Is open acute Achilles tendon rupture repair still justified? A single center experience and critical appraisal of the literature.

Margaux van Maele[1], Dominique Misselyn[2], Willem-Jan Metsemakers[2,3], An Sermon[2,3], Stefaan Nijs[2,3], Harm Hoekstra[2,3]

1 KU Leuven - University of Leuven, Faculty of Medicine, B-3000 Leuven, Belgium

2 University Hospitals Leuven, Department of Trauma Surgery, B-3000 Leuven, Belgium

3 KU Leuven - University of Leuven, Department of Development and Regeneration, B-3000 Leuven, Belgium

Corresponding Author: Prof. Harm Hoekstra MD PhD FEBS, harm.hoekstra@uzleuven.be

Corresponding address: University Hospitals Leuven, Department of Trauma Surgery, Herestraat 49, B-3000 Leuven, Belgium

Funding

not applicable

Disclosures

The authors declare that they have no competing interests

Key words

Achilles tendon rupture, functional outcome, economics

Abbreviations

AATR	: acute Achilles tendon rupture
ATRS	: Achilles tendon total rupture score
CVRF	: cardio vascular risk factors
LOS	: length of stay
FU	: follow-Up

ABSTRACT

Introduction: Acute Achilles tendon ruptures are injuries with multiple treatment strategies with possibly far reaching consequences. Open repair is associated with a high complication rate, whereas percutaneous techniques are associated with higher re-rupture rates. The goal of this study was to evaluate the clinical outcome and economic burden of open surgical repair and define a medically and economically sound treatment protocol for acute Achilles tendon ruptures.

Methods: Between June 2012 and December 2016 one hundred and five patients with an acute Achilles tendon rupture, treated in an open surgical manner, were studied retrospectively. All demographic, clinical and hospital-related costs were retrieved from the electronic patient database. ATRS questionnaires were sent to assess the functional outcome. A response rate of 70.5% was achieved.

Results: We recorded a complication rate of 40%, respectively sural nerve hypoesthesia (14.3%), delayed wound healing (28.6%), infection (20.9%) and re-rupture (4.8%). Surgical resident, as primary operating surgeon was associated with a higher complication rate (p=0.042). Overall, a median functional ATRS score of 17 (IQR 6.5-39.5) was recorded. Infection was associated with significantly higher total healthcare costs per patient as compared to re-rupture (€17,435 *vs*. €4,537, p=0.013). The total cost for surgical debridement (n=6) was approximately 5-times higher than for re-rupture (n=5), €108,382 *vs.* €22,272. The median ATRS score for surgical debridement after infection and re- rupture did not differ significantly from the overall ATRS score, respectively 32 (IQR 21-63) and 28 (IQR 15-28). Nevertheless, a difference of 10 points is considered clinically relevant.

Conclusion: The overall functional outcome of open repair of Achilles tendon ruptures is rather good, however associated with a high complication rate, mainly due to wound problems and infection. Although several risk factors were identified, only the operating surgeon is modifiable. Considering the high total costs for surgical debridement in the context of infection compared to re-rupture surgery, despite equal functional outcome, we decided to change clinical practice to reduce the complication rate and healthcare costs. The outcome and precise costs for percutaneous repair will be addressed.

INTRODUCTION

Acute Achilles tendon ruptures (AATR) are a common trauma with possibly disabling consequences (1). The incidence of Achilles tendon rupture varies between 18 and 31.17 per 100,000 per year (1,2). Although AATR are most common in young male adults participating in sports, an increasing incidence is reported in the elderly population (3,4).

AATR can be treated either operatively or nonoperatively. A significantly higher risk of re-rupture and deep venous thrombosis is reported with nonoperative management of AATR (5–7), while surgical repair results in less re-ruptures, comparable to better functional outcome (heel-rise height, heel-rise work, hopping test, endurance test) and quicker return to work (5–8). However, infections are more frequent with a surgical approach (7,9). Nevertheless, the conservative approach is a valuable treatment option with good results when patients follow a good rehabilitation program. Whether open or percutaneous operative treatment is best remains unclear (1,2). Open surgical treatment is associated with a significantly lower risk of re-rupture (10). Nonetheless, higher complication rates of infection and adhesions have been reported (10–12). In contrast, percutaneous repair of AATR has been associated with a lower infection rate, a higher risk of sural nerve hypoesthesia, and a good to excellent functional outcome compared to open surgical treatment (13–16). Furthermore, percutaneous repair could possibly result in higher re-rupture rates, although literature is ambiguous on this (17,18).

Until recently, we have treated AATR in an open surgical manner with early functional rehabilitation (19). However, clinical assessment revealed a complication rate of approximately 25%. Therefore, transition of open to percutaneous repair of AATR could possibly be advantageous. The goal of this study was to evaluate our current practice of open surgical treatment of AATR and assess the functional outcome. We aimed to implement an up-to-date treatment protocol. Therefore, we compared outcome of the current treatment protocol for AATR to available literature on percutaneous techniques. Furthermore, to curb the continuing increase in healthcare costs, a cost breakdown analysis was performed for the surgical treatment of AATR and the financial impact of complications was determined.

PATIENTS AND METHODS

Patients

Between June 2012 and December 2016, 167 consecutive patients aged 18 years and over, were treated for an AATR at the Department of Trauma Surgery of the University Hospitals Leuven. It concerned a retrospective cohort study. Exclusion criteria were age < 18 years, patients who passed away, lived abroad or did not speak Dutch, nonoperative treatment, non-acute ruptures (>3 weeks), and polytrauma patients. Finally, a total of 105 patients with operatively treated AATR were included in this study. Ethical approval for this study was obtained in compliance with national legislation and the guidelines of the ethics committee of University Hospitals Leuven.

Demographics and clinical characteristics

All demographic and clinical variables were retrieved from the University Hospitals Leuven electronic medical file database KWS as well as from questionnaires. Variables were divided into 3 groups: demographics, risk factors for AATR, and operative characteristics. Patient characteristics included age, gender, ASA-score and cardiovascular risk factors (CVRF). CVRF were the presence of current cardiovascular diseases (e.g. cerebrovascular accident, myocardial infarction, peripheral artery disease), diabetes mellitus, obesity (BMI ≥ 30 kg/m²), smoking at the time of injury, dyslipidemia, hypercholesterolemia, alcohol abuse, rheumatoid arthritis (20). Specific risk factors for AATR were categorized as the use of corticosteroids and fluoroquinolones, medication impairing wound healing such as adrenergic β-agonists, and chemotherapeutic agents, and the pre-rupture symptoms (i.e. tendinosis) (21). Operative variables include the rank of the operating surgeon (staff surgeon, fellow or resident) and complication rate. Complications were categorized as hypoesthesia (i.e. sural nerve), impaired wound healing (> 2 weeks), superficial surgical site infection treated with antibiotics, deep surgical site infection requiring surgical debridement, and re-rupture surgery of the Achilles tendon.

Functional outcome measure

A validated Dutch questionnaire of the Achilles Tendon Total Rupture Score (ATRS) was sent to all included patients (22,23). The ATRS is a validated patient-reported outcome measure instrument for the outcome after treatment of patients with a total Achilles tendon rupture. The ATRS specifically evaluates symptoms and their effect on physical activity in patients with an AATR. The questionnaire contains 10 items, each an 11-point Likert scale (0-10). By reversing the original scale, the final maximal score is 100, indicating there are severe symptoms and major limitations, whereas zero indicates no symptoms and full function (23). A 10-point difference is suggested as a clinically relevant difference (22).

Healthcare costs and utilization

Healthcare costs were retrieved from the financial department of the University Hospitals Leuven. It concerns all hospital-related costs from the first to the last clinical contact. These costs were categorized into five main categories: honoraria or fees, materials, hospitalization (daily patient care cost), daycare stay and pharmaceuticals (24). In Belgium, honoraria are based on a fee-for-service principle and consist mainly of fees related to medical activities such as surgery, consults and imaging. The fees are independent of the rank of the surgeon because they are charged under the attending physician. Materials were defined as costs related the required materials for the operative treatment of AATR. Costs for received drugs were categorized as pharmaceuticals. Determining the performance impact due to differences in length-of-stay (LOS), the actual LOS of the patient was multiplied by € 441 (the average national day-based care fee) (25). This result was interpreted as the actual hospitalization-related costs of a patient. All costs were allocated with prices of 2017. Additionally, we addressed the number of interventions, hospital admissions, ambulatory consults and daycare admissions. Costs and utilization of healthcare was calculated until last (outpatient) contact.

Statistical analysis

Statistical analysis of all data was performed using IBM SPSS 25.0 (SPSS Inc. Chicago, IL) software. Continuous variables are presented as the median and interquartile distribution, categorical variables as numbers and percentages. Chi-Square statistics was used for the comparison of nominal variables and the Mann- Whitney *U* test for the comparison of nonparametric variables. The Pearson correlation test and Spearman correlation test were used respectively for continuous and nominal variables. For all tests, a significance level of $p < 0.05$ was accepted. A stepwise multiple logistic regression analysis was performed on significant variables, conducted from the bivariate analysis, to determine independent significant variables that influence the outcome.

RESULTS

Descriptives

The patient demographic and clinical characteristics are summarized in Table 1. 74/105 patients responded to the questionnaires, indicating a response rate of 70.5%. The median clinical follow-up was 4.2 months (IQR 2.9-6.1) months. Median overall follow-up up until receiving the questionnaires was 21.8 (IQR 6.9-37.4) months. The overall follow-up corresponds with the healthcare cost calculation. Responders and non-responders differed significantly in median overall follow-up and number of cardiovascular risk factors (30.8 *vs.* 4.2 months, p<0.001 and 1 *vs.* 0, p=0.051, responders *vs.* non-responders, respectively).

Functional outcome and its determinants

A median ATRS score of 17 was recorded. Bivariate analysis on the ATRS was performed in regard to all demographics, risk factors for AATR, and operative characteristics. All results are presented in Table 2. Further investigation into influencing factors on ATRS was performed by analyzing bivariate significant results in a linear regression model. Medication impairing healing (p=0.038), the presence of rheumatoid arthritis (p=0.038) and pre-rupture symptoms (p=0.001) were identified as the most important variables affecting the ATRS negatively.

Comparison of superficial and deep infection, and re-rupture-based patient clusters revealed no significant difference in ATRS (Table 3, Figure 1). The median ATRS score between patients after surgical debridement and re-rupture surgery did not differ significantly (p= 0.774). Only non- infectious re-ruptures were reported.

How can the complication rate be reduced?

The rank of the surgeon was associated with a higher complication rate. Surgical residents caused overall significantly more complications, p=0.042. In surgical residents a clear trend towards higher infection risk (p=0.064) and sural nerve hypoesthesia (p= 0.113) was observed. Infection was associated with dyslipidemia (p=0.036). A trend towards statistical significance was also seen for the operating surgeon (p=0.064), hypercholesterolemia (p=0.08) and alcohol use (p=0.054). In addition, alcohol use was associated with an increased number of re-ruptures (p=0.001) as well as cardiovascular risk factors (p=0.007).

Healthcare costs

The distribution of the healthcare costs and utilizations are summarized in Table 4. Infection (n=24) was associated with significantly higher total healthcare costs per patient, almost exclusively due to surgical debridement (€2,469 *vs*. €14,966, superficial *vs*. deep infection, respectively, p<0.001). The total healthcare cost for surgical debridement were mainly driven by hospitalization (LOS) and fees with a relative share of 66% and 26%, respectively (Figure 2). The total cost for surgical debridement was approximately 5-times higher than for re-rupture (€108,382 *vs.* €22,272, debridement *vs.* re-rupture, respectively, p=0.013).

DISCUSSION

The goal of this study was to evaluate the clinical and functional outcome of open surgical treatment of AATR and to compare the results to percutaneous repair described in literature, in order to justify a transition to a new treatment protocol for AATR. Moreover, the impact of complications on the total healthcare costs and utilizations was determined.

In accordance with the literature, AATR occurred predominantly in middle-aged men (26). Despite an overall good functional outcome, we found a relatively high complication rate after open AATR repair. It mainly concerned here delayed wound healing, infectious complications, and sural nerve hypoesthesia. This is in line with the literature for open surgical treatment of AATR (13,14,26). AATR followed by surgical debridement (Figure 3) showed worse functional outcome. Despite a clear trend towards less favorable functional outcome scores, the median ATRS score after surgical debridement (i.e. deep infection), did not differ significantly from non-infectious patients due to divergent IQR values. Nevertheless, a difference of at least 10 points in ATRS scores can be considered as clinically relevant (22). Fortunately, the number of patients requiring surgical debridement was limited, as well as the number of patients requiring surgical repair for re-rupture of the Achilles tendon. Only non-infectious re-ruptures were reported (n=5) of which 3 patients answered the questionnaire. The ATRS after re-rupture surgery was not significantly higher, although a clinically relevant 10-point difference was seen in 2 out of 3 patients (66.6%) (Table 3). The median ATRS score between surgical debridement and re-rupture surgery did not differ significantly (p= 0.774). The functional outcome is also strongly influenced by medication impairing healing, the presence of rheumatoid arthritis and pre-rupture symptoms. This can be explained by medication use for other morbidities and difficult controllable chronic pain mechanisms.

We aimed to compare the outcome of the current open treatment protocol for AATR to available literature on percutaneous techniques and non-operative treatment. A critical appraisal of the literature reveals a significantly better functional outcome and quicker return to work in favor of the surgically treated patients (5–8). However, the literature shows that there is no significant difference in functional outcome between patients treated open and percutaneously (13,26,16,27). Nevertheless, the reported complication rate is higher after open AART, ranging up to 26.1% (13). These patients mainly suffer from infection, delayed wound healing and adhesions. Although percutaneously treated patients show lower complication rates in terms of wound infections, they have an increased risk of re-rupture (3.1 - 6.4%) and sural nerve hypoesthesia (4.5 - 5.5%) (16,18).

In turn, we observed that the complication rate of open surgical repair was strongly associated with the rank of the operating surgeon. Patients operated by surgical residents showed a significantly higher complication rate (i.e. infection and sural nerve hypoesthesia). Although several risk factors for infection were identified, none of them seem immediately modifiable, except the operating surgeon. Therefore, training and teaching of surgical residents play a key-role to reduce complications.

Healthcare cost and utilization analysis after open AATR revealed an important economic burden due to infection and re-ruptures. Only a few studies have studied the economic burden of surgical repair of AATR. Specifically, percutaneous repair is shown to be more favorable in terms of economic management compared to open surgical repair, with comparable outcomes, and conservative treatment is economically preferable to surgical repair, although functionally surgical treatment is preferred as previously mentioned (27-28). Up to date there is no available literature on the impact of complications after open AATR repair on healthcare costs and utilization. Particularly deep infection requiring surgical debridement, was found to be the most significant causal factor for increased total healthcare costs and utilization, due to prolonged hospitalization and higher fees. The distribution of healthcare costs was equal to what we have shown previously for the treatment of tibial fractures, wherein the total healthcare costs are mainly driven by the LOS (29).

Considering the total healthcare cost for surgical debridement was approximately 5-times higher than for re-rupture, a transition to percutaneous AATR repair seems justified. Although the incidence of re-rupture could possibly increase when a percutaneous repair is executed, the benefit of a lower infection rate will likely outweigh the increased re-rupture risk regarding the respective healthcare cost differences (15,16,30).

This study has its limitations related to its retrospective design. Incomplete and inaccurate coding in electronic medical file database KWS was a main concern of this study. As a consequence of the rather low response rate of 70.5%, there were only a limited number of patients available for statistical analysis (e.g. re-rupture). Furthermore, it remains unclear from our data to what extent postoperative functional rehabilitation could possibly affect the functional outcome measured by the ATRS score. With the continuing increase in healthcare costs and the rapid gaining importance of health economics, it seems justified to include the economic burden in decision-making about the surgical treatment of AATR. However, since healthcare financing is country-specific, data and conclusions from this study cannot simply be compared linearly, without taking the differences in healthcare financing into account.

In conclusion, the high complication rate, due to wound healing problems and infections, together with the high total healthcare costs associated with open AATR, force us to reconsider our treatment protocol for AATR. Various studies have shown a lower infection risk and equal treatment efficacy of percutaneous AATR compared the open surgical approach. Despite the re-rupture rate of percutaneous AATR is reported to be higher, we have shown that the effect on functional outcome and its economic burden will probably be limited. Therefore, the transition to a percutaneous AATR seems justified. We decided to change practice in order to reduce the complication rate and healthcare costs. The clinical and functional outcome as well as the precise costs for percutaneous AATR will be reported in the future.

REFERENCES

1. Zhang H, Tang H, He Q, Wei Q, Tong D, Wang C, et al. Surgical Versus Conservative Intervention for Acute Achilles Tendon Rupture: A PRISMA-Compliant Systematic Review of Overlapping Meta-Analyses. Medicine (Baltimore). 2015 Nov;94(45):e1951.
2. Wu Y, Lin L, Li H, Zhao Y, Liu L, Jia Z, et al. Is surgical intervention more effective than non-surgical treatment for acute Achilles tendon rupture? A systematic review of overlapping meta-analyses. Int J Surg. 2016 Dec;36(Pt A):305–11.
3. Ganestam A, Kallemose T, Troelsen A, Barfod KW. Increasing incidence of acute Achilles tendon rupture and a noticeable decline in surgical treatment from 1994 to 2013. A nationwide registry study of 33,160 patients. Knee Surg Sports Traumatol Arthrosc. 2016 Dec 20;24(12):3730–7.
4. Leppilahti J, Puranen J, Orava S. Incidence of Achilles tendon rupture. Acta Orthop Scand. 1996 Jun;67(3):277–9.
5. Nilsson-Helander K, Silbernagel KG, Thomeé R, Faxén E, Olsson N, Eriksson BI, et al. Acute achilles tendon rupture: a randomized, controlled study comparing surgical and nonsurgical treatments using validated outcome measures. Am J Sports Med. 2010 Nov 27;38(11):2186–93.
6. Olsson N, Silbernagel KG, Eriksson BI, Sansone M, Brorsson A, Nilsson-Helander K, et al. Stable surgical repair with accelerated rehabilitation versus nonsurgical treatment for acute Achilles tendon ruptures: a randomized controlled study. Am J Sports Med. 2013 Dec 6;41(12):2867–76.
7. Holm C, Kjaer M, Eliasson P. Achilles tendon rupture - treatment and complications: A systematic review. Scand J Med Sci Sports. 2015 Feb;25(1):e1–10.
8. Metz R, Verleisdonk E-JMM, van der Heijden GJ-M-G, Clevers G-J, Hammacher ER, Verhofstad MHJ, et al. Acute Achilles Tendon Rupture. Am J Sports Med. 2008 Sep 30;36(9):1688–94.
9. Willits K, Amendola A, Bryant D, Mohtadi NG, Giffin JR, Fowler P, et al. Operative versus Nonoperative Treatment of Acute Achilles Tendon Ruptures. J Bone Jt Surgery-American Vol. 2010 Dec 1;92(17):2767–75.
10. Wilkins R, Bisson LJ. Operative Versus Nonoperative Management of Acute Achilles Tendon Ruptures: A Quantitative Systematic Review of Randomized Controlled Trials. Am J Sports Med. 2012 Sep 1;40(9):2154–60.
11. Khan RJK, Fick D, Keogh A, Crawford J, Brammar T, Parker M. Treatment of Acute Achilles Tendon Ruptures. J Bone Jt Surg. 2005;87(10).
12. Pajala A, Kangas J, Ohtonen P, Leppilahti J. Rerupture and deep infection following treatment

of total Achilles tendon rupture. J Bone Joint Surg Am. 2002 Nov;84–A(11):2016–21.

13. Khan RJK, Fick D, Keogh A, Crawford J, Brammar T, Parker M. Treatment of Acute Achilles Tendon Ruptures:A Meta-Analysis of Randomized, Controlled Trials. J Bone Jt Surg. 2005 Oct 1;87(10):2202.
14. Lonzarić D, Kruščić A, Dinevski D, Povalej Bržan P, Jesenšek Papež B. Primary surgical repair of acute Achilles tendon rupture: comparative results of three surgical techniques. Wien Klin Wochenschr. 2017 Jan 26;
15. Alcelik I, Saeed ZM, Haughton BA, Shahid R, Alcelik JC, Brogden C, et al. Achillon versus open surgery in acute Achilles tendon repair. Foot Ankle Surg. 2017 May 4;
16. Yang B, Liu Y, Kan S, Zhang D, Xu H, Liu F, et al. Outcomes and complications of percutaneous versus open repair of acute Achilles tendon rupture: A meta-analysis. Int J Surg. 2017 Apr;40:178–86.
17. Bradley JP, Tibone JE. Percutaneous and open surgical repairs of Achilles tendon ruptures: A comparative study. Am J Sports Med. 1990 Mar 23;18(2):188–95.
18. Čretnik A, Kosanović M, Smrkolj V. Percutaneous versus Open Repair of the Ruptured Achilles Tendon. Am J Sports Med. 2005 Sep 30;33(9):1369–79.
19. Porter MD, Shadbolt B. Randomized controlled trial of accelerated rehabilitation versus standard protocol following surgical repair of ruptured Achilles tendon. ANZ J Surg. 2015 May;85(5):373–7.
20. Monteban P, van Den Berg J, van Hees J, Nijs S, Hoekstra H. The outcome of proximal fifth metatarsal fractures: redefining treatment strategies. European Journal of Trauma and Emergency Surgery. 2017 Oct 12;1–8.
21. Seeger JD, West WA, Fife D, Noel GJ, Johnson LN, Walker AM. Achilles tendon rupture and its association with fluoroquinolone antibiotics and other potential risk factors in a managed care population. Pharmacoepidemiol Drug Saf. 2006 Nov;15(11):784–92.
22. Nilsson-Helander K, Thomee R, Gravare-Silbernagel K, Thomee P, Faxen E, Eriksson BI, et al. The Achilles Tendon Total Rupture Score (ATRS): Development and Validation. Am J Sports Med. 2006 Nov 7;35(3):421–6.
23. Opdam KTM, Zwiers R, Wiegerinck JI, Kleipool AEB, Haverlag R, Goslings JC, et al. Reliability and validation of the Dutch Achilles tendon Total Rupture Score. Knee Surgery, Sports Traumatology, Arthroscopy. 2016 Jul 14;1–7.
24. Smeets B, Nijs S, Nderlita M, Vandoren C, Hoekstra H. Health Care Usage and Related Costs in Fibular Plating for AO Type 44-B Ankle Fractures in a Belgian University Hospital: An Exploratory Analysis. J Foot Ankle Surg. 2016 May 1;55(3):535–41.
25. Reul M, Verschaeve M, Mennes T, Nijs S, Hoekstra H. Functional outcome and economic

burden of operative management of patellar fractures: the pivotal role of onerous implants. Eur J Trauma Emerg Surg. 2017 Sep 30;1–10.

26. Tejwani NC, Lee J, Weatherall J, Sherman O. Acute achilles tendon ruptures: a comparison of minimally invasive and open approach repairs followed by early rehabilitation. Am J Orthop (Belle Mead NJ). 2014 Oct;43(10):E221-5.
27. Carmont MR, Heaver C, Pradhan A, Mei-Dan O, Gravare Silbernagel K. Surgical repair of the ruptured Achilles tendon: The cost-effectiveness of open versus percutaneous repair. Knee Surgery, Sport Traumatol Arthrosc. 2013;21(6):1361–8.
28. Truntzer JN, Triana B, Harris AHS, Baker L, Chou L, Kamal RN. Cost-minimization Analysis of the Management of Acute Achilles Tendon Rupture. J Am Acad Orthop Surg. 2017 Jun;25(6):449–57.
29. Metsemakers WJ, Smeets B, Nijs S, Hoekstra H. Infection after fracture fixation of the tibia: Analysis of healthcare utilization and related costs. Injury. 2017;48(6):1204–10.
30. Wang T, Mei G, Shi Z, Chai Y, Zhang C, Hou C. [A comparative study on repair of acute Achilles tendon rupture using three operating techniques]. Zhongguo Xiu Fu Chong Jian Wai Ke Za Zhi. 2012 Jul;26(7):814–8.

Table 1. Patient demographics, operative and postoperative characteristics (n=105)

Age (years)	44.0 (35.5 - 51.0)
Gender	
Male	89 (84.8%)
Female	16 (15.2%)
ASA-score	
1	68 (64.8%)
2	32 (30.5%)
3	5 (4.8%)
Specific risk factor medication	5 (4.8%)
CVRF	
Current cardiovascular disease	5 (4.8%)
Diabetes mellitus	3 (2.9%)
Obesity	11 (10.5%)
Smoking	26 (24.8%)
Dyslipidemia	9 (8.6%)
Hypercholesterolemia	10 (9.5%)
Arterial hypertension	5 (4.8%)
Alcohol abuse	9 (8.6%)
Rheumatoid arthritis	5 (4.8%)
Pre-rupture complaints	4 (3.8%)
Operating surgeon	
Staff member	40 (38.1%)
Fellow	31 (29.5%)
Resident	34 (32.4%)
Complications	42 (40.0%)
Hypoesthesia sural nerve	15 (14.3%)
Delayed wound healing	30 (28.6%)
Infection	22 (20.9%)
Treated with antibiotics	16 (15.2%)
Treated with surgical debridement	6 (5.7%)
Re-rupture	5 (4.8%)
Clinical follow-up (days)	127 (89-186)
Overall follow-up (days)	665 (211-1137)

Continuous parameters are expressed as median values with their respective interquartile range. Percentages of demographic, operative and postoperative variables are displayed according to total number of tendon ruptures (n=105).

Abbreviations: ASA, American Society of Anesthesiologists; CVRF, cardiovascular risk factors; FU, follow up.

Table 2. Correlation analysis

	ATRS score	Complications	Hypoesthesia sural nerve	Delayed wound healing	Infection	Re-rupture
Age (years)	-0.116	-0.144	-0.154	-0.050	-0.015	-0.136
Gender	0.156	0.036	0.068	0.137	0.075	-0.090
ASA-score	0.136	0.042	0.053	0.109	0.169	-0.026
Medication	0.196	-0.032	0.007	-0.085	0.071	0.218
Number of CVRF	0.191	0.145	0.009	0.058	0.272*	0.262*
CV disease	0.043	0.019	0.037	0.074	0.114	-0.049
Diabetes	0.044	0.014	-0.081	0.052	0.079	-0.034
Obesity	0.036	0.072	-0.074	0.073	0.094	0.133
Smoking	0.193	0.141	0.079	0.039	0.130	0.175
Dyslipidemia	0.060	0.116	-0.057	0.108	0.283*	0.149
Hypercholesterolemia	0.079	0.072	-0.074	0.073	0.245*	0.133
Hypertension	-0.043	-0.032	0.007	0.027	0.071	-0.055
Alcohol use	0.063	0.073	-0.038	-0.044	0.159	0.402**
Rheumatoid arthritis	0.201	-0.032	0.145	-0.085	-0.012	-0.055
Pre-rupture complaints	0.204	0.019	0.037	0.074	0.148	-0.049
Operator	-0.099	-0.280*	-0.242*	-0.226*	-0.304**	0.085

Correlation analysis. Correlations are noted as r values. The resulting correlation coefficients are marked if statistical significant:* $p < 0.05$ or (**) if $p<0.01$. *Abbreviations:* ATRS, Achilles tendon total rupture score; ASA, American Society of Anesthesiologists; CVRF, cardiovascular risk factors; CV, cardiovascular disease.

Table 3. Functional outcome (n=74)

	ATRS score	*p value*
Median ATRS score	17 (6.5-39.5)	
No complications (n=40)	19 (13.5-40)	
Complications (n=34)	12 (5.3-38.3)	
Between groups p value		0.283
No infection (n=55)	17 (6-41)	
Infection treated with antibiotics (n=14)	15 (7.5-19)	
Infection treated with surgical debridement (n=5)	32 (21-63)	
Between groups p value		0.225
No re-rupture (n=71)	17 (6-29)	
Re-rupture (n=3)	28 (15-28)	
Between groups p value		0.337

Continuous parameters are expressed as median values and their respective interquartile range.

Table 4. Healthcare costs and utilization (n=105)

	All (n=105)	*Infection treated with surgical debridement (n=6)*	*Re-rupture (n=5)*
Healthcare costs (in €)			
Fees	1172 (1057-1343)	€3839 (2678-4771)*	€2241 (2080-2492)**
Materials	0	€0 (0-18)	€0 (0-210)
Hospitalization	882 (441-1323)	€9923 (8710-17,420)*	€1764 (1103-2205)
Daycare stay	31 (30-62)	€30 (22-563)*	€61 (46-77)
Pharmaceuticals	184 (173-204)	€707 (441-981)*	€355 (313-401)
Total cost	2211 (1874-2658)	€14,966 (12,188-23,118)*	€4537 (3810-5058)**
Healthcare utilization			
Number of interventions	1	5 (3-7)*	2
Number of hospital admissions	1	3 (2-3)*	2 **
Total length-of-stay (LOS)	2 (1-3)	23 (20-40)*	4 (3-5)
Number of ambulatory consults	4 (3-6)	7 (5-10)*	8 (7-13)**
Number of daycare admissions	1 (1-2)	1 (1-3)	2 (2-3)

Continuous parameters are expressed as median values with their respective interquartile range. Categorical variables are expressed as numbers and percentages, according to total number of patients in each category as indicated in the corresponding columns. The resulting p values are marked (*) if $p < 0.05$ when comparing the healthcare costs and utilization to no infection (n=83) and as (**) when comparing to no re-rupture (n=100).

LEGENDS

Figure 1.

Comparison of ATRS scores among different complications

Figure 2.

Comparison of total healthcare costs distribution among different complications

Figure 3.

Surgical debridement for deep surgical site infection

A 30-year-old patient treated for an AATR in an open surgical manner. The postoperative course was complicated by wound dehiscence and deep infection. A debridement was performed several times and the wound treated with VAC-therapy. Eventually the wound was closed using an adipocutaneous lateral calcaneal artery perforator-based flap.

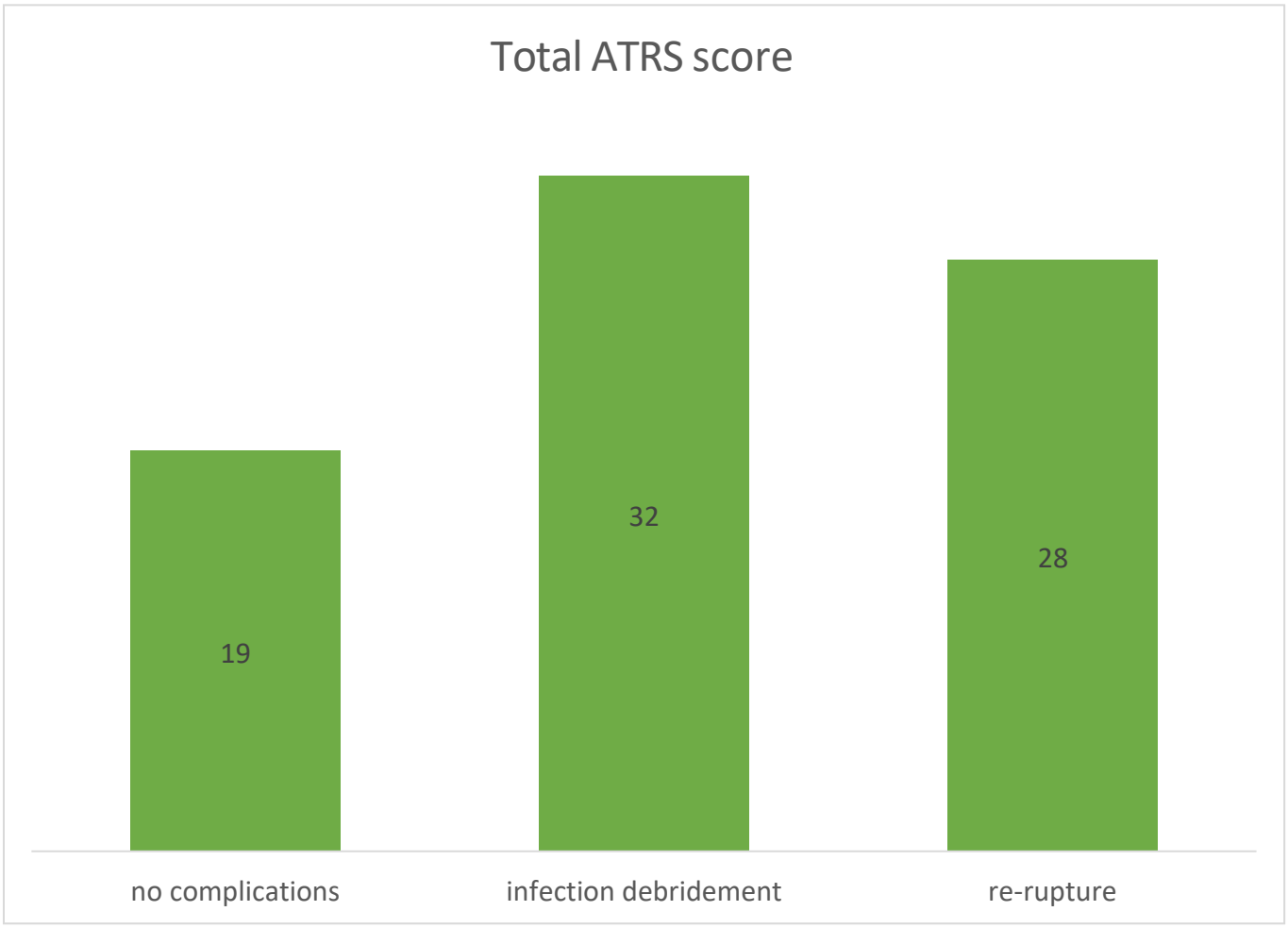
Total ATRS score
19
32
28
no complications
infection debridement
re-rupture

Figure 1

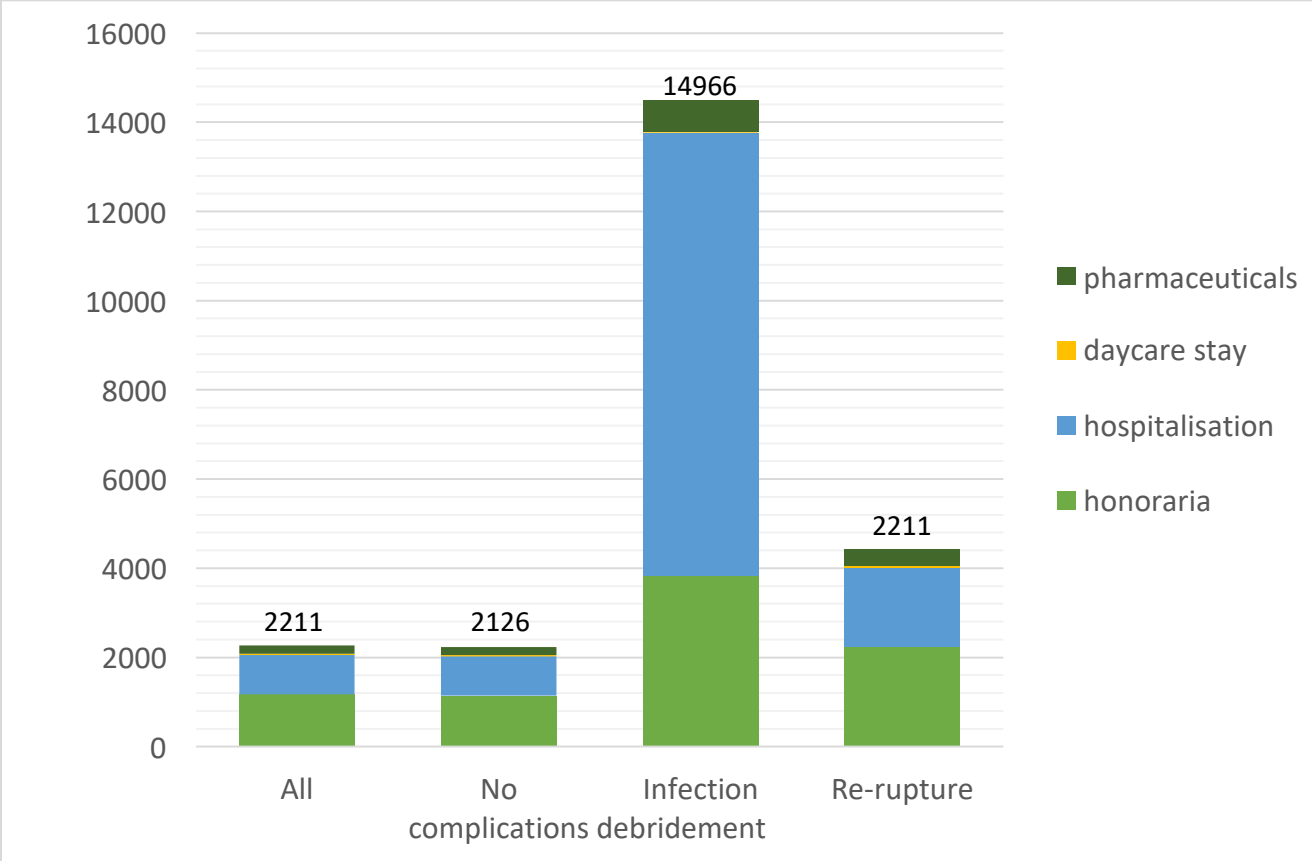
16000
14000
12000
10000
8000
6000
4000
2000
0
14966
2211
2211
2126
All
No complications
Infection debridement
Re-rupture
pharmaceuticals
daycare stay
hospitalisation
honoraria

Figure 2



Figure 3A



Figure 3B



Figure 3C