Arch Orthop Trauma Surg (2011) 131:33–38
DOI 10.1007/s00402-010-1097-0

ORTHOPAEDIC SURGERY

Achilles tendon ruptures in diabetic patients

Nicola Maffulli · Umile Giuseppe Longo · Gayle D. Maffulli · Anil Khanna · Vincenzo Denaro

Received: 10 January 2010 / Published online: 6 April 2010

Abstract
Aim The aim of this study is to evaluate the results of percutaneous repair of an acute AT rupture in diabetic patients.
Method The study included 39 subjects who were operated at our institution. We performed pre-operative evaluations the day of surgery, and report the results of post-operative evaluation at the final follow-up.
Results The Achilles tendon total rupture score had a post-operative average rating of 70.4 ± 13 (range 55–92). All patients were able to fully weight bear on the operated limb by the end of the eighth post-operative week. Eight patients suffered from a superficial infection of the surgical wound.
Conclusion In conclusion, percutaneous repair of the AT is a viable option for diabetic patients.

Keywords Achilles tendon · Ruptures · Complications · Diabetes · Infections

Introduction

The increasing prevalence of obesity and a sedentary lifestyle are key contributors to the rising prevalence of type 2 diabetes throughout the world [39]. As the incidence of diabetes mellitus (DM) is globally increasing, the related complications are also mounting. Microvascular and macrovascular damages are often challenging complications, being responsible for morbidity and mortality caused by DM. Retinopathy, arteriopathy, peripheral neuropathy, and poor wound healing are well known complications of DM [5].

The musculoskeletal system is involved in DM [38], but its effects on tendons are not fully understood [8]. A statistically significant correlation between Achilles tendinopathy and DM has been found in men younger than 44 [11]. A recent study showed that normal, but in the high range of normal, plasma glucose levels may be a risk factor for rotator cuff tear [13]. At a tissue level, the tendon may be directly affected by non-enzymatic glycosylation processes which change collagen cross-links [2]. The cross-linking of collagen by the non-enzymatic advanced glycation endproducts formation or the enzymatic glucose incorporation has been indicated as one of the main mechanisms underlying the increased arterial stiffness in diabetic patients or diabetic complications in general [35, 36].

A higher rate of deep infection has been reported in diabetic patients undergoing surgery [1]. In patients with operatively managed Achilles tendon ruptures, diabetes increased the risk of wound complications by 3.4 times [3]. A deep infection after surgery for AT repair can have devastating effects, and is a major management challenge. Management of acute AT ruptures can be broadly classified as operative (open or percutaneous) or non-operative (cast immobilisation or functional bracing). Open operative management of acute AT ruptures significantly reduces the risk of re-rupture compared with non-operative management, but operative management is associated with a significantly higher risk of other complications. Operative

N. Maffulli (✉) · G. D. Maffulli · A. Khanna
Centre for Sports and Exercise Medicine, Barts and The London School of Medicine and Dentistry, Mile End Hospital, 275 Bancroft Road, London E1 4DG, UK
e-mail: n.maffulli@qmul.ac.uk

U. G. Longo · V. Denaro
Department of Orthopaedic and Trauma Surgery, Campus Biomedico University, Rome, Italy

risks may be reduced by performing surgery percutaneously [7, 12].

The incidence of overt sequelae in diabetic patients undergoing surgery has traditionally been reported higher than in non-diabetic patients [3]. Despite the relevance of the problem, to date no studies have addressed the specific issue of the management of acute AT ruptures in such patients.

The present study evaluated prospectively the surgical outcomes of percutaneous repair of an acute AT rupture in a cohort of diabetic athletes.

Materials and methods

Our institutional review board approved the study, and all patients gave written informed consent to participate in the study.

Between May 1996 and December 2003, we operated on 39 consecutive diabetic patients who sustained an acute tear of the AT and underwent a surgical repair. All the patients were secondary or tertiary referrals to the senior author.

Eligibility criteria

Patients were included in the study if (1) they sustained an acute Achilles tendon rupture within 2 weeks of the index procedure, (2) they had no previous injuries to the AT, (3) they had a unilateral tear, (4) they had not suffered from a contralateral AT tear; (5) they had not suffered a tear of another tendon in the ipsi- or contralateral limb, (6) they were under active medical management for type II diabetes.

Patients were excluded from the study if they had (1) an associated tear of another tendon in the ipsi- or contralateral limb, (2) previous surgery on the Achilles tendon, (3) a fracture of the calcaneus, (4) neuromuscular disorders. The patients' post-operative management and clinical follow-up was performed according to what previously described [27].

Patient's demographics

The study included 39 subjects (28 men, and 11 women; mean age at operation: 53.6 ± 11.7 years, range 38–78 years).

36 patients suffered their AT tear following indirect trauma, and three reported to have sustained a direct hit on the affected Achilles tendon. The mechanism of injury was activity-related in 21 of the 39 patients (3 playing golf, 6 hill walking, 5 fly fishing, 3 power walking, one playing badminton, one playing squash, one playing tennis, one playing indoor soccer). The other 15 patients who sustained an indirect trauma reported to have experienced the injury while pushing a car (six patients), lifting a heavy weight (two patients), stepping off the curb (two patients), descending a step (four patients), and falling off a bicycle (one patient).

A fellowship trained orthopaedic surgeon with a special interest in these injuries performed all procedures. All patients underwent percutaneous repair of the AT tear using the technique described by Sutherland and Maffulli [40] in the period 1996–2001, and the technique described by McClelland and Maffulli in the period 2002–2003 [30]. All patients were operated within 48 h of presentation to the senior author, and within 2 weeks of the original injury (6.1 ± 2 days, range 1–14 days). Prophylactic antibiotics and anti-thrombotic prophylaxis were not routinely used.

Two orthopaedic trainees who had not been involved in the initial management of the patients involved in the present study assessed all the patients. All had received specific training for the purposes of this study.

Evaluation

We performed pre-operative evaluations the day of surgery, and report the results of post-operative evaluation at a final follow-up at an average of 64 months (range 48–100 months) from the operation. Each patient was evaluated for limb dominance, trauma history, duration and type of pre-operative symptoms, and post-operative Achilles tendon total rupture score (ATRS) [32].

Clinical examination consisted of evaluation of the ankle motion, skin sensitivity, and adherence between skin and tendon. No imaging assessments were performed for the purposes of this study. We invited each patient by mail, sending an introductory letter explaining the purpose of the study, and an information sheet explaining what the project entailed. If a package was returned with an 'addressee unknown' notice, we performed an extensive search using hospital records, telephone book and the internet. After 6 weeks from the original mailing, the package was re-sent to the non-responders. If there was still no response, a follow-up telephone call attempted to encourage participation in the study. If this attempt failed, this was counted as a non-response. Of the 39 patients potentially able to participate in this study, we were able to track down 33 patients.

Functional assessment

The ATRS [32] was used to evaluate post-operative patients' symptoms and physical activity outcome after management of Achilles tendon rupture.

Anthropometric measurements

The maximum calf circumference was measured in both the affected and the contralateral leg using a commercially available steel tape measurer [10]. The measurer was able to reproduce within 5% the duplicate measurements on the same calf [17, 20].

Isometric gastrocsoleus muscle strength

Isometric plantar flexion strength of the gastrocsoleus muscle complex was determined bilaterally with the ankle at neutral (0°) position by using a custom-made apparatus [19]. The apparatus consists of a footplate, the angle of which could be varied and locked into a given position. An analog-to-digital converter (ADC-10, PICO Technology, Cambridge, UK) connected the strain gauge on the footplate to a voltmeter (Picoscope, PICO Technology). In its turn, the voltmeter was connected to a computer. The changes in voltage were then converted into Newtons to measure strength. The apparatus was calibrated by suspending known weights from 2.5 to 37.5 kg before and after each patient was tested, giving a linear response. Each patient supported the lower limb in the leg rest, with the heel placed firmly at the top of the footplate and with the plantar aspect of the foot resting at ease. The patient was then asked to exert maximal isometric force on the footplate for 3–5 s. The maximum result was noted. The amplifier was used each time to return the voltmeter to 0. Each patient performed two maximal attempts, and the average was used for further analysis.

Complications

Complications were divided into three categories: minor complications, general complications, major complications.

Minor complications included wound complications. General complications indicated as pain, swelling and weakness. Major complications included deep infections; chronic infection; deep vein thrombosis; pulmonary embolism; tendon lengthening; death.

Post-operative management

Following the percutaneous repair of the torn Achilles tendon, patients were immobilized with their ankle in gravity equinus, they were encouraged to bear weight on the operated limb as soon as possible to full weight bearing, and were discharged home on the day of the procedure. All patients were given an appointment for review 2 weeks post-operatively (OPD1), when they received a single cast change, with the ankle accommodated in a removable anterior splint in a plantigrade position, secured to the lower leg and foot with Velcro straps. Removal of the foot straps under supervision of a physiotherapist allowed the ankle to be plantar flexed fully but not dorsiflexed [27, 28]. These exercises were performed against manual resistance. At OPD2 (6 weeks post-operatively), the anterior splint was removed, and the patient referred to physiotherapy for active mobilisation.

At OPD3 (12 weeks post-operatively), patients were assessed as to whether they were able to undertake more vigorous physiotherapy, and were encouraged to gradually return to their normal activities. Progressive activities were incorporated as strength allowed, with the aim to return to unrestricted activities 6 months following surgery.

Patients were reviewed during the sixth post-operative month. They were then followed up at 3-month intervals and discharged at 9 or 12 months after the operation, once they were able to perform at least five toe raises unaided on the operated leg and after they returned to their normal activities. Patients were prompted to contact the operating surgeon should any problems arise at any time after the operation.

Statistics

Descriptive statistics were calculated. Comparisons between the operated and the normal limb from the same person were performed using the McNemar's test to analyse binary data, and the Wilcoxon test on the difference in scores for continuous data. Significance was set at the 0.05 level.

Results

The mean operative time was 20 ± 9 min (range 13–30).

Surgery

All patients were able to fully weight bear on the operated limb by the end of the eighth post-operative week. Eight patients suffered from a superficial infection of the surgical wound. They received oral antibiotics for 5–14 days, and 9 of the 11 healed uneventfully. Two of them needed surgical debridement and washout, and healed after 5 weeks of elevation and antibiotics, with no adverse effect to the operated tendon.

Six patients reported hypersensitivity of the surgical wounds. They were counselled to rub hand cream over the wounds several times a day, and were asymptomatic by the sixth post-operative week. Two patients developed a hypertrophic scar in the distal wound, where it rubbed against the shoe. At final review, all patients were pleased

with the appearance of the operative scars. Inspection and palpation revealed that the operated tendon was always thicker than the contralateral [29].

Pain on weight bearing

27 of the 33 patients on whom we have a full data set experienced no pain on weight bearing. Four individuals reported pain after weight bearing for long periods. No patient experienced pain after weight bearing for short periods.

Pain at other times

25 of the 33 patients on whom we have a full data set reported no pain when not weight bearing, five experienced pain during cold weather, and three reported occasional pain at rest. No patients suffered constant pain, either when weight bearing or at any other time.

Perceived reduction in muscle strength

24 of the 33 patients on whom we have a full data set perceived a reduction in the strength of their triceps surae muscle group, and 16 patients were able to perform single leg tiptoe stands. Four individuals were not able to stand on tiptoe, but one of these patients reported being unable to stand on tiptoe before the injury.

Swelling

19 of the 33 patients on whom we have a full data set experienced swelling in the area of the Achilles tendon or around the ankle. All patients reported swelling around the ankle or in the area of the Achilles tendon after prolonged standing or walking.

Cramps

15 of the 33 patients on whom we have a full data set suffered from cramps in the affected leg.

Functional assessment

The ATRS [32] had a post-operative average rating of 70.4 ± 13 (range 55–92).

Anthropometric measurements

The maximum calf circumference was significantly decreased in the operated limb (45.6 ± 7.1 vs. 41.1 ± 8.3 cm, $P = 0.03$).

Isometric gastrocsoleus muscle strength

The duplicate measurements showed a high intraobserver reliability ($r = 0.91$, $P = 0.0023$). The t test paired sampled statistics showed that the operated limb was always less strong than the non-operated one.

Discussion

We evaluated the results of diabetic patients with an acute tear of the AT managed using percutaneous repair with absorbable sutures. In our hands, percutaneous repair of the AT is a viable option for diabetic patients, producing acceptable outcome.

Major strengths of the present study are that a single fully trained surgeon performed all the operation using well established techniques, and that the follow-up evaluations were performed by independent assessors. Our follow-up of at least 4 years is long enough to consider that, by then, the results of surgery had stabilised, and recovery effected and stabilised. Another strength of this investigation is that we used the ATRS, a patient-reported instrument with high reliability, validity, and sensitivity for measuring outcome after management in patients with a total Achilles tendon rupture [32]. However, it should be pointed out that not all patients, especially older patients, are able to respond to all the questions.

All our patients were managed with percutaneous surgery. To our knowledge, our series is the largest in literature to analyse the clinical outcome of diabetic patients with acute AT ruptures managed in such fashion. Percutaneous repair is becoming well accepted in the management of acute AT tears [15, 16]. There is evidence that percutaneous repair methods yield similar failure rates for re-rupture when compared to open techniques [7, 12]. The major advantages of percutaneous repair are less iatrogenic damage to normal tissues, lower post-operative pain, accurate opposition of the tendon ends minimising surgical incisions, thus protecting against wound breakdown and wound complications [37], and improved cosmesis [14, 18, 21–26]. Although sural nerve injury has been reported as a potential complication of this kind of surgery, new techniques have minimised the risk of sural nerve damage [4]. Indeed, our own work in this respect confirms that sural nerve problems can be minimised using local anaesthesia and newer percutaneous repair techniques. Percutaneous repair in diabetic patients with AT rupture may minimise the rate of infections arising from traditional open repairs [31]. In our hands, the rate of sural nerve injuries is remarkably low, and probably reflects the attention to details, the fact that the procedure is performed under local anaesthesia, and the accurate placement of the surgical

incisions. The lower rate of iatrogenic sural nerve injuries reported using newer techniques is comforting, and reflects the experience of other authors [6].

All our patients had type 2 diabetes. Type 2 diabetes is part of the metabolic syndrome [33], patients with diabetes are often overweight, and there is a correlation between lower limb tendinopathy and adiposity [9]. Our rate of complications was high, despite of use of minimally invasive techniques. The finding that diabetic patients have high rate of post-operative infection is not new [1, 3], and it is also of note the fact that tendon healing in these patients impaired. Diabetic patients with neuropathy or vasculopathy have higher complication rates than both diabetic patients without these comorbidities and non-diabetic patients [41]. Finally, at a tissue level, the tendon may be directly affected by non-enzymatic glycosylation processes which change collagen cross-links [2]. The biosynthesis of collagen is characterised by the presence of a large number of post-translational modifications such as hydroxylation and glycosylation of the polypeptide chains which are unique to collagen and a few other proteins [34]. The modification of collagen by glucose fixation on free amino groups of collagen is characterised by an altered solubility, and increased resistance to enzymatic digestion, and variations in crosslinking [34]. Since collagen is a widely distributed tissue protein, disturbance in its structure and function will have important consequences in many body organs [34]. The cross-linking of collagen by the non-enzymatic advanced glycation endproducts formation or the enzymatic glucose incorporation has been indicated as one of the main mechanisms underlying the increased arterial stiffness in diabetic patients or diabetic complications in general [35, 36].

While we cannot advocate percutaneous repair for all acute ruptures of the AT in diabetic patients, we suggest that it should be kept as part of the management options. Given the poor tendon healing in diabetic patients, it is possible that conservative management, though intrinsically safer in terms of avoiding surgical complications, may results in poor and more prolonged tendon healing and greater degree of disability. In these patients, we do not advocate traditional open techniques, given the well established, and possibly unavoidable, skin healing complication rate observed even in non-diabetic patients undergoing surgery [37].

Our diabetic patients could have been assessed pre-operatively and at final follow-up using more sophisticated clinical means, such as, for example, two point discrimination testing. However, this is not part of our routine assessment, and would have needed to be standardised and optimised. Given the involvement of several junior doctors in the pre-operative management of these patients, this would was not practical.

It would have been interesting to assess the imaging characteristics of the healing tendon, and ascertain whether there were quantitative and qualitative differences between the diabetic and non-diabetic patients. This may well be the subject of future endeavours in this field.

A further limitation of the present investigation is the fact that we only focus on the surgical management of Achilles tendon rupture in diabetic patients. We are aware that conservative management is widely practised, but we point out that these patients were secondary or tertiary referrals to the senior author, and that we therefore had no access to patients whose injury was managed conservatively. It would be interesting to perform such comparison, although we suspect that a randomized controlled trial may be difficult to pursue given the relative rarity of the condition (an average of five patients per year referred to a surgeon with a special interest in the condition, and the only surgeon taking care of this injury for a tertiary referral population of 1.5 million people).

In conclusion, we suggest that percutaneous repair under local anaesthesia for acute AT ruptures in diabetic patients gives satisfactory and predictable results.

Conflict of interest statement None.

References

1. Aderinto J, Keating JF (2008) Intramedullary nailing of fractures of the tibia in diabetics. J Bone Joint Surg Br 90:638–642
2. Bai P, Phua K, Hardt T, Cernadas M, Brodsky B (1992) Glycation alters collagen fibril organization. Connect Tissue Res 28:1–12
3. Bruggeman N, Turner NS, Dahm DL, Voll AE, Hoskin TL, Jacofsky DJ, Haidukewych GJ (2004) Wound complications after open Achilles tendon repair: an analysis of risk factors. Clin Orthop Relat Res 427:63–66
4. Carmont MR, Maffulli N (2008) Modified percutaneous repair of ruptured Achilles tendon. Knee Surg Sports Traumatol Arthrosc 16:199–203
5. Chaturvedi N (2007) The burden of diabetes and its complications: trends and implications for intervention. Diabetes Res Clin Pract 76(Suppl 1):S3–S12
6. Cretnik A, Kosanovic M, Smrkolj V (2004) Percutaneous suturing of the ruptured Achilles tendon under local anesthesia. J Foot Ankle Surg 43:72–81
7. Ebinesan AD, Sarai BS, Walley GD, Maffulli N (2008) Conservative, open or percutaneous repair for acute rupture of the Achilles tendon. Disabil Rehabil 30(20–22):1721–1725
8. Gaida JE, Alfredson L, Kiss ZS, Wilson AM, Alfredson H, Cook JL (2009) Dyslipidemia in Achilles tendinopathy is characteristic of insulin resistance. Med Sci Sports Exerc 41:1194–1197
9. Gaida JE, Cook JL, Bass SL (2008) Adiposity and tendinopathy. Disabil Rehabil 30:1555–1562
10. Haggmark T, Liedberg H, Eriksson E, Wredmark T (1986) Calf muscle atrophy and muscle function after non-operative vs operative treatment of Achilles tendon ruptures. Orthopedics 9:160–164
11. Holmes GB, Lin J (2006) Etiologic factors associated with symptomatic Achilles tendinopathy. Foot Ankle Int 27:952–959

12. Khan RJ, Fick D, Keogh A, Crawford J, Brammar T, Parker M (2005) Treatment of acute Achilles tendon ruptures. A meta-analysis of randomized, controlled trials. J Bone Joint Surg Am 87:2202–2210
13. Longo UG, Franceschi F, Spiezia F, Ruzzini L, Maffulli N, Denaro V (2009) Higher fasting plasma glucose levels within the normoglycemic range and rotator cuff tears. Br J Sports Med 43:284–287
14. Longo UG, Ramamurthy C, Denaro V, Maffulli N (2008) Minimally invasive stripping for chronic Achilles tendinopathy. Disabil Rehabil 30:1709–1713
15. Longo UG, Ronga M, Maffulli N (2009) Achilles tendinopathy. Sports Med Arthrosc 17:112–126
16. Longo UG, Ronga M, Maffulli N (2009) Acute ruptures of the Achilles tendon. Sports Med Arthrosc 17:127–138
17. Maffulli N (1992) The effects of intensive training on the musculo-skeletal system of elite young athletes. PhD thesis, University of London, London, United Kingdom
18. Maffulli N, Ajis A, Longo UG, Denaro V (2007) Chronic rupture of tendo Achillis. Foot Ankle Clin 12:583–596, vi
19. Maffulli N, Dymond NP, Regine R (1990) Surgical repair of ruptured Achilles tendon in sportsmen and sedentary patients: a longitudinal ultrasound assessment. Int J Sports Med 11:78–84
20. Maffulli N, Kenward MG, Irwin AS, Porter RW (1997) Assessment of late results of surgery in talipes equino-varus: a reliability study. Eur J Pediatr 156:317–319
21. Maffulli N, Longo UG, Denaro V (2009) Complications after surgery or nonoperative treatment for acute Achilles tendon rupture. Clin J Sport Med 19:441–442
22. maffulli N, Longo UG, Denaro V (2009) Letter to the editor: minimally invasive paratenon release for non-insertional Achilles tendinopathy. Foot Ankle Int 30:1027–1028
23. Maffulli N, Longo UG, Gougoulias N, Denaro V (2008) Ipsilateral free semitendinosus tendon graft transfer for reconstruction of chronic tears of the Achilles tendon. BMC Musculoskelet Disord 9:100
24. Maffulli N, Longo UG, Oliva F, Ronga M, Denaro V (2009) Minimally invasive surgery of the achilles tendon. Orthop Clin North Am 40:491–498, viii–ix
25. Maffulli N, Longo UG, Ronga M, Khanna A, Denaro V (2010) Favorable outcome of percutaneous repair of Achilles tendon ruptures in the elderly. Clin Orthop Relat Res 468(4):1039–1046
26. Maffulli N, Longo UG, Spiezia F, Denaro V (2010) Free hamstrings tendon transfer and interference screw fixation for less invasive reconstruction of chronic avulsions of the Achilles tendon. Knee Surg Sports Traumatol Arthrosc 18(2):269–273
27. Maffulli N, Tallon C, Wong J, Lim KP, Bleakney R (2003) Early weightbearing and ankle mobilization after open repair of acute midsubstance tears of the Achilles tendon. Am J Sports Med 31:692–700
28. Maffulli N, Tallon C, Wong J, Peng Lim K, Bleakney R (2003) No adverse effect of early weight bearing following open repair of acute tears of the Achilles tendon. J Sports Med Phys Fitness 43:367–379
29. Maffulli N, Testa V, Capasso G, Bifulco G, Binfield PM (1997) Results of percutaneous longitudinal tenotomy for Achilles tendinopathy in middle- and long-distance runners. Am J Sports Med 25:835–840
30. McClelland D, Maffulli N (2002) Percutaneous repair of ruptured Achilles tendon. J R Coll Surg Edinb 47:613–618
31. Nestorson J, Movin T, Moller M, Karlsson J (2000) Function after Achilles tendon rupture in the elderly: 25 patients older than 65 years followed for 3 years. Acta Orthop Scand 71:64–68
32. Nilsson-Helander K, Thomee R, Gravare-Silbernagel K, Thomee P, Faxen E, Eriksson BI, Karlsson J (2007) The Achilles tendon total rupture score (ATRS): development and validation. Am J Sports Med 35:421–426
33. Pradhan A (2007) Obesity, metabolic syndrome, and type 2 diabetes: inflammatory basis of glucose metabolic disorders. Nutr Rev 65:S152–S156
34. Rathi NA, Asokan RGC, Chandrakasan R (1989) In vivo glycosylation of dermal and tendon type I collagen. Biochem Med Metab Biol 41:70–76
35. Reddy GK (2003) Glucose-mediated in vitro glycation modulates biomechanical integrity of the soft tissues but not hard tissues. J Orthop Res 21:738–743
36. Reddy GK, Stehno-Bittel L, Enwemeka CS (2002) Glycation-induced matrix stability in the rabbit Achilles tendon. Arch Biochem Biophy 15:174–180
37. Saxena A, Maffulli N, Nguyen A, Li A (2008) Wound complications from surgeries pertaining to the Achilles tendon: an analysis of 219 surgeries. J Am Podiatr Med Assoc 98:95–101
38. Smith LL, Burnet SP, McNeil JD (2003) Musculoskeletal manifestations of diabetes mellitus. Br J Sports Med 37:30–35
39. Stewart KJ (2004) Exercise training: can it improve cardiovascular health in patients with type 2 diabetes? Br J Sports Med 38:250–252
40. Sutherland A, Maffulli N (1998) A modified technique of percutaneous repair of ruptured Achilles tendon. Oper Orthop Traumatol 10:50–58
41. Wukich DK, Kline AJ (2008) The management of ankle fractures in patients with diabetes. J Bone Joint Surg Am 90:1570–1578