CASE SERIES

Functional Evaluation of Acute Achilles Tendon Rupture Treatment Using the Dresden Technique: A Case Series

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Abstract

Aim and background: To evaluate functional outcomes, quality of life, and complications after repair of acute Achilles tendon rupture using a minimally invasive Dresden technique. Achilles rupture is common, and management remains debated; minimally invasive approaches aim to preserve functional outcomes while reducing soft tissue complications and sural nerve injury risk.

Materials and methods: Single-center case series (2015–2024) at a tertiary orthopedic institute. Adults with noninsertional acute ruptures (≤2 weeks) underwent repair by two senior surgeons trained in the Dresden technique, using minor instrument modifications and a standardized rehabilitation protocol. Outcomes included Foot and Ankle Outcome Score (FAOS), Achilles Tendon Total Rupture Score (ATRS), EuroQol 5-Dimension 5-Level questionnaire (EQ-5D-5L), Patient Reported Outcomes Measurement Information System (PROMIS) Physical Function v2.0–SF10a, heel-rise test, calf circumference, maximum plantarflexion/dorsiflexion, and gravitational equinus angle.

Statistics: Descriptive analyses; Spearman correlations among patient-reported outcomes; paired Wilcoxon tests for side-to-side comparisons.

Results: Thirty-one patients (mean age 37.0 ± 10.55 years; 64.5% male) completed follow-up. Mean scores: FAOS 99.03 ± 1.73, ATRS 98.29 ± 2.64, EQ-5D-5L 0.98 ± 0.03, PROMIS 61.0 ± 0.51 (range 60.3–61.5). Heel-rise: 24/31 (77.4%) maintained single-leg support. Complications: none for infection, wound dehiscence, rerupture, or deep vein thrombosis (DVT); two transient sural nerve-related symptoms resolved by 2 months. Plantarflexion: 25.42° (operated) vs 25.45° (nonoperated), mean difference 0.03° (SD 0.18), $p > 0.05$. Dorsiflexion and gravitational equinus: no significant side-to-side differences. Calf circumference difference 1.08 cm ($p < 0.05$), not correlated with functional scores ($p > 0.05$). Very strong, statistically significant intercorrelations were observed among FAOS, ATRS, EQ-5D-5L, and PROMIS.

Conclusion: The modified minimally invasive Dresden repair yielded excellent functional outcomes, high quality-of-life scores, and very low complication rates, with no meaningful deficits in ankle range of motion. Calf atrophy was small and not functionally relevant.

Clinical significance: This technique appears safe, reproducible, and tissue-sparing, achieving outcomes comparable to open repair while potentially mitigating soft tissue and nerve-related complications. Findings support its use in appropriate patients; prospective comparative studies are warranted to confirm these results.

Keywords: Achilles tendon rupture, Case report, Complications, Dresden, Minimally invasive, Open, Sural, Tenorrhaphy, Wound.

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Introduction

The Achilles tendon is formed by the gastrocnemius and soleus muscles and is the largest and strongest tendon in the human body. Since Hippocrates' first description of its rupture, numerous controversies and complications have continued to raise questions regarding the optimal treatment approach.[1]

The annual incidence of rupture is 18 per 100,000 inhabitants,[2,3] with a bimodal distribution: the younger group, between 30 and 39 years of age, typically consists of recreational athletes who engage in sports with low weekly frequency, while the second group is between 50 and 59 years of age.[4] The condition is more common in men, with a male-to-female ratio of 12:1[2]; and patients over 65 years of age are more susceptible to surgical complications.[5]

The most commonly affected anatomical region lies 2–6 cm proximal to the Achilles tendon insertion,[4] with two main theories regarding the pathogenesis of rupture: (1) The degenerative and (2) the mechanical theories.[4]

There are four possible treatment modalities for this condition: (1) nonsurgical management, (2) open surgery, (3) percutaneous repair, and (4) minimally invasive surgery. Considerable controversy remains regarding which is the best treatment option, and which patients would benefit most from each approach.[4,6,7]

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Minimally invasive techniques are increasingly employed due to their advantages in management. Through a small incision, the tenorrhaphy is performed with a smaller surgical approach than

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that of open surgery while offering greater protection to neural structures compared with the percutaneous technique.

Regardless of the treatment modality chosen by the orthopedic surgeon, certain principles should be followed,[4] such as minimizing the morbidity of the injury (avoiding weakening of the triceps surae), ensuring the closest possible return to preinjury function, and preventing complications both from the injury itself and from the selected treatment method.

When comparing different treatment approaches, some differences in outcomes can be observed. The rerupture rate is higher with nonsurgical treatment,[8,9] reaching up to 18% in conservative management compared with 3.5% in open surgical repair, suggesting a potential advantage of surgery.[6] However, some serious complications inherent to surgical treatment—particularly infection, wound dehiscence, and sural nerve injury—are relatively common, reaching up to 34% in open surgical repair.[6] This scenario has fostered the development of less invasive techniques.

The percutaneous technique was first described by Ma and Griffith in 1977. Subsequent studies demonstrated lower rates of complications such as wound dehiscence and infection, shorter operative times, and even faster return to work and sports.[10]

The sural nerve exhibits considerable anatomical variation in its position relative to the Achilles tendon and is not visualized at any stage of the percutaneous technique, rendering it susceptible to injury, which can occur in up to 40% of cases.[1] In 2006, Amlang et al.[11] in Dresden developed a minimally invasive technique that demonstrated promising results. In their prospective study involving 62 acute ruptures, they reported 98% good or very good outcomes in the patients' subjective assessment, one case of superficial infection, and no sural nerve injuries.

We reproduced this technique with certain modifications to the surgical instruments, suture knotting, and rehabilitation protocol, leading us to believe that it is a reproducible procedure with low complication rates, yielding excellent functional outcomes and improvements in quality of life.

The literature reports that minimally invasive techniques provide functional results comparable to those of conventional open repair.[12] Regarding complications, particularly those related to soft tissues, some studies suggest no significant difference,[13] whereas others indicate an advantage of minimally invasive approaches over traditional open repair.[14]

The aim of this study is to evaluate the outcomes of tenorrhaphy performed using the modified minimally invasive Dresden technique[11] in patients operated on over the past 10 years at our institute.

Materials and Methods

Eligibility Criteria

This study is a case series of patients who underwent surgery at the hospital of our service, between 2015 and 2024.

During this period, acute Achilles tendon ruptures—defined as injuries with a maximum duration of 2 weeks—were surgically treated by two senior orthopedic surgeons trained in the Dresden technique, which was applied in all cases.

Diagnosis was established through medical history and physical examination, including palpation and visualization of the lesion, in association with the Thompson and Matles tests. Only noninsertional ruptures, located at least 2 cm proximal to the calcaneal insertion and not within the myofascial region, were included.

Exclusion criteria comprised open injuries, reoperations, tendon lesions associated with bone injuries, neuromuscular disorders, congenital clubfoot, and rheumatologic diseases.

Finally, given that the study population was drawn from the public healthcare system and to avoid potential bias related to transportation, only patients residing in the Western and Central zones of São Paulo were invited to participate.

Applying these criteria, 36 patients were contacted, of whom 31 attended the follow-up evaluation.

Functional Assessment

Functional assessment was performed using functional scores, calf circumference measurements, and triceps surae strength tests. All scores were administered by the primary investigator, who personally instructed and explained each scoring system to the patients. The informed consent form was also presented and signed under the investigator's guidance.

Specific functional evaluation for acute Achilles tendon ruptures was carried out using the Achilles Tendon Total Rupture Score (ATRS), a score developed for this purpose and validated for Brazilian Portuguese.

Quality of life was assessed using two instruments. The first was the Foot and Ankle Outcome Score (FAOS),[15] a descriptive score encompassing five domains—(1) pain, (2) symptoms, (3) activities of daily living, (4) sports and recreational function, and (5) foot- and ankle-related quality of life—validated for Brazilian Portuguese.[16] The second was the EuroQol 5-Dimension 5-Level questionnaire (EQ-5D-5L), which also comprises five domains: (1) mobility, (2) self-care, (3) activities of daily living, (4) pain, and (5) anxiety/depression.

Additionally, the Patient Reported Outcomes Measurement Information System (PROMIS) was applied. For a more comprehensive assessment, we used the Physical Function v2.0–Short Form 10a, which evaluates not only lower limb function but also its integration into daily activities that may be indirectly affected by lower limb impairment.

The patients' physical activity level after the tendon injury was evaluated using the Physical Activity Scale (PAS), which classifies activity into six levels, ranging from no physical activity (level 1) to intense physical activity performed several times a week (level 6).[17,18]

To indirectly assess muscle strength, we used the single-leg heel-rise test on a platform with a 10° incline,[19] as well as calf circumference measurement—performed according to the recommendations of the Asian Working Group for Sarcopenia (AWGS), 2019: Patient standing, with the measuring tape placed around the widest part of the calf.

To assess postoperative complications, we collected data on: age; sex; postoperative infection; wound dehiscence; rerupture; thromboembolic events; sural nerve injury; maximum plantarflexion; and maximum dorsiflexion. Maximum active plantarflexion was measured with the patient in the prone position, knees flexed at 90°, while maximum active dorsiflexion was assessed with the patient seated, legs hanging over the examination table, and knees flexed at 90°. The gravitational equinus angle was also measured, with the patient in the supine position, knees extended, and feet hanging off the examination table.

Minimally Invasive Surgical Technique

During surgery, the patient is placed in the prone position. A 2 cm longitudinal incision is made along the medial border of the tendon, approximately 2 cm proximal to the rupture site.

Following subcutaneous dissection, the fascia enclosing the leg compartments is visualized. This fascia is incised longitudinally until the paratenon is identified, which is preserved in accordance with the principle of maintaining the tendon's intrinsic healing potential.

At this stage, a plane is identified between the fascia and the paratenon. This is the operative field where tendon repair and suture placement occur. It is important to note that developing this plane through blunt dissection protects the sural nerve, as the nerve lies in a plane superficial to the fascia. For this reason, the surgical instrument must allow for tissue dissection without perforation, thus preventing a change in tissue planes and potential injury to the sural nerve.

The surgical instrument was adapted by our team to feature a rounded tip with three holes through which the sutures are passed. A handle angled at 30° relative to the shaft facilitates gliding from the incision site to the tendon insertion (Fig. 1).

Once the subfascial plane is visualized, an instrument is introduced along the medial border and another along the lateral border, advancing distally to the insertion of the Achilles tendon. At this point, the instrument's holes are located by palpating through the skin.

After locating the hole, a No. 1.0 Vicryl suture is passed through the skin into the most distal portion of the tendon, incorporating as much tendon thickness as possible. Two additional No. 1.0 Vicryl sutures are then placed, spaced 0.5–1 cm apart. By gently pulling on the instruments, we assess the tension of the sutures on the tendon and observe whether there is symmetrical medial and lateral movement. This maneuver verifies that all three sutures passed through both instruments are correctly positioned within the tendon.

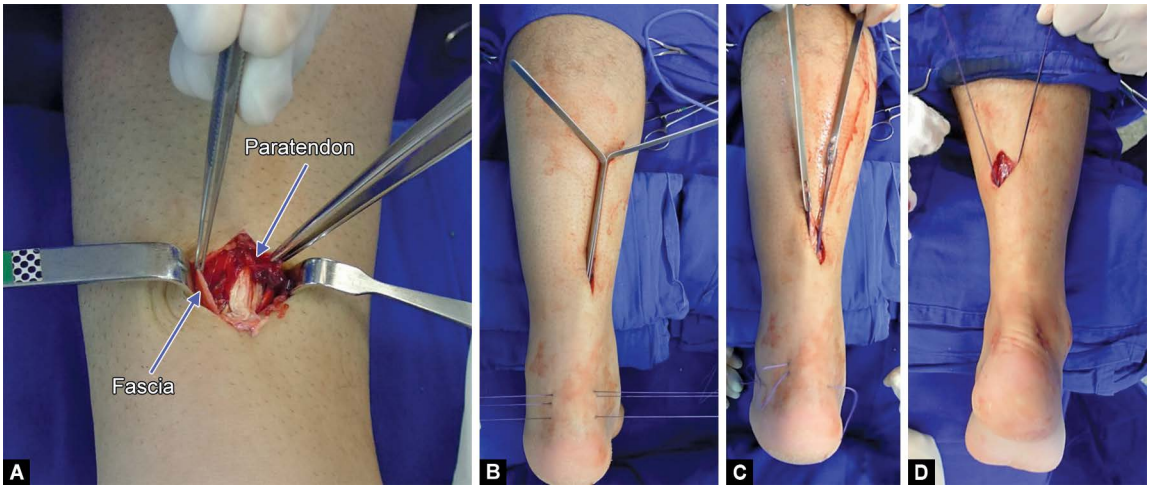
Once proper suture placement is confirmed, the instruments are withdrawn proximally through the incision, so that the sutures exit the skin through the same holes where they were introduced. This step also protects the sural nerve by preventing the formation of a loop around it.

When the instruments are fully withdrawn through the incision, the six suture ends are exteriorized proximally, enabling the tenorrhaphy.

We again verify that the three sutures are securely anchored to an adequate tendon volume by firmly pulling on their ends while mobilizing the ankle in plantarflexion. Using the physiological equinus of the contralateral side as a reference, the operated ankle is positioned under appropriate tension to complete the tenorrhaphy at the proximal stump (Fig. 2).

The proximal suture is placed for each of the three strands at 0.5 cm intervals. The medial half of each strand is anchored to the medial surface of the Achilles tendon with two fixation anchored stitches, maintaining the previously established tension. The

Fig. 1: View of the instruments, one designed for the medial border and the other for the lateral border of the tendon. Note the proximal handle angulation and the rounded tip containing three holes, which allow for blunt tissue dissection without perforation



Figs 2A to D: (A) Medial incision to the tendon, showing the fascia and the paratenon; (B) Instrument inserted through the incision to the tendon insertion, with three Vicryl sutures already in place; (C) Sutures being pulled proximally through the incision; (D) Suture traction demonstrating proper positioning within the tendon, producing plantarflexion

Table 1: Mean values of parameters comparing the operated and nonoperated sides of each patient

Parameter	*Mean op/SD*	*Mean nop/SD*	*Mean diff/SD*	*p*
Maximum plantarflexion (°)	25.42/2.68	25.45/2.73	0.03/0.18	0.317
Maximum dorsiflexion (°)	15.71/1.74	15.65/1.90	0.06/0.76	0.6258
Gravitational equinus angle (°)	4/0.89	4.16/1.10	0.16/0.45	0.059
Calf circumference (cm)	35.23/1.79	36.31/1.68	1.08/0.45	0.00000123

Mean diff, difference in means between operated and nonoperated sides; Mean nop, mean value for the nonoperated side; Mean op, mean value for the operated side; *p*: Wilcoxon test; SD, standard deviation

procedure is completed with closure of the fascia, subcutaneous tissue, and skin. A splint maintaining the physiological equinus position is then applied, following Amlang's rehabilitation protocol.

Rehabilitation

We followed the functional rehabilitation protocol developed at our institution, which consists of maintaining the patient immobilized with a splint in the physiological equinus position until the 4th postoperative day. At that time, the splint is removed, and protected weight-bearing is initiated using a removable below-knee orthosis with a 3 cm heel lift. Full weight-bearing is allowed as tolerated by the patient, accompanied by isometric exercises performed while protected by the orthosis.

From the 4th postoperative week, the patient begins active exercises up to 90° of ankle dorsiflexion, progressing until the 6th week, when the full range of motion is permitted.

At the 6th week, the heel lift is removed, and weight-bearing with the orthosis is maintained until the completion of the 8th week, at which point muscle strengthening exercises are intensified. From the 10th postoperative week onward, the orthosis is discontinued.

Results

Data from 31 participants were collected regarding the following variables: FAOS, PAS, Heel Rise Test, ATRS, EQ-5D-5L, PROMIS, difference in calf circumference, age, sex, infection, wound dehiscence, rerupture, deep vein thrombosis (DVT), sural nerve injury, maximum plantarflexion, maximum dorsiflexion, and gravitational equinus angle.

The mean age was 37 years (SD = 10.55). Of the 31 patients, 20 (64.5%) were male.

Regarding functional outcomes, the sample showed a mean FAOS score of 99.03 (SD = 1.73) and a mean ATRS score of 98.29 (SD = 2.64).

In terms of quality-of-life variables, the mean PROMIS score was 61 (range: 60.3–61.5; SD = 0.51), and the EQ-5D-5L index had a mean of 0.98 (SD = 0.03).

For the heel rise test, 24 patients (77.4%) were able to maintain single-leg stance, while 7 patients (22.6%) were not.

There were no cases of infection, wound dehiscence, rerupture, or DVT. Two cases of sural nerve-related symptoms were observed within the first two postoperative months—one with Tinel's sign and one with local hypoesthesia—both of which resolved spontaneously.

Postoperative PAS scores were predominantly at level 4 (moderate physical activity, 1–2 hours/week).

Statistical analysis using Spearman's correlation coefficient revealed a very strong and statistically significant association between FAOS, ATRS, EQ-5D-5L, and PROMIS. A very strong correlation was observed between FAOS and ATRS scores ($p < 0.001$), indicating that higher FAOS functional scores were strongly associated with better ATRS scores. Similarly, FAOS demonstrated a very strong correlation with the EQ-5D-5L index ($p < 0.001$) and with the PROMIS score ($p < 0.001$), suggesting that better lower-limb function is directly related to improved perceived quality of life and self-reported physical function.

Achilles Tendon Total Rupture Score also showed a very strong correlation with both EQ-5D-5L ($p < 0.001$) and PROMIS ($p < 0.001$), reinforcing the consistency among the different functional and quality-of-life assessment tools used. Finally, EQ-5D-5L and PROMIS scores demonstrated perfect correlation ($p < 0.001$), indicating that both scales varied identically within the analyzed sample.

The statistical analysis of maximum plantarflexion between the operated and nonoperated sides showed that the mean angle on the operated side was 25.42°, compared with 25.45° on the nonoperated side—a mean difference of only 0.03° (SD = 0.18°)—with $p > 0.05$, indicating no statistically significant difference between sides. With respect to maximum dorsiflexion and the gravitational equinus angle, neither demonstrated a statistically significant difference between the operated and nonoperated sides.

When comparing calf circumference between sides, the mean difference was 1.08 cm, with $p < 0.05$, indicating statistical significance. These findings are summarized in Table 1.

Discussion

When performing the minimally invasive Dresden technique, our aim is to minimize the complications associated with conventional open repair while preserving functional outcomes. Yılmaz et al. published a retrospective study of 42 patients evaluating functional outcomes after open Achilles tendon repair.[20] As in our study, they found a positive correlation between ATRS and FAOS. However, when examining the values separately, their cohort presented a mean FAOS of 76.14 ± 16.75 and a mean ATRS of 65.17 ± 24.46—both lower than those found in our study. Nilsson-Helander et al. also published a randomized controlled trial in which 49 patients underwent open repair, reporting a mean ATRS of 75 (range 31–100).[21]

Regarding functional outcomes and their impact on quality of life, our case series demonstrated a positive correlation between ATRS and FAOS, each when compared separately with PROMIS and EQ-5D-5L results. These findings indicate high concordance among the different clinical outcome measures, reinforcing the convergent validity of the instruments used to assess patient function and quality of life.

Although we identified a statistically significant mean difference of 1.08 cm in calf circumference between the operated and nonoperated sides, this atrophy did not translate into differences in functional outcomes or quality-of-life scores. Statistically, no significant correlation was observed between functional scores and calf circumference ($p > 0.05$), suggesting that the observed

atrophy had no functional relevance in our study population, given the activity levels undertaken by the participants. These findings are in line with reports in the literature comparing minimally invasive and open repair techniques, such as the case series by Eken et al.[22]

Another key consideration when opting for the minimally invasive approach is the lower complication rate. In our series, complications were defined as rerupture, sural nerve injury, infection, wound dehiscence, and DVT. We recorded no cases of these complications, except for two patients who presented sural nerve-related symptoms—one with a positive Tinel's sign and another with hypoesthesia—both of which resolved by the second postoperative month. This contrasts with purely percutaneous repair techniques, where sural nerve injury rates of up to 13% have been reported.[6]

While aiming for functional results equivalent to open repair but with fewer complications—particularly regarding the soft-tissue envelope—it is essential to balance the degree of tissue exposure to ensure adequate protection of neurovascular structures. The Dresden technique meets this criterion: With appropriate incision and dissection, the instruments are introduced into the subfascial plane, which is anatomically distinct from the sural nerve plane,[23] thereby ensuring its protection during the procedure.

Finally, as already noted, no infections were recorded in our series. This complication deserves specific mention, as it is a feared event in orthopedic surgery. The literature reports infection rates for open Achilles tendon repairs of around 2.36%.[8] For minimally invasive repairs, Amlang et al.[11] reported an infection rate of 1.6%. One of the main technical differences between open and minimally invasive procedures lies in the degree of soft-tissue disruption. By minimizing soft tissue invasion, we also aim to reduce infection risk—a complication that, depending on severity, may lead to tendon exposure, tissue loss, and multiple subsequent procedures involving a multidisciplinary team, prolonged hospitalization, and higher healthcare costs, particularly in public health systems.

Limitations of the present study include the small sample size and the fact that it was conducted in a single geographic region, which may introduce bias.

Conclusion

Our series of patients treated with the Dresden technique demonstrated excellent functional outcomes and favorable perceived quality of life, with mean scores of FAOS (99.03), ATRS (98.29), EQ-5D-5L (0.98), and PROMIS (61). Statistical correlations revealed a very strong and significant association among all functional and quality-of-life variables, indicating consistency between the instruments used and reinforcing the reliability of the data obtained. Furthermore, the absence of complications, combined with the low incidence and reversibility of sural nerve-related symptoms, supports the safety of the technique employed.

Clinical Significance

The modified minimally invasive Dresden repair yielded excellent patient-reported outcomes with preserved ankle range of motion and very low complication rates. The small side-to-side calf circumference difference was not functionally relevant, supporting this tissue-sparing, subfascial approach as a safe and reproducible alternative to open repair for acute (≤2 weeks), noninsertional Achilles ruptures. Its compatibility with early protected weight-bearing and structured rehabilitation further enhances recovery.

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