision, technical standardization, and institutional improvements—including the implementation of laminar flow in the operating room and enhanced oversight by the CCIH—can ensure safe and effective outcomes, even in resource-limited teaching environments. Consequently, the study demonstrates that SUS university hospitals can deliver surgical care of a quality equivalent to international standards while simultaneously fulfilling their fundamental mandate of training specialists.

**Authors' Contributions:** Each author contributed personally and significantly to the development of this article: ACWP *(https://orcid.org/0009-0003-0161-0900), TNF *(https://orcid.org/0000-0003-2988-2097), OOJ *(https://orcid.org/0000-0001-7766-9974) Conceived and planned the activities that led to the study, wrote the manuscript, and participated in the review process; DSQ *(https://orcid.org/0009-0001-2759-8431), BRGMC *(https://orcid.org/0000-0002-5314-5161) Interpreted the study results and participated in the review process; LFMS *(https://orcid.org/0000-0001-9563-5946), RMC *(https://orcid.org/0000-0002-1007-3532), RBS *(https://orcid.org/0000-0002-1899-5005) Participated in the review process

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