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Long-Term Results of Mini-Open Repair Technique in the Treatment of Acute Achilles Tendon Rupture: A Prospective Study

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ABSTRACT

An ideal surgical treatment of acute Achilles tendon rupture includes restoring the original length of the tendon, minimizing possible adhesions with the surrounding tissues, minimizing the risk of repeat rupture, alleviating wound problems, and providing an acceptable cosmetic outcome. In the mini-open repair technique, unlike the percutaneous repair technique, the quality of the tenodesis can be visualized without disturbing the healing potential of the surrounding tissues, thus minimizing wound problems. The purpose of the present study was to assess the long-term results of the mini-open repair technique in patients with acute Achilles tendon rupture. A total of 20 consecutive patients with acute Achilles tendon rupture, admitted to our inpatient clinic from October 2003 to March 2008, were included in the present study. The patients underwent Achilles tenodesis with the mini-open repair technique, and each patient was followed up for 5 years. The study was completed in April 2013. The surgical procedure was performed with the assistance of a device designed in our orthosis laboratories, similarly to that defined by Assal et al. Of the 20 patients, 18 were male and 2 were female. Their mean age was 39.3 (range 21 to 55) years. The Achilles tendon rupture was located on the left side in 15 patients (75%) and on the right side in 5 patients (25%). The mean follow-up duration was 58.5 (range 18 to 60) months and no complications occurred during the follow-up period, including repeat rupture, wound site infection, and sural nerve injury. The mean American Orthopaedic Foot and Ankle Society scale score for the patients was 99.2 (range 94 to 100) points at the final follow-up visit. All our patients were able to return to work and sporting activities. According to the Trillat scores, the outcome was excellent in 19 patients and good in 1 patient at the 18th postoperative month. No complaint, such as pain or loss of function, that might have a negative effect on the patients' business or social life was detected in 18 patients who were assessed at 5 years after surgery; 2 patients could not be reached at 5 years. In conclusion, as a technique combining percutaneous and open surgical techniques, mini-open repair of Achilles tendon rupture allows a satisfactory end-to-end approximation of the tendon just in the open surgery and provides the wound healing advantages of percutaneous surgery.

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Achilles tendon ruptures are the most common among middle-age males who occasionally exercise (1,2). Repetitive micro-trauma and tendon weakness related to inadequate healing constitute the predisposing factors for the most commonly ruptured tendons, including the supraspinatus, biceps, and Achilles tendons. Direct and indirect mechanisms can be responsible for Achilles tendon ruptures. Achilles tendon ruptures have been treated conservatively for many years, and several studies have reported that no significant difference exists between the outcomes of surgical and conservative treatments in terms of functionality and strength (3,4). However, surgical treatment came into prominence consequent to the extended period of immobilization, significant loss of strength, particularly in plantarflexion, and greater rates of repeat rupture associated with conservative treatment (5,6). Although recent studies have favored surgery in the treatment of acute Achilles tendon rupture, the most appropriate surgical technique remains controversial (7). Some studies have supported conventional open surgical techniques to minimize the risk

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Table 1
Inclusion and exclusion criteria

Criteria
Inclusion
All consecutive patients with acute Achilles tendon rupture
Exclusion
Patients with Achilles tendon rupture admitted >3 wk after event
History of steroid use
Open tendon ruptures and/or associated with soft tissue defects
Tendon ruptures <2 cm to insertion or >8 cm from insertion

of repeat rupture. Open surgical techniques are usually chosen for professional athletes. However, a percutaneous technique has been shown as an option and supported by some surgeons with the aim of soft tissue protection (8).

Ma and Griffith (9) described a percutaneous repair technique for minimizing the soft tissue problems concerned with open procedures and reported good outcomes in 18 patients treated using their technique. However, their technique carries 2 potential risks. The first risk is sural nerve injury owing to the close anatomic neighborhood with the path the needle takes and the nerve. The second risk is an inability to assess the quality of the tenodesis because this technique does not use a surgical incision that allows exposure of the tendon ends (10).

From the results of many studies, we believe that surgery is the best treatment modality in Achilles tendon rupture. Kakluchi (10) described a new method that combines the advantages of open and percutaneous techniques in 1994 and reported the results of this method. Assal et al (11) developed a device called the Achillon to improve on the method reported by Kakluchi (10). They conducted a preliminary study using 16 fresh cadavers and presented their new device and reported the results of a multicenter, prospective study of 87 patients in 2002 (11). In the present study, we assessed the outcomes of a mini-open surgical technique in patients with acute Achilles tendon rupture.

Patients and Methods

Patients

Twenty consecutive patients with acute Achilles tendon rupture, admitted to Gülhane Military Medicine Faculty Orthopedics and Traumatology inpatient clinic from October 2003 to March 2008, were included in the present study. The patients underwent a mini-open surgery, and all the patients were followed up for 5 years. The study was completed in April 2013. Patients with chronic Achilles tendon rupture for >3 weeks, a history of surgery at that site, a history of steroid use, open ruptures and/or ruptures associated with a soft tissue defect, and ruptures <2 cm to the insertion or >8 cm from the insertion were excluded from the present study (Table 1).

Of the 20 patients, 18 were male and 2 were female. Their mean age was 39.3 (range 21 to 55) years. The Achilles tendon rupture was located on the left side in 15 patients (75%) and the right side in 5 (25%). None of our patients was a professional sportsman; however, all of them were involved in amateur sports. Of the 20 patients, 14 developed tendon rupture while playing football, 2 developed rupture while playing tennis, and the others developed tendon rupture during basketball or volleyball games, the pentathlon, and the high jump. Most of our patients stated that they had been participating in a similar sport about once a week. The clinical and demographic characteristics of the patients are presented in Table 2.

Preoperative Patient Evaluation

On physical examination, all patients presented with a palpable gap in the Achilles tendon associated with a positive Thompson test. The distance between the palpable gap and the calcaneal tuberosity was measured with a ruler. The location of the rupture was an average of 46 (range 34 to 56) mm proximal to the calcaneal tuberosity. Anteroposterior and lateral radiographs of the ankle were taken to exclude the possibility of any associated fracture. Ultrasonography was used to establish the diagnosis and location of the rupture. The ultrasound findings showed that the mean distance between the rupture site and calcaneal tuberosity was 42 (range 32 to 53) mm. Magnetic resonance imaging was not used at the diagnosis. A detailed medical history was taken to ensure the absence of any contraindications for patient inclusion.

Surgical Technique

All the patients included in the present study were treated with an identical surgical technique, the same postoperative orthoses, and the same rehabilitation program. All surgical procedures and the follow-up examinations for all patients were performed by the same surgeon team. The mean time between hospital admission and surgery was 18 (range 5 to 48) hours. All surgical interventions were performed with the patient under spinal anesthesia. The mean operative time was 40 (range 32 to 64) minutes. The mean hospital stay was 2.5 (range 2 to 4) days.

After the induction of spinal anesthesia, a tourniquet was placed around the proximal part of the thigh, and the patient was placed prone on the operating table. A single dose of a second-generation cephalosporin was administered prophylactically to all patients 30 minutes before the start of the procedure. The gap was palpated, and a 2- to 3-cm longitudinal incision was made over the gap (Figs. 1 and 2). The surgical procedure was performed with the assistance of a device designed in our orthosis laboratories, similar to that defined by Assal et al (11), with 2 metallic internal and 2 external arms that contain a number of symmetrical holes used to allow the needle to pass and an adjustable arm opening from the right side (Fig. 3). Cadavers were used when designing the device. The tendon repair was performed using 3 no. 1 Monocryl® sutures (Ethicon, Johnson & Johnson, Somerville, NJ). The paratenon was closed using 2-0 Monocryl, and the skin was closed with subcuticular 4-0 Monocryl suture.

Postoperative Rehabilitation

A short leg cast was applied to the patient in equinus position at 20° to 30°. The sutures were removed on the 12th postoperative day for all patients. For the first

Table 2
Clinical and demographic characteristics

Patient No.	Sex	Age (y)	Profession	Laterality	Rupture Cause	Follow-Up Period (mo)
1	Male	37	Officer	Left	Football on synthetic turf field	60
2	Male	45	Petty officer	Left	Football on synthetic turf field	60
3	Male	44	Official	Right	Football on synthetic turf field	60
4	Male	29	Officer	Left	Running	60
5	Male	21	Private	Left	High Jump	18
6	Male	39	Officer	Left	Football on synthetic turf field	61
7	Male	55	Retiree	Left	Football on synthetic turf field	60
8	Male	36	Officer	Left	Football on synthetic turf field	60
9	Male	41	Petty officer	Left	Football on synthetic turf field	60
10	Male	29	Master sergeant	Left	Pentathlon	61
11	Male	42	Petty officer	Right	Football on synthetic turf field	60
12	Male	34	Officer	Left	Volleyball	60
13	Male	37	Petty officer	Left	Football on synthetic turf field	60
14	Female	35	Nurse	Right	Tennis	61
15	Female	42	Officer	Right	Basketball	60
16	Male	36	Officer	Left	Football	60
17	Male	47	Officer	Right	Football	60
18	Male	41	Master sergeant	Left	Football	19
19	Male	43	Petty officer	Left	Football	60
20	Male	53	Retiree	Left	Football on synthetic turf field	60

Fig. 1. Preoperative evaluation for incision.

3 weeks, active range of motion exercises (for the toe, knee, and hip joints) and muscle strengthening exercises (for the knee and hip muscles) were recommended, with the aim of preserving muscle strength. The patients used crutches to ambulate. In the follow-up visit at 3 weeks, the cast was renewed in 3 patients; the cast had become loose owing to the resolution of edema. The casts were removed at the end of the sixth postoperative week, and rehabilitation was started. Stretching and strengthening exercises were recommended to achieve a normal range of motion for the ankle. The 6-week physical therapy program consisted of ankle dorsiflexion stretching and plantarflexion stretching exercises, heel elevation, standing on tiptoes, and walking. At 12 weeks postoperatively, sports similar to jogging were allowed; however, sports demanding more physical effort were not allowed until the end of 6 months.

Follow-Up and Outcome Measurements

The follow-up examinations of the patients were performed according to a standard protocol by the same surgeon from the surgical team that had performed the surgical procedure. The patients were interviewed in person at 3 and 6 weeks postoperatively after the removal of the short leg cast and at 6, 12, and 18 months. The telephone follow-up interview was performed at 5 years. Of the 20 patients, 18 were interviewed and assessed; however, 2 patients could not be contacted at the 5-year follow-up point. The assessments of the patients at 6, 12, and 18 months included the American Foot and Ankle Society (AOFAS) scale scores, Trillat scale scores (12), Achilles tendon performance score, and gait patterns of the patients using 3-dimensional (3D) computed gait analysis. Furthermore, the ankle plantarflexion strength was assessed by having the patient stand on tiptoe, as recommended by Kitaoka et al (13). Also, the sural nerve cutaneous sensation to the lateral calf and dorsum of the foot was examined. The assessment of our patients at 5 years included only questioning regarding the occurrence of repeat rupture and pain and the functional, social, and professional status of the patients and their participation in sporting activities.

Statistical Analysis

SPSS, version 15.0 (BM Corp, Armonk, NY), was used. The postoperative and follow-up scores of the patients were compared using the Student t test, and $p < .05$ was considered statistically significant.

Fig. 2. Incision length with mini-open repair technique.

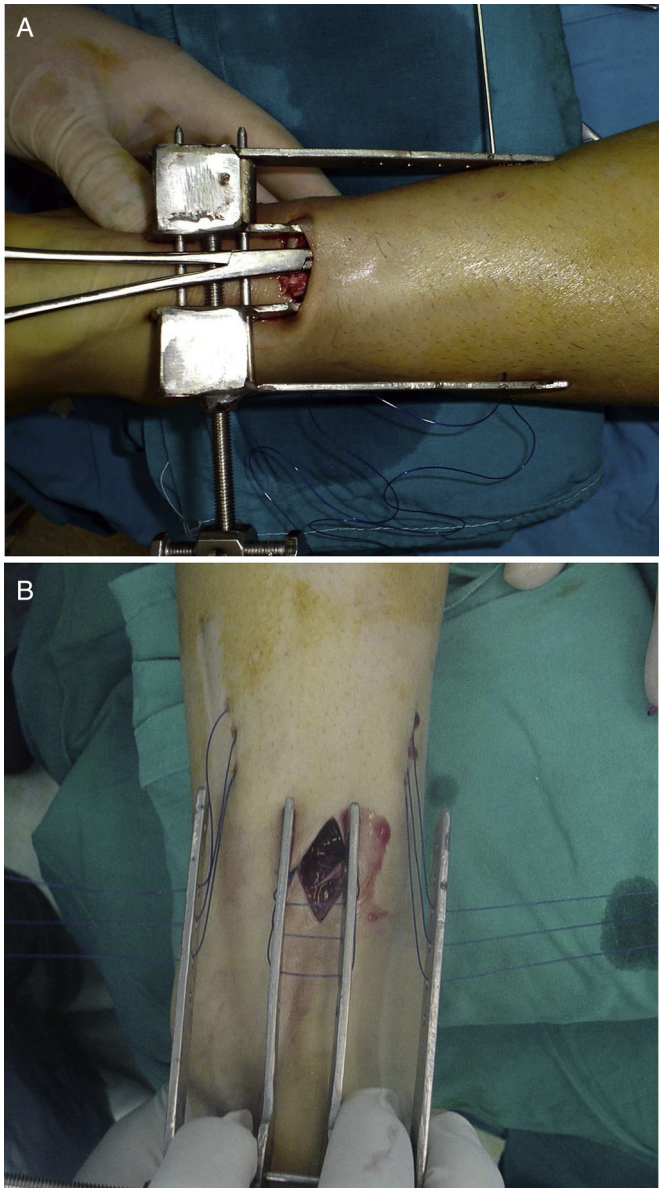

Fig. 3. (*A* and *B*) The device used for surgery.

Results

A total of 20 patients (18 males and 2 females) were included in the study. The mean age of the patients was 39.3 (range 21 to 55) years. The wound healing process was completed without problems (Fig. 4). None of our patients developed superficial or deep surgical site infections, and no clinical evidence of deep vein thrombosis or pulmonary embolism was observed. In addition, no sensory loss in the foot or ankle associated with sural nerve injury or any case of repeat rupture was observed among our patients during the surveillance period, including the fifth year after surgery.

The mean AOFAS scale scores of our patients in the follow -up visits were 90.2, 95, 98, and 99.2 at 3, 6, 12, and 18 months, respectively. All our patients could return to their work and all could return to their sporting activities at their preinjury level. Also, all our patients successfully completed the "1-minute standing on tiptoe without support" test in the follow-up visit at 12 months, and no difference was found between the injured extremity and healthy extremity in the "single extremity jump-landing" test. According to the Trillat

Fig. 4. View of incision scare at 6 months postoperatively.

scores at 18 months postoperatively, 19 patients were doing very well and 1 was doing well.

In the assessment of the patient parameters using 3D computed gait analysis at the follow-up visit at 12 months, no statistically significant difference was found between the healthy side and surgically treated side in the "single limb stance" test during dynamic gait. Furthermore, no difference was found between the surgically treated side leg and healthy leg in stride length when trying to increase the stride length by increasing the swing phase. The gait analysis did not reveal any statistically significant differences between the 2 sides in the maximum plantarflexion and dorsiflexion angles. No statistically significant differences were found between the surgically treated side and the healthy side in the work output of the muscle, external moment applied to the joint, work output of the gastrosoleus muscle group in the stabilization of dorsal flexion, or power output by a concentric contraction during the push-off period aimed at the forward progression of the foot (Table 3 and Fig. 5). The fifth-year assessment of our patients did not reveal any complaint that might have had a negative effect on their social or professional life, such as pain and functional loss.

Discussion

The emphasis on physical activity during recent years has been considered to result in an increase in the rate of Achilles tendon injuries associated with amateur and recreational sports (14,15). Independent of the chosen method of treatment, persistent functional deficits can be observed even years after the rupture of the Achilles tendon (16,17). Although the most recent meta-analyses have reported a significantly lower risk of repeat rupture associated with open surgery techniques compared with conservative treatment, it is well known that the risks of surgical site complications and skin adhesions persist (14,18–20). Percutaneous and minimally invasive techniques are believed to reduce these complications. In percutaneous

Table 3
Results of postoperative 3-dimensional computerized gait analysis (N = 20 patients)

Variable	Surgically Treated Extremity	Healthy Extremity	*p* Value
Ankle dorsiflexion/plantar moment (N·m)	1.4 ± 0.32	1.54 ± 0.17	.4
Ankle power (W)	2.72 ± 0.69	3.42 ± 0.82	.2
Maximum ankle dorsiflexion (°)	17.27 ± 2.93	14.8 ± 1.5	.07
Maximum ankle plantarflexion (°)	9.33 ± 5.93	12.25 ± 3.8	.2
Cadence (steps/min)	107.37 ± 5.7	107.45 ± 6.05	.91
Single support (s)	0.41 ± 0.03	0.43 ± 0.02	.07
Step length (m)	0.63 ± 0.04	0.58 ± 0.08	.14
Double support (s)	0.27 ± 0.03	0.26 ± 0.03	.74
Walking speed (m/s)	1.1 ± 0.13	1.09 ± 0.14	.52

Fig. 5. (*A* to *C*) Functional evaluation of patients at 18 months postoperatively.

techniques, although the risk of wound problems is lower, the risk of nerve injuries and repeat rupture is higher. However, the minimally invasive technique theoretically reduces the incidence of wound problems and the risk of repeat rupture (21–23).

Guillo et al (24) conducted prospective studies of minimally invasive techniques. Although these studies lacked a comparable control group, they reported perfect outcomes in returning to the preinjury levels of muscle strength and activities of the patients (24). In another study by Assal et al (11), the medium-term outcomes were reported as perfect, and they reported that no surgical site infection or sural nerve injury was observed. Although percutaneous repair of the Achilles tendon is known to reduce the risk of repeat rupture compared with nonsurgical treatment modalities and reduces the risk of wound site infection compared with open surgery methods (25), sural nerve injuries constitute a risk factor with this treatment modality (26).

In a study by Aktas and Kocaoglu (21), the open surgery technique was compared with the minimally invasive technique, and no significant difference was found between the 2 modalities in the AOFAS scale scores and incidence of repeat rupture. However, postoperative wound site complications were reported to be more frequent in the open surgery group (21).

In a systematic review conducted by Bartel et al (27) in 2014, the overall complication rate was 30.4% after open surgery, 15.3% after conservative treatment, and 10.3% after mini-open surgery, and the risk of repeat rupture was 3.4%, 12.6%, and 2.1%, respectively. In addition, in the same review, the wound site infection rate was 4% after open surgery, 0% after conservative treatment, and 0% after mini-open surgery; the incidence of sural nerve injuries was lower with the mini-open technique compared with open surgery (27). Similarly, no case of repeat rupture or sural nerve lesion or wound site problem was observed during 5 years of follow-up in our study. Direct visualization of the tenodesis in the mini-open technique, the small skin incision, and protection of the paratenon during dissection that minimizes concerns regarding the blood supply in the area are among the advantages of this treatment modality (11,28).

The present study had some strengths. The main strength of the present study was the patient selection and follow-up duration. We selected patients with acute Achilles tendon rupture (not >3 weeks) and followed them for 5 years. The use of comprehensive methods such as the AOFAS scale, Trillat scale, Achilles tendon performance test, and 3D computed gait analysis is another strength of the study. The main limitation was the relatively small sample size. In addition, the surgical procedure was performed with the assistance of a device designed in our orthosis laboratories, similar to that defined by Assal et al (11).

In conclusion, in the present study, no case of repeat rupture was observed in patients treated with the mini-open Achilles tendon repair technique during a 5-year follow-up period. From the clinical findings and gait analysis results, at the end of 1 year, most of our patients had returned to their muscle strength and daily life activities at the preinjury level. None of the most common complications such as sural nerve lesions or surgical site problems was observed in our patients and excellent cosmetic outcomes were obtained.

References

1. Inglis AE, Sculco TP. Surgical repair of ruptures of the tendo Achillis. Clin Orthop 156:160–169, 1981.
2. Hart TJ, Napoli RC, Wolf JA, Cangiano S. Diagnosis and treatment of ruptured Achilles tendon. J Foot Surg 27:30–39, 1988.
3. Lea R, Smith L. Non-surgical treatment of tendo Achilles rupture. J Bone Joint Surg 54A:1398–1406, 1972.
4. Nistor L. Surgical and nonsurgical treatment of Achilles tendon rupture. J Bone Joint Surg 63-A:394–399, 1981.
5. Cetti R, Christensen S, Ejtsed R, Jensen NM, Jorgensen U. Operative versus nonoperative treatment of Achilles tendon rupture. Am J Sports Med 21:791–799, 1993.
6. Kellam JF, Hunter MB, McElwain JP. Review of the operative treatment of Achilles tendon rupture. Clin Orthop 201:80–83, 1985.
7. *Les oeuvres*, ed 9, edited by A Pare, Claude Rigaud et Claude Obert, Lyon, France, 1633.
8. Maffuli N. Current concepts review—rupture of the Achilles tendon. J Bone Joint Surg 81:1019–1036, 1999.
9. Ma GWC, Griffith TG. Percutaneous repair of acute closed ruptured Achilles tendon. Clin Orthop 128:247–255, 1977.
10. Kakluchi M. A combined open and percutaneous technique for repair of tendo Achillis: comparison with open repair. J. Bone Joint Surg Br 77:60–63, 1995.
11. Assal M, Jung M, Stern R. Limited open repair of Achilles tendon ruptures. J Bone Joint Surg Am 84-A:161–170, 2002.
12. Trillat A, Jouvinroux, Marsan C, Bremant JJ. Treatment of Achilles tendon ruptures. Lyon Chir 63:603–606, 1967.
13. Kitaoka HB, Alexander IJ, Adelaar RS, Nunley JA, Myerson MS. Clinical rating systems for the ankle-hindfoot, midfoot, hallux, and lesser toes. Foot Ankle Int 15:349–353, 1994.
14. Khan RJ, Carey Smith RL. Surgical interventions for treating acute Achilles tendon ruptures. Cochrane Database Syst Rev 9:CD003674, 2010.
15. Taglialavoro G, Biz C, Mastrangelo G, Aldegheri R. The repair of the Achilles tendon rupture: comparison of two percutaneous techniques. Strategies Trauma Limb Reconstr 6:147–154, 2011.
16. Horstmann T, Lukas C, Merk J, Brauner T, Mündermann A. Deficits 10 years after Achilles tendon repair. Joint Sports Med 33:474–479, 2012.
17. Olsson N, Nilsson-Helander K, Karlsson J, Eriksson BI, Thomée R, Faxén E, Silbernagel KG. Major functional deficits persist 2 years after acute Achilles tendon rupture. Knee Surg Sports Traumatol Arthrosc 19:1385–1393, 2011.
18. McMahon SE, Smith TO, Hing CB. A meta-analysis of randomised controlled trials comparing conventional to minimally invasive approaches for repair of an Achilles tendon rupture. Foot Ankle Surg 17:211–217, 2011.
19. Jiang N, Wang B, Chen A, Dong F, Yu B. Operative versus nonoperative treatment for acute Achilles tendon rupture: a meta-analysis based on current evidence. Int Orthop 36:765–773, 2012.
20. 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 40:2154–2160, 2012.
21. Aktas S, Kocaoglu B. Open versus minimal invasive repair with Achillon device. Foot Ankle Int 30:391–397, 2009.
22. Garrido IM, Deval JC, Bosch MN, Mediavilla DH, Garcia VP, González MS. Treatment of acute Achilles tendon ruptures with Achillon device: clinical outcomes and kinetic gait analysis. Foot Ankle Surg 16:189–194, 2010.
23. Henríquez H, Muñoz R, Carcuro G, Bastías C. Is percutaneous repair better than open repair in acute Achilles tendon rupture? Clin Orthop Relat Res 470:998–1003, 2012.
24. Guillo S, Del Buono A, Dias M, Denaro V, Maffulli N. Percutaneous repair of acute ruptures of the tendo Achillis. Surgeon 11:14–19, 2013.
25. Cretnik A, Kosanović M, Smrkolj V. Percutaneous suturing of the ruptured Achilles tendon under local anesthesia. J Foot Ankle Surg 43:72–81, 2004.
26. Maes R, Copin G, Averous C. Is percutaneous repair of the Achilles tendon a safe technique? A study of 124 cases. Acta Orthop Belg 72:179–183, 2006.
27. Bartel AF, Elliott AD, Roukis TS. Incidence of complications after Achillon mini-open suture system for repair of acute midsubstance Achilles tendon ruptures: a systematic review. J Foot Ankle Surg 53:744–746, 2014.
28. Feldbrin Z, Hendel D, Lipkin A, Zin D, Schorr L. Achilles tendon rupture and our experience with the Achillon device. Isr Med Assoc J 12:609–612, 2010.