



Treatment of acute and closed Achilles tendon ruptures by minimally invasive tenocutaneous suturing

Minimal invaziv tenokutanöz dikişle akut ve kapalı Aşil tendonu yırtığının tedavisi

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BACKGROUND

Achilles tendon rupture is a common injury, and its complications can impair function. Numerous operations have been described for reconstructing the ruptured tendon, but these methods can compromise microcirculation in the tendon and can seriously impair its healing. Suturing with a minimally invasive tenocutaneous technique soon after the rupture and systematic functional exercise can greatly reduce the possibility of complications.

METHODS

Between June 1996 and February 2009, we treated 88 patients (54 males; age range, 21-66 years) with this method.

RESULTS

After follow-up ranging from 1-7 years, the mean American Orthopedic Foot and Ankle Society ankle-hind foot score was 95 (range, 90-98), and the maximum length of postoperative scarring was 3 cm. One patient re-ruptured his Achilles tendon one year after surgery in an accident, but after 10 months, the repaired tendon was still intact. In another patient, the nervus suralis was damaged during surgery by piercing the tension suture at the near end, causing postoperative numbness and swelling. The tension suture was quickly removed, and the patient recovered well with conservative treatment. No large irregular scars, such as those sustained during immobilization, were present over the Achilles tendon.

CONCLUSION

Minimally invasive percutaneous suturing can restore the original length and continuity of the Achilles tendon, is minimally invasive, and has fewer postoperative complications than other methods.

Key Words: Ankle; injury; surgery; trauma.

AMAÇ

Aşil tendonu yırtığı sık rastlanan bir yaralanmadır, komplikasyonları işlevini bozabilir. Yırtılmış tendonun rekonstrüksiyonu için sayısız operasyon tanımlanmış olmasına rağmen bu yöntemler tendonda mikrosirkülasyonu riske atabildiği gibi tendonun iyileşmesini ciddi derecede bozabilir. Yırtıktan hemen sonra minimal invaziv tenokutanöz teknikle dikiş atma ve sistemik fonksiyonel egzersiz, komplikasyon riskini büyük ölçüde azaltabilir.

GEREÇ VE YÖNTEM

Haziran 1996 ile Şubat 2009 arasında bu yöntemle 21-66 yaş arası 88 (54 erkek) hasta tedavi edildi.

BULGULAR

Bir ile 7 yıl arası izlemden sonra ortalama (Amerikan Ortopedik Ayak ve Ayak Bileği Derneği (American Orthopedic Foot and Ankle Society) ayak bileği ayak arkası skoru 95 (90-98 arası) ve ameliyat sonrası skarın maksimal uzunluğu 3 cm idi. Bir hasta, cerrahiden 1 yıl sonra bir kazada Aşil tendonunu yeniden yırtmıştı. Ancak 10 ay sonra onarılmış tendon hâlâ sağlamdı. Başka bir hastada uca doğru atılan gerim dikişinin delip geçmesine bağlı olarak nervus suralis zedelendi, ameliyat sonrası his kaybı ve ödeme neden oldu. Bu dikiş hemen çıkartıldı ve hasta konservatif tedaviyle iyileşti. Aşil tendonu üzerinde uzun süre hareketsiz kalkanlarda olduğu gibi düzensiz büyük skarlar yoktu.

SONUÇ

Minimal invaziv perkutanöz dikiş Aşil tendonunun orijinal uzunluk ve bütünlüğünü sağlayabildiği gibi diğer yöntemlere göre ameliyat sonrası komplikasyonları daha az olan minimal invaziv bir yöntemdir.

Anahtar Sözcükler: Ayak bileği; yaralanma; cerrahi; travma.

Despite the fact that acute ruptures of the Achilles tendon account for about 35% of all tendon tears,^[1] the optimal treatment is still controversial.^[2-5] Proposed techniques can be classified as conservative management, open repair, and percutaneous repair.^[6]

Some authors strongly recommend conservative management,^[5,7] but cast immobilization may lead to elongation of the tendon with reduced strength of the calf muscles, and it carries a high rate of re-ruptures.^[8]

Open repair of acute and closed ruptures of the Achilles tendon is widely accepted.^[9,10] However, surgical complications can influence patients' functional restoration and quality of life.^[11,12] These complications are of particular importance to athletes, who have high requirements for functional restoration.^[13]

Percutaneous suture of an Achilles tendon rupture is a simple and safe method that has functional results similar to those of open repair and a substantially lower complication rate.^[14,15] However, our surgical strategy in treating acute and closed Achilles tendon rupture differs from standard percutaneous approaches in that we use minimally invasive tenocutaneous suturing, "comb" the ruptured Achilles tendon to promote healing, and suture the tendinous sheath completely to preserve the blood supply.

We report here our results in treating 88 patients with acute and closed Achilles tendon ruptures with this minimally invasive tenocutaneous suturing. The surgery was followed by regular visits over several years to observe the clinical effects and possible complications of this technique.

MATERIALS AND METHODS

We studied all patients with acute and closed Achilles tendon ruptures who underwent minimally invasive tenocutaneous suturing at our institution between June 1996 and February 2009. None of the patients underwent bilateral Achilles tendon repair. Achilles tendon ruptures were diagnosed with magnetic resonance imaging scans (MRI) scans and physical exami-

nation (Fig. 1b, c) by the surgeon. All patients were also followed through clinic visits and telephone calls by our surgeon.

Surgical Procedure

Surgery was performed within three days of presentation. All patients received continuous epidural anesthesia while in a ventricumbent position with a tourniquet applied above the knee in the exsanguinated foot. In surgery, the surgeon located the rupture gap, placed a 3-cm transverse incision along the rupture site (Fig. 2a), and then cut open the aponeurosis lengthwise. The tendinous sheath was usually complete, and the ruptured end of the Achilles tendon was shaped like a horsetail (Fig. 2b). The hematoma at the ruptured end was removed, and the "horsetails" at the two ruptured ends were combed (Fig. 2c). The skin was pierced with a cutting needle from inside to outside at about 4-5 cm on the side near the ruptured section, and about 2-3 cm at the far side of the ruptured section to avoid the surface projection of the nervus suralis and prevent its damage.

Double-stranded #10 thread was passed through the skin and the Achilles tendon. The ankle was put in plantar flexion so that the ends of the tendon overlapped by 2 cm, and the tension suture was knotted outside the skin (Fig. 2c). Before knotting, ankle flexion was confirmed to be the same as that of the contralateral ankle joint so that the tendon could be restored to its original length. The incision was then closed and covered with a rubber urethral catheter to reduce compression on the skin (Fig. 2c). In case of exstrophy of the horsetail thread-like fiber and distention, the incision could be loosely closed with absorbable sutures to bring ends of the tendon into an introversion and to ensure proper continuity in the appearance of the tendon, as well as to reduce scarring. Meanwhile, the aponeurosis and tissues surrounding the tendon were repaired with a 4-0 absorbable suture to maintain circulation (Fig. 2d). A step by step schematic diagram of the surgical technique is shown in Fig. 3.



Fig. 1. The ruptured Achilles tendon of a 19-year-old man. (a) Preoperative scan; (b) Preoperative T1 MRI scan; (c) Preoperative T2 MRI scan.

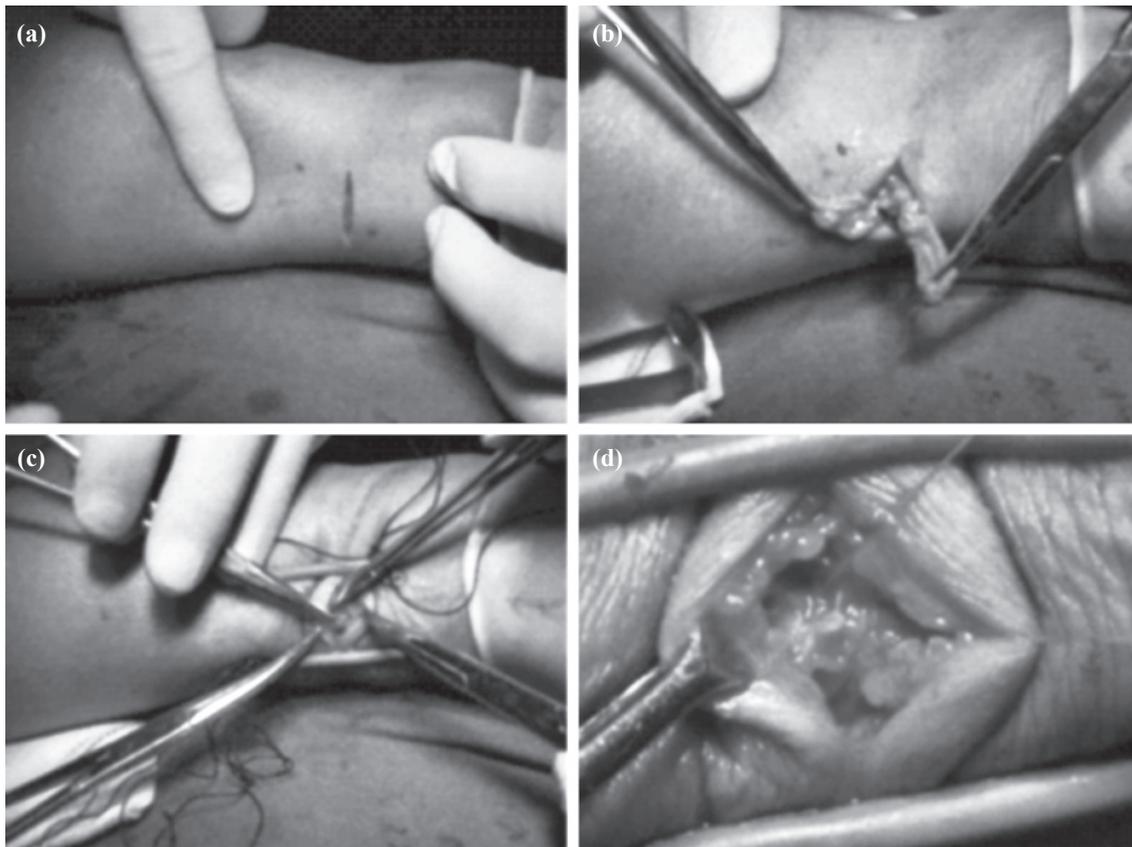


Fig. 2. Operative repair of a ruptured Achilles tendon of a 19-year-old man. (a) A 3 cm incision is made over the rupture site; (b) The ruptured end of the Achilles tendon is identified by its horsetail shape; (c) The sutured tendon is covered with a rubber urethral catheter to reduce compression on the skin; (d) The aponeurosis and tissues surrounding the tendon were repaired with a 4-0 absorbable suture.

Postoperative Care

After surgery, the knee and ankle were each flexed 30° and immobilized in a plaster cast. A window was left at the Achilles tendon to allow the dressing to be changed. The day after surgery, patients began plantar flexion and dorsal angulation exercises for the metatarsophalangeal and interphalangeal joints and contracting and relaxing exercises for the quadriceps femoris to reduce swelling and prevent the formation of venous emboli.

Patients were encouraged to move other parts of their body to prevent atrophy of the quadriceps femoris, strengthen the body's immunity, and enhance blood circulation at the wound, which helped reduced inflammation and swelling at the surgical site. Patients were also asked to do isometric exercises of the gastrocnemius and musculus soleus.

After surgery, patients were allowed to rise from their beds on crutches, but were cautioned not to place weight on the injured leg and to keep the foot in plantar flexion. The cast was changed after 2 weeks, and the degree of plantar flexion was reduced to 15°. After the cast was removed at 4 weeks, patients were in-

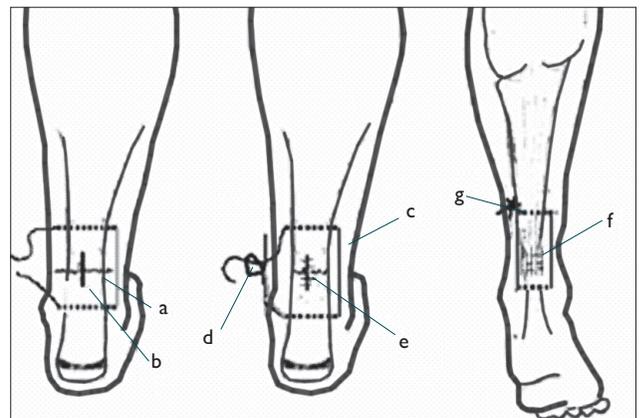


Fig. 3. Step by step schematic diagram of the surgical technique. (a) 3-cm transverse incision along the rupture site; (b) Incision of the aponeurosis lengthwise; (c) The sutured tendon is covered with a rubber urethral catheter. (d) Knot of the tension suture; (e) The aponeurosis and tissues surrounding the tendon were repaired with absorbable suture; (f) Suture in skin; (g) Tension suture was knotted outside the skin.

structed to flex the ankle while in bed. After 8 weeks, patients were allowed to stand with crutches and were encouraged to place some weight on the leg, gradually

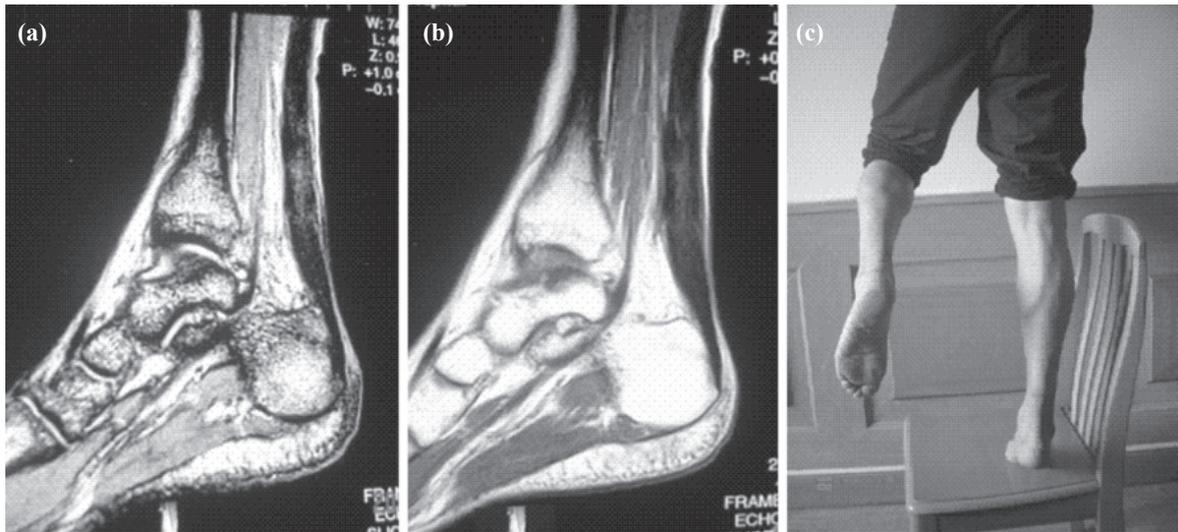


Fig. 4. The repaired ruptured Achilles tendon of a 19-year-old man. (a) Postoperative MRI scan. (b) MRI scan of the contralateral, uninjured Achilles tendon. (c) Appearance of the tendon with the heel raised.

increase the degree of flexion and extension, and walk with a thick gauze cushion in the shoe. Full weight-bearing was allowed 8 to 10 weeks after surgery.

The athletes and opera actors were encouraged to conduct adaptive rehabilitation exercises after the plaster was removed, such as swimming and cycling, and could gradually resume their training after 3-4 months. Steroid and aldosterone drugs were not used during the treatment.

Follow-Up Examinations and Endpoints

Patients were followed until 2009. Three months after surgery, MRI scans of the ankle were obtained and the healing of the Achilles tendon was visually evaluated by three of the present authors, and the American Orthopedic Foot and Ankle Society's (AOFAS) ankle-hind foot score was determined for all.^[16] In addition, the radiological and visual appearances of the repaired tendon were compared with normal radiological and visual appearance.

RESULTS

We identified 88 patients (54 males) ranging in age from 21-66 years (mean, 39.5 years) who were eligible for the study. By profession, 8 (9%) were martial arts actors from the Beijing Opera, 5 (5.68%) were opera teachers, 25 (28.41%) were athletes, 45 (51.14%) were sports fans, and 5 (5.68%) were elderly patients with a slight injury experienced while walking. Most injuries were work-related, but in 2 (2.27%) patients, a direct strike from a heavy object had ruptured the tendon.

All patients had recent closed injuries without symptoms of autoimmunization, genetic collagen disorder, contagious diseases, or incomplete neural functions. One patient died and one was lost to follow-up

after two months. This patient lost to follow-up was not known. Follow-up for the remaining 86 patients ranged from 1-7 years (mean, 2 years).

Postoperative Functional Assessment

Of the 88 patients, 78 (88.6%) had an MRI checkup three months after the surgery. In general, check-ups revealed continuity of the Achilles tendon, which was properly repaired and shaped and was close to, or had approached, the imaging result of a normal Achilles tendon (Fig. 4a, b). The raising heel test showed that 83 (94.3%) patients could raise their heels forcefully and that the shape of the Achilles tendon was good (Fig. 4c). Mean AOFAS ankle-hind foot score was 95 (range, 90-98), and the maximum length of postoperative scarring was 3 cm. No large irregular scars, such as those sustained during immobilization, were present over the Achilles tendon.

Postoperative Complications

One patient re-ruptured the same Achilles tendon one year after surgery in a sports accident. The tendon was repaired with Kessler suturing and purely reverse reinforced suturing of the gastrocnemius. Ten months after repair, the repaired tendon was still intact.

In another patient, the nervus suralis was damaged during surgery (possibly by inadvertently piercing the tension suture at the near end), causing postoperative numbness and swelling. The tension suture was quickly removed at the patient's bedside, external immobilization with the cast was prolonged by two months, and exercise intensity was increased more gradually than in other patients. The symptoms disappeared after four months, and the patient recovered well and has experienced no more ruptures.

No other complications, such as infection, skin

necrosis, adhesion between the tendon and skin, formation of a cystic lesion at the tendon, or stiffening of the ankle joint, were found in any patient during surgery or the follow-up visits.

DISCUSSION

We treated the ruptured Achilles tendons of 88 patients with our minimally invasive percutaneous suturing. This procedure preserved the original length, continuity, and appearance of the tendon with few postoperative complications.

The Achilles tendon is the strongest and largest tendon in the human body. About 15 cm long, it originates from the lower third of the calf and inserts at the mid-point of the tuberosity of the calcaneus. It has a pad of bursa synovialis at the front and back. The tendon has no sheath, only loose reticular tissue that links the tendon with the surrounding aponeurosis. It is vascularized.^[17] During surgery, we repaired the aponeurosis to ensure a good blood supply to the tendon. We believe we can achieve better healing by “combing” the horse-tail-like ends of the tendon and overlapping them by 2 cm when making the repair. Other percutaneous suturing methods do not straighten the tendon fiber, so we believe these methods are not as strong.

Traditional Achilles suturing methods include the steel wire Bunnell method and the mattress suturing method, among many others. These “direct open repairs” of the ruptured tendon can require a large incision, seriously damage tissues around the tendon, impair circulation to the tendon, and predispose the repair to postoperative infection and adhesion. Studies of the blood supply to the Achilles tendon^[18,19] revealed that these methods can impair microcirculation inside the tendon and seriously impair healing.

In contrast, many surgeons find the modified Kessler suturing and fine-thread intermittent suturing of tendon bundles to be simpler, more efficient, and more practical, and therefore, the preferred method for restoring the Achilles tendon.^[20] Furthermore, some research has found that suturing with a minimal percutaneous incision soon after the rupture and systematic functional exercise can greatly reduce the possibility of complications.^[21-23] Lansdaal et al. found that minimally invasive Achilles tendon repair in Bunnell’s suture in combination with a functional rehabilitation program is a safe and quick procedure with a low rate of re-rupture and a high level of patient satisfaction.^[24,25] Recent studies have found that long-term outcome after minimally invasive Achilles tendon rupture repair is excellent, with a low rate of complications.^[26,27]

We believe our minimally invasive percutaneous suturing conforms to the anatomical physiological feature of the Achilles tendon and meets the healing

requirements inside the tendon. In particular, the technique has the following advantages:

1) The small incision reduces damage to the tissues surrounding the tendon. We only make a simple repair on the ruptured end to make it neat. This method does not require a regular direct incision that requires strong suturing of the ruptured ends to provide continuous and steady tension. The method provides good blood circulation at the ruptured ends, reduces the possibility of postoperative adhesions, and provides good conditions for tendon repair.

2) We placed tenocutaneous sutures in the healthy part of the tendon, far away from the ruptured end. This method provides steady and continuous tension for the repair of the tendon. This “distant” tension allows the matching of ruptured ends, shares most of the tension at the ruptured end, and avoids the influence of tension on the blood supply to the ruptured ends.

3) The method retains the horsetail shape at the residual end of the ruptured tendon. Overlapping tissues are properly arranged and not directly sutured, which maintains the appearance of the tendon. The overlapping length provides a repair that will not differ greatly from the desired length of the tendon. Moreover, it will not lead to possible shortening of the Achilles tendon caused by “direct open” surgery, and the ankle joint has a better degree of mobility after the surgery.

4) The ruptured ends of the Achilles tendon were repaired using absorbable fine suture to maintain neat matching between the ruptured ends. Hence, knots of regular suturing are not seen at the two ruptured ends of the tendon, and the possibility of infections and postoperative complications is reduced.

5) A gradual functional restoration plan is followed after the surgery. Patients are encouraged to start functional exercise as early as possible to reduce postoperative adhesion as well as to restore function. The goal is restore the level of function that existed before the rupture.

In conclusion, minimally invasive tenocutaneous suturing for repair of ruptured Achilles tendons can provide good results with few complications. The method combines features of tension suturing and percutaneous suturing, and it preserves blood circulation to the Achilles tendon through “distant” tension. Through a single neat and accurate incision, the method can restore the original length, continuity, appearance, and function of the tendon.

The limitations of our research are that the sample size is small, the outcome assessors are also part of the surgical team, and there were no means of comparing the intervention to other therapies or the outcome status to the preoperative status. However, our research

is hypothesis-generating, and the descriptive statistical findings can be used in the development of future prospective cohort studies and randomized controlled trials.

REFERENCES

- Józsa L, Kvist M, Bálint BJ, Reffy A, Järvinen M, Lehto M, et al. The role of recreational sport activity in Achilles tendon rupture. A clinical, pathoanatomical, and sociological study of 292 cases. *Am J Sports Med* 1989;17:338-43.
- Cetti R, Christensen SE, Ejsted R, Jensen NM, Jorgensen U. Operative versus nonoperative treatment of Achilles tendon rupture. A prospective randomized study and review of the literature. *Am J Sports Med* 1993;21:791-9.
- Wills CA, Washburn S, Caiozzo V, Prietto CA. Achilles tendon rupture. A review of the literature comparing surgical versus nonsurgical treatment. *Clin Orthop Relat Res* 1986;207:156-63.
- Lo IK, Kirkley A, Nonweiler B, Kumbhare DA. Operative versus nonoperative treatment of acute Achilles tendon ruptures: a quantitative review. *Clin J Sport Med* 1997;7:207-11.
- Weber M, Niemann M, Lanz R, Müller T. Nonoperative treatment of acute rupture of the achilles tendon: results of a new protocol and comparison with operative treatment. *Am J Sports Med* 2003;31:685-91.
- Maffulli N. Rupture of the Achilles tendon. *J Bone Joint Surg Am* 1999;81:1019-36.
- Ingvar J, Tägil M, Eneroth M. Nonoperative treatment of Achilles tendon rupture: 196 consecutive patients with a 7% re-rupture rate. *Acta Orthop* 2005;76:597-601.
- Leppilähti J, Puranen J, Orava S. Incidence of Achilles tendon rupture. *Acta Orthop Scand* 1996;67:277-9.
- Rothenbühler JM, Korkodelovic B, Regazzoni P. Surgical treatment of Achilles tendon rupture. [Article in German] *Z Unfallchir Versicherungsmed* 1991;84:25-33. [Abstract]
- Burchhardt H, Krebs U, Schlemminger R, Stanković P. Rupture of the Achilles tendon. Causes and late results after surgical management. [Article in German] *Z Orthop Ihre Grenzgeb* 1992;130:109-13.
- Majewski M, Rickert M, Steinbrück K. Achilles tendon rupture. A prospective study assessing various treatment possibilities. [Article in German] *Orthopade* 2000;29:670-6. [Abstract]
- Cretnik A, Kosanovic M, Smrkolj V. Percutaneous versus open repair of the ruptured Achilles tendon: a comparative study. *Am J Sports Med* 2005;33:1369-79.
- Yinger K, Mandelbaum BR, Almekinders LC. Achilles rupture in the athlete. Current science and treatment. *Clin Podiatr Med Surg* 2002;19:231-50, v.
- Sirový M, Carda M. Open vs. percutaneous suture repair of the subcutaneous Achilles tendon rupture. [Article in Czech] *Rozhl Chir* 2007;86:594-9. [Abstract]
- Doral MN, Bozkurt M, Turhan E, Ayvaz M, Atay OA, Uzümçügil A, et al. Percutaneous suturing of the ruptured Achilles tendon with endoscopic control. *Arch Orthop Trauma Surg* 2009;129:1093-101.
- Kitaoka HB, Alexander IJ, Adelaar RS, Nunley JA, Myerson MS, Sanders M. Clinical rating systems for the ankle-hindfoot, midfoot, hallux, and lesser toes. *Foot Ankle Int* 1994;15:349-53.
- Boushel R, Langberg H, Green S, Skovgaard D, Bulow J, Kjaer M. Blood flow and oxygenation in peritendinous tissue and calf muscle during dynamic exercise in humans. *J Physiol* 2000;524:305-13.
- Carr AJ, Norris SH. The blood supply of the calcaneal tendon. *J Bone Joint Surg [Br]* 1989;71:100-1.
- Ahmed IM, Lagopoulos M, McConnell P, Soames RW, Sef-ton GK. Blood supply of the Achilles tendon. *J Orthop Res* 1998;16:591-6.
- Gabel S, Manoli A 2nd. Neglected rupture of the Achilles tendon. *Foot Ankle Int* 1994;15:512-7.
- Gorschewsky O, Vogel U, Schweizer A, van Laar B. Percutaneous tenodesis of the Achilles tendon. A new surgical method for the treatment of acute Achilles tendon rupture through percutaneous tenodesis. *Injury* 1999;30:315-21.
- Rebecato A, Santini S, Salmaso G, Nogarin L. Repair of the achilles tendon rupture: a functional comparison of three surgical techniques. *J Foot Ankle Surg* 2001;40:188-94.
- Riedl S, Sandberger L, Nitschmann K, Meeder PJ. Suture of fresh Achilles tendon rupture. Comparison of open with percutaneous suture technique. [Article in German] *Chirurg* 2002;73:607-14. [Abstract]
- Lansdaal JR, Goslings JC, Reichart M, Govaert GA, van Scherpenzeel KM, Haverlag R, et al. The results of 163 Achilles tendon ruptures treated by a minimally invasive surgical technique and functional aftertreatment. *Injury* 2007;38:839-44.
- Pavic R. The results of 163 Achilles tendon ruptures treated by a minimally invasive surgical technique and functional aftertreatment [Injury 2007;38(7):839-44]. *Injury* 2008;39:499-500; author reply 500.
- Metz R, van der Heijden GJ, Verleisdonk EJ, Kolfshoten N, Verhofstad MH, van der Werken C. Effect of complications after minimally invasive surgical repair of acute achilles tendon ruptures: report on 211 cases. *Am J Sports Med* 2011;39:820-4.
- Valente M, Crucil M, Alecci V, Frezza G. Minimally invasive repair of acute Achilles tendon ruptures with Achillon device. *Musculoskelet Surg* 2012;96:35-9.