

Flexor hallucis longus transfer and composite anterolateral thigh fascio-cutaneous flap for reconstruction of massive chronic and infected Achilles tendon lesion. A case report and review of the literature

Luca Di Lenarda¹, Vittorio Ramella², Chiara Ratti¹, Laura Grezar², Gianluca Canton¹, Giovanni Papa², Luigi Murena¹

¹Orthopaedics and Traumatology Unit, Cattinara Hospital - Azienda Sanitaria Universitaria Giuliano-Isontina (ASUGI), University of Trieste, Trieste (Italy); ²Plastic Surgery Unit, Cattinara Hospital - Azienda Sanitaria Universitaria Giuliano-Isontina (ASUGI), University of Trieste, Trieste (Italy)

Abstract. Achilles tendon reconstruction with substance loss and infection in the overlying soft tissues is a challenge. There is no standardized treatment in literature for these cases. We describe a one-stage tendon reconstruction, using flexor hallucis longus (FHL) tendon transfer and an anterolateral thigh flap with vascularized fascia lata in a patient with re-rupture of the Achilles tendon, soft tissue infection and a tendon defect of 10 cm in length. The surgical procedure has had a successful outcome; patient has recovered normal gait, has recovered complete ankle range of motion with only a partial loss in plantar flexion of the big toe, without any loss in strength. No complications have emerged at follow-up. This technique is promising in treating large Achilles tendon defects with overlying soft tissue infection in a one-stage procedure. (www.actabiomedica.it)

Key words: ankle, heel, rearfoot, chronic Achilles rupture, FHL transfer, thigh free flap, Achilles tendon infection,

Introduction

Reconstruction of the Achilles tendon with substance loss and infection in the overlying soft tissues is a challenge: controlling local infection, offering a stable coverage, and restoring active plantar flexion of the foot and strength for normal walking are difficult goals to achieve, especially in the presence of massive tendon defects. Different methods have been presented for wound coverage at the posterior heel (1, 2). In the year 2000 Lee et al. were the first to use a free composite anterolateral thigh flap with vascularized fascia lata for the reconstruction of complex Achilles tendon defects with overlying soft tissue infection (3). In their paper these authors report three patients treated for tendon defects ranging from 3.5 to 5.5 cm in length.

In 2003 Kuo et al. reported of four patients treated for combined loss of Achilles tendon and overlying soft tissue by means of ALT composite flap with vascularized fascia lata rolled on itself. According to these authors the fascia lata receives sufficient blood supply via the prefascial and subfascial vascular plexuses when attached to the ALT flap. These characteristics make the ALT flap a good solution in comparison to other free composite flaps for combined reconstruction of Achilles tendon and soft tissues (4).

Flexor hallucis longus tendon transfer is a technique that has been proposed for salvage treatment of neglected, chronic Achilles tendon lesion associated with large tendon defects (5). First described by Hansen in 1991 (6), it has rapidly found the favour of some surgeons for the treatment of chronic Achilles

tendon rupture (7) as it permits to augment a repair or replace an irreparable lesion. When performed through a single incision, this technique has minimal morbidity and complications, and it can provide excellent functional and clinical outcomes with very good patients' satisfaction (5).

In 2015, in a multicentric study, Soons et al. reported on functional results after reconstruction of both tendon and soft-tissue defects by free flap surgery in seven patients with wound complications after repair of the Achilles tendon. The soft tissue coverage was obtained using either a radial forearm free flap or an ALT free flap. The Achilles tendon was reconstructed using either a tendon graft within the flap (palmaris longus or tensor fascia lata) or by transfer of the flexor hallucis longus tendon to the Achilles tendon (8).

In this case report, we present a successful reconstruction of the Achilles tendon in a patient with tendon re-rupture, overlying soft tissue infection, and massive tendon defect after debridement, utilizing a free composite ALT flap with vascularized fascia lata and flexor hallucis longus tendon transfer. The FHL transfer was performed to augment the repair, considering the remarkable extension of the Achilles tendon defect. In the presence of Achilles tendon substance loss below two to three centimeters the Authors usually perform a V-Y repair, while for larger tendon loss they are used to augment the V-Y repair with a FHL transfer. The latter technique can be safely performed with excellent results even in the presence of a 6-centimeter tendon loss. For massive loss of substance, the use of auto or allograft is indicated. However, when facing infections and chronic lesion some concerns can arise with the use of non-vascularized tissue.

To the best of the authors' knowledge this is the first report of the combined use of FHL tendon transfer and free composite ALT flap.

Case report

A 64-year-old male patient presented to the emergency room with redness and purulent secretion from a surgical incision at the level of the Achilles tendon. The patient had undergone a right Achilles tendon repair

two months prior for a rupture after minor trauma and a history of local corticosteroid injections.

The patient was a social smoker, had no comorbidities, was taking no pharmaceutical drugs and had rather high functional demands. Six months before the traumatic rupture he had taken two cortisone injections in the tendon, due to persistent pain during dorsal and plantar flexion of the foot.

Following the injections, the patient continued to have pain. He underwent an ultrasound and an MRI, which revealed a partial rupture of the Achilles tendon. The patient was treated conservatively.

Shortly after, the patient inadvertently made a sudden dorsal flexion movement of the foot and felt a "pop" accompanied by acute pain in his right Achilles tendon. A rupture of the tendon was assessed by ultrasound. The patient was surgically treated one week after trauma with an open procedure for direct Achilles tendon repair augmented with the plantar gracilis tendon as an auto-graft.

Two months after surgery, the patient presented to our emergency room with redness and purulent secretion from the surgical incision. At physical examination, a fistula in the middle-third of the wound with cutaneous hyperaemia was assessed.

The patient was brought in the operating theatre for radical debridement and removal of necrotic soft tissues. In collaboration with plastic surgeons, a negative pressure therapy was started. His wound cultures grew methicillin-susceptible *Staphylococcus Aureus* (MSSA). Antibiotics were administered (Levofloxacin 500mg twice per day and Rifampicin 600mg once a day, then switched to Oxacillin 2g, six times per day).

Two weeks later, after the infection was eradicated, the definitive reconstructive procedure was performed. The procedure was carried out simultaneously by orthopaedic surgeons (LM and CR) and plastic surgeons (VR) (Fig. 1).

Patient was placed in a supine position. The incision used for the previous surgery was lengthened by 10 cm proximally and 3 cm distally. A second conservative debridement of the soft tissues both in the proximal and distal tendon were performed. The posterior tibial artery and vein were isolated. After debridement, a 10 cm gap in the Achilles tendon could be assessed (Fig. 2).



Figure 1. Dehiscence of the skin overlying the Achilles tendon before surgical procedure.



Figure 2. Intraoperative findings. Tendon defect measuring 10 cm after debridement.

An incision along the fascia was then performed, at the distal third of the deep posterior compartment of the leg; the muscle belly of the flexor hallucis longus (FHL) was identified (Fig. 3), then the tendon was isolated, the tibial nerve and the posterior tibial artery were protected.

A tenotomy of the FHL with the ankle and the first toe in forced plantar flexion was performed. The harvested FHL resulted with a 4 cm tendon stump distal to the myotendinous juncture. The tendon was then basted with sutures (Fig. 4), inserted through a bone tunnel performed on the calcaneus bone and then further stabilized with an interference screw (Figs. 5, 6).



Figure 3. Identification of the muscle belly of the FHL. The plantar flexion of the big toe confirms we are pulling the correct muscle belly.

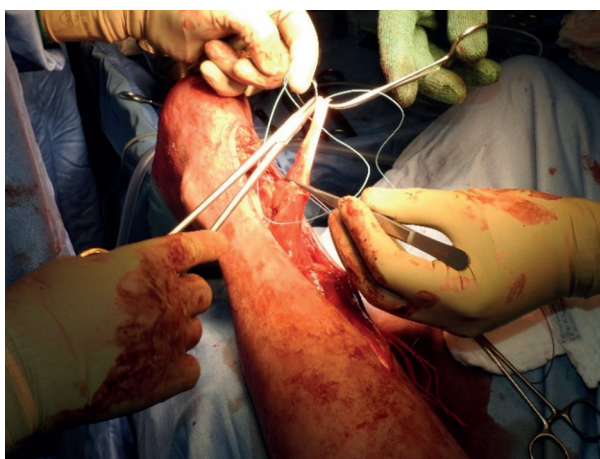


Figure 4. FHL tendon was basted after tenotomy.

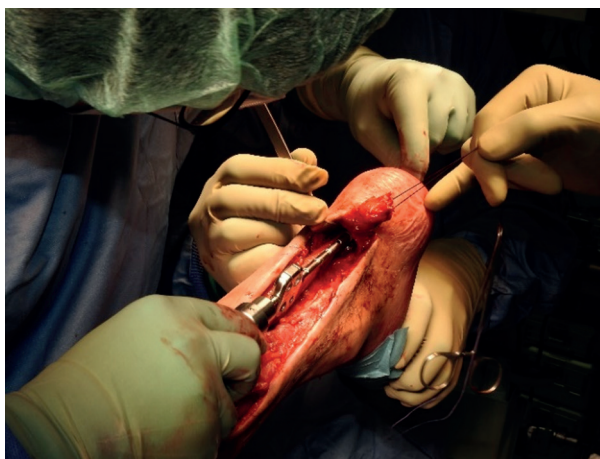


Figure 5. FHL tendon was inserted in the calcaneus and stabilized in the correct position using an anchor.



Figure 6. End result after Achilles tendon debridement and FHL tendon transfer.

Correct tension of the graft was achieved comparing it to the physiological plantar flexion of the healthy contralateral ankle.

The ALT flap was designed with a 22x6 cm skin island including the underlying fascia lata. Laterally, the fascia was taken with a larger size using a 16.5x6 cm rectangular design. The excess of fascia was taken laterally in order to leave space during the inset phase for the medial passage of the pedicle. This precaution avoided the tendon reconstruction with the fascia lata and the long flexor of the big toe compressing or constraining the pedicle. Particular attention was paid to the packing of the vascularized fascia lata to ensure greater strength and resistance. The “accordion” folding on itself guarantees a good thickness of the graft and a good load distribution among the layers.

An incision was performed along the marks which were made preoperatively at the anterolateral region of the thigh, proceeding medially to laterally (Fig. 7).

The miocutaneous perforator was isolated, dissecting the descending branch of the lateral circumflex femoral artery along the medial edge of the vastus lateralis muscle. The pedicle was isolated, including the vascularized fascia lata which must be kept intact deep in the flap. The pedicle was disconnected from the donor site, and the flap was raised up. Insetting was performed over the Achilles tendon, where the loss of soft tissue substance was placed. The anastomosis was performed with the posterior tibial artery T-L and with the posterior tibial vein T-T. The ischemia time

was 40 minutes. The patency of the anastomosis was confirmed with doppler ultrasound and the milking test (Fig. 8).

The fascia lata was then tubulized, an infratendinous tunnel was created at the distal stump of the Achilles tendon and the distal portion of the fascia lata was inserted and sutured in a Pulvertaft-like fashion. Subsequently, the fascia lata was sutured at the proximal stump of the Achilles tendon, opened, and sutured on the muscle fascia in a fan shape, paying attention during the repair, to achieve adequate tension (Fig. 9).

At the end of the procedure strength of the construct was assessed with forced dorsiflexion of the foot and stretch of the grafts, with a satisfying result.

A drainage was inserted inferolaterally and then sutured.

The patient was immobilized in a cast with the foot in plantar flexion for 4 weeks after surgery and was then given progressive weightbearing using a

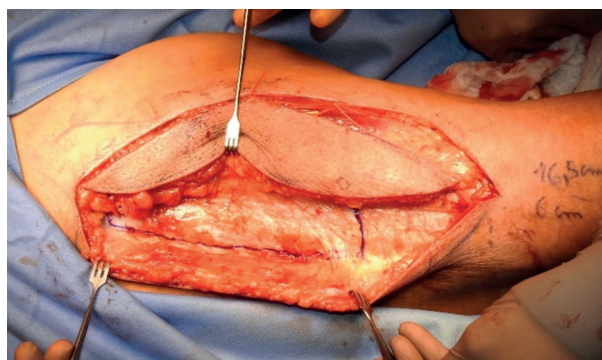


Figure 7. Preparation of the ALT flap with vascularized fascia lata.



Figure 8. ALT flap with fascia lata inset, temporary positioning before definitive sutures.



Figure 9. Tubulized fascia lata was sutured to the tendon stumps overlying the newly transferred FHL tendon.

Walker boot with three wedges, progressively removing them during the following weeks. Full weight-bearing without the boot was allowed ten weeks after surgery (Fig.10).

At 8 months follow-up the patient could walk without gait problems or pain. The hallux had lost some ROM of active plantar flexion when compared to the opposite hallux, maintaining plantar flexion strength of 5 against resistance. The sural triceps strength was 5, with a slight decrease in calf circumference. The patient was able to walk on his tip toes (Fig. 11).

Discussion

The Achilles tendon is the strongest and most robust tendon in the human body. In spite of this, it is the most common tendon to rupture in the lower extremities, invalidating gait as well as dorsal and plantar flexion of the foot (9). The most common rupture point is at 3-5 cm from the tendon's insertion to the calcaneus (10), corresponding to the watershed region of the tendon (11, 12). The incidence of Achilles tendon ruptures is on the rise, especially in middle aged men who live an active life. Surgical and conservative treatments are both viable options in treating acute Achilles tendon rupture (13). By contrast, in chronic ruptures, which are defined as a rupture with a delay in diagnosis or treatment for more than 6 weeks (14), non-surgical treatment is very rare in literature (15). Surgical techniques used to repair chronic rupture are: direct repairs,



Figure 10. Wound healing after three months from surgery.



Figure 11. Eight months from surgery. Patient was able to perform a heel raise and recovered complete ankle ROM with no deficit in strength.

advancement flaps (e.g. turndown flaps), tendon transfers (e.g. flexor hallucis tendon (FHL), peroneus brevis), augmentation with synthetic materials, autografts or allografts or a combination of techniques (16).

The rate of secondary rupture or dehiscence of the tendon, precipitated through soft tissue necrosis or occult repair site infection, is 3,6-8,8% (17-19). Functional restoration can be a challenge for the reconstructive surgeon due to complex and highly efficient biomechanics of the lower extremity. Multiple local and distant tissue reconstruction options have been reported in the

literature. Minor or partial ruptures may be treated with skin grafts after adequate debridement (20), while larger tendon defects (3–4 cm), may be reapproximated using flexor hallucis longus or gastrocnemius aponeurosis turnovers and peroneal muscle transfers (14, 21).

In more severe cases requiring multiple debridement, with vascular comorbidity, or massive skin/tendon defects, free tissue transfer may be required for a stable wound closure and good functional outcome (22).

The literature generally agrees that the fundamental aspect of treatment involves extensive debridement of the infected and/or necrotic tissue and antibiotic coverage (23), even though each author has his or her own opinion on how tendon and soft tissue defects should be addressed. These opinions range from extensive debridement with functional rehabilitation alone (24, 25), to local tendon/tissue transfer (26–31), to free flaps (21, 32–36). Additional variations of treatment include single versus staged procedures (37, 38), the utilization of cement spacers (37, 38), tissue expanders (38) and negative-pressure wound therapy (39, 40).

In accordance with the literature, there are multiple flaps which can be used to reconstruct the Achilles tendon. In the present case, the authors evaluated pros and cons of each of them and took into account which were the objectives set for reconstruction.

The chance of setting up a flap that would guarantee an adequate share of well-vascularized tissue and which could reduce the rate of major complications is appealing. According to Lee et al. and Inoue et al. the composite anterolateral thigh fascio-cutaneous flap allows simultaneous transfer of the fascia and skin, both being well vascularized. A vascularized tendon substitute has the advantage of higher resistance to infection, faster healing, fewer adhesions, and better gliding capability (3, 33).

In the present case the authors wanted to set up a reliable flap equipped with a long and large-caliber vascular peduncle, which is why the technique of Wei et al. was excluded. They describe a composite free groin flap with iliac bone and abdominal fascia to reconstruct the skin-aponeurosis-bone complex. The superficial circumflex iliac artery, which is the main pedicle of the groin flap, is relatively little and easily damaged (41).

The use of muscle flaps wasn't taken into account by authors as one of their main purposes was to perform a one-step surgical procedure; for this reason, it

was decided not to use flaps of grosser thickness that require a second debulking surgery such as the latissimus dorsi (LD) used by Lee et al. or the gracilis described by Huemer et al (36, 42). Furthermore, the LD described by Lee et al. was also excluded as it was raised up as a flap of denervated muscle, thus losing part of its muscle function (36).

Considering the high rate of failure in restoring satisfying function in high demanding patients in the presence of a massive defect, the authors excluded the lateral-arm flap described by Smit et al. raised with the triceps tendon, since in this paper the size of tendon defects isn't specified (43).

Similarly, the technique with tensor fasciae lata (TFL) flap described by Dabernig et al. was excluded for the risk of failure to achieve a strong junction between the fascia and the bone (44).

The Radial forearm flap plus Flexor Carpi Radialis tendon described by Innocenti et al. seems to be a good reconstructive option with a thin and pliable skin and a long tendon, but it needs the sacrifice of the radial artery (45).

As a matter of fact, an important aspect that has to be considered when planning the reconstruction is the morbidity at the donor site: Deiler et al. asserted that tensor fasciae lata perforator flap is a great choice for Achilles tendon reconstruction, with minimal morbidity at the donor site, easy first intention healing, and no significant atrophy of the tensor fasciae lata muscle (46).

The proposal of Kim et al. based on dorsal pedis free flap may lead to limited excursion of the toes with not entirely negligible donor site morbidity (47).

Papp et al. stated that the infragluteal flap represents a good alternative for Achilles tendon reconstruction, even though there is the danger of injuring the posterior femoral cutaneous nerve while harvesting the flap, that can result in sensitivity deficit in the posterior area of the thigh (48).

Recently Tiengo et al. reported of seven patients that underwent tendon and soft tissue reconstruction in Achilles tendon region with a chimeric anterolateral thigh flap and rolled-up fascia lata. These authors conclude that single-stage composite reconstruction with a fasciocutaneous flap with a strip of fascia lata is a safe and reliable strategy for composite reconstruction of the Achilles tendon region (49).

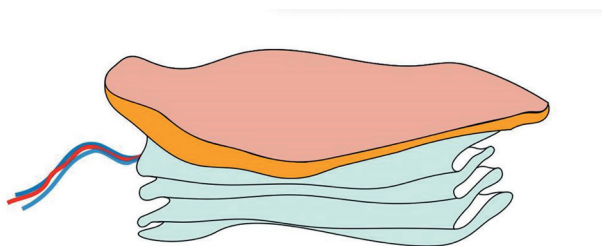


Figure 12. ALT flap with fascia lata folded on itself.

In the present technique the authors preferred to fold the fascia lata on itself instead of rolling it up like Tiengo et al., to ensure a homogeneous distribution of the force over the different layers and to have the possibility to open it up and suture it to the muscle fascia during the proximal fixation of the graft. (fig.12 e fig. 9).

The present technique, based on the use of flexor hallucis longus tendon transfer and on an anterolateral thigh flap with vascularized fascia lata, provides reconstruction of Achilles tendon defect by means of vascularized tissue, with better healing power and a decreased likelihood of developing adhesions. Considering the defect size, the augmentation with FHL guarantees strong repair, it facilitates adequate intraoperative tensioning of the reconstruction, and it helps to restore satisfactory function and strength during rehabilitation.

There is no consensus treatment for chronic and infected Achilles tendon lesions but, in the present case, the authors have achieved good clinical outcomes, without complications, despite the large tendon loss.

Conflict of Interest: Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article

Consent to publish: the participant has consented to the submission of the case report to the journal.

References

- Jachna JT, Toby EB, Horton GA. Radial forearm free flap for coverage of postoperative lateral heel wounds after open reduction and internal fixation of the calcaneus. *J. Foot Ankle Surg* 2003; 42(5):276–281.
- Johnson L, Liette MD, Green C, Rodriguez P, Masadeh S. The Reverse Sural Artery Flap: A Reliable and Versatile Flap for Wound Coverage of the Distal Lower Extremity and Hindfoot. *Clin Podiatr Med Surg* 2020; 37(4):699–726.
- Lee JW, Yu JC, Shieh SJ, Liu C, Pai JJ. Reconstruction of the Achilles tendon and overlying soft tissue using ante-rotational thigh free flap. *Br. J. Plast. Surg* 2000; 53(7):574–577.
- Kuo Y-R, Kou M-H, Chou W-C, Liu Y-T, Lutz BS, Jeng S-F. One-stage reconstruction of soft tissue and Achilles tendon defects using a composite free anterolateral thigh flap with vascularized fascia lata: clinical experience and functional assessment. *Ann. Plast. Surg* 2003; 50(2):149–155.
- Abubeih H, Khaled M, Saleh WR, Said GZ. Flexor hallucis longus transfer clinical outcome through a single incision for chronic Achilles tendon rupture. *Int Orthop* 2018; 42(11):2699–2704.
- Jahss M. Disorders of the foot and ankle: medical and surgical management, WB Saunders 2nd edn. 1991:2355–2360.
- Wapner K, Pavlock G, Hecht P, Naselli F, Walther R. Repair of chronic Achilles tendon rupture with flexor hallucis longus tendon transfer. *Foot ankle* 1993; 14(8):443–449.
- Soons J, Rakhorst HA, Ruettermann M, Luijsterburg AJ, Bos PK, Zöphel OT. Reconstruction of defects involving the Achilles tendon and local soft tissues: a quick solution for a lingering problem. *Bone Joint J.* 2015; 97-B(2):215–20.
- O'Brien M. The anatomy of the Achilles tendon. *Foot Ankle Clin* 2005; 10(2):225–238.
- Krueger-Franke M, Siebert CH, Scherzer S. Surgical treatment of ruptures of the Achilles tendon: a review of long-term results. *Br. J. Sports Med* 1995; 29(2):121–125.
- Theobald P, Benjamin M, Nokes L, Pugh N. Review of the vascularisation of the human Achilles tendon. *Injury* 2005; 36(11):1267–1272.
- Chen TM, Rozen WM, Pan W, Ashton MW, Richardson MD, Taylor GI. The arterial anatomy of the Achilles tendon: Anatomical study and clinical implications. *Clin Anat* 2009; 22(3):377–385.
- Touzell A. The Achilles tendon: Management of acute and chronic conditions. *Aust J Gen Pract* 2020; 49(11):715–719.
- Maffulli N, Via AG, Oliva F. Chronic Achilles Tendon Rupture. *Open Orthop. J* 2017; 11(1):660.
- González-Murillo M, Rodrigo-Alonso A, Figueiredo-González H, Salgado-Rodrigo AM, Mota-Blanco SM. Conservative treatment of a chronic rupture of Achilles tendon: case report. *Acta Ortop. Mex* 2016; 30(6):323–325.
- Koh D, Lim J, Chen JY, Singh IR, Koo K. Flexor hallucis longus transfer versus turndown flaps augmented with flexor hallucis longus transfer in the repair of chronic Achilles tendon rupture. *Foot Ankle Surg* 2019; 25(2):221–225.
- 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; 40(9):2154–2160.
- 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(6):791–799.
19. Keating JF, Will EM. Operative versus non-operative treatment of acute rupture of tendo Achillis: a prospective randomised evaluation of functional outcome. *J. Bone Joint Surg Br* 2011; 93(8):1071–1078.
 20. Attinger CE, Ducic I, Hess CL, Basil A, Abbruzzese M, Cooper P. Outcome of skin graft versus flap surgery in the salvage of the exposed achilles tendon in diabetics versus nondiabetics. *Plast. Reconstr. Surg* 2006; 117(7):2460–2467.
 21. Haas F, Seibert FJ, Koch H, et al. Reconstruction of combined defects of the Achilles tendon and the overlying soft tissue with a fascia lata graft and a free fasciocutaneous lateral arm flap. *Ann. Plast. Surg* 2003; 51(4):376–382.
 22. Iorio ML, Han KD, Evans KK, Attinger CE. Combined Achilles tendon and soft tissue defects: Functional outcomes of free tissue transfers and tendon vascularization. *Ann. Plast. Surg* 2015; 74(1):121–125.
 23. Winters B, Da Rin de Lorenzo F, Beck D. What Is the Treatment 'Algorithm' for Infection After Achilles Tendon Repair/Reconstruction? *Foot Ankle Int* 2019; 40:71–73.
 24. Bae SH, Lee H-S, Seo SG, Kim SW, Gwak H-C, Bae S-Y. Debridement and Functional Rehabilitation for Achilles Tendon Infection Following Tendon Repair. *J. Bone Joint Surg. Am* 2016; 98(14):1161–1167.
 25. Fourniols E, Lazennec J-Y, Rousseau M-A. Salvage technique for postoperative infection and necrosis of the Achilles tendon. *Orthop. Traumatol. Surg. Res* 2012; 98(8):915–920.
 26. Anderson MR, Bell DE, Ketz JP. Flexor Hallucis Longus Muscle and Tendon Transfer for the Treatment of Achilles Tendon Wounds. *Foot ankle Int* 2018; 39(2):205–209.
 27. Dekker TJ, Avashia Y, Mithani SK, Matson AP, Lampley AJ, Adams SB. Single-Stage Bipedicle Local Tissue Transfer and Skin Graft for Achilles Tendon Surgery Wound Complications. *Foot Ankle Spec* 2017; 10(1):46–50.
 28. Hansen U, Moniz M, Zubak J, Zambrano J, Bear R. Achilles tendon reconstruction after sural fasciocutaneous flap using Achilles tendon allograft with attached calcaneal bone block. *J. foot ankle Surg* 2010; 49(1):86.e5–10.
 29. Lee K, Moon JS, Seo JG, Lee WC. One-stage treatment of deep infection following repair of Achilles tendon rupture with flexor hallucis longus transfer. *Knee Surg. Sports Traumatol. Arthrosc* 2009; 17(3):313–315.
 30. Lui TH, Chan KB. Achilles tendon infection due to *Mycobacterium chelonae*. *J. foot ankle Surg* 2014; 53(3):350–352.
 31. Simonson DC, Elliott AD, Roukis TS. Catastrophic Failure of an Infected Achilles Tendon Rupture Repair Managed with Combined Flexor Hallucis Longus and Peroneus Brevis Tendon Transfer. *Clin. Podiatr. Med. Surg* 2016; 33(1):153–162.
 32. Feibel RJ, Jackson RL, Lineaweaver WC, Buncke HJ. Management of chronic achilles tendon infection with mus-culotendinous gracilis interposition free-flap coverage. *J. Reconstr. Microsurg* 1993; 9(5):321–325.
 33. Inoue T, Tanaka I, Imai K, Hatoko M. Reconstruction of Achilles tendon using vascularised fascia lata with free lateral thigh flap. *Br. J. Plast. Surg* 1990; 43(6):728–31.
 34. Kim C-H, Tark M-S, Choi C-Y, Kang S-G, Kim Y-B. A single-stage reconstruction of a complex Achilles wound with modified free composite lateral arm flap. *J. Reconstr. Microsurg* 2008; 24(2):127–130.
 35. Kim SW, Hong JP, Lee WJ, Chung YK, Tark KC. Single-stage Achilles tendon reconstruction using a composite sensate free flap of dorsalis pedis and tendon strips of the extensor digitorum longus in a complex wound. *Ann. Plast. Surg* 2003; 50(6):653–657.
 36. Lee HB, Lew DH, Oh SH et al. Simultaneous reconstruction of the Achilles tendon and soft-tissue defect using only a latissimus dorsi muscle free flap. *Plast. Reconstr. Surg* 1999; 104(1):111–119.
 37. Beals TC, Severson EP, Kinikini D, Aoki S. Complex Achilles reconstruction for massive soft tissue loss: allograft, autograft, and use of a temporary cement spacer. *J. Orthop. Trauma* 2010; 24(8):e78–80.
 38. Kane JM, Raikin SM. Treatment of Catastrophic Infection After Surgery for Insertional Achilles Enthesopathy: A Case Report and Review of the Literature. *Foot Ankle Spec* 2015; 8(4):324–329.
 39. Mosser P, Kelm J, Anagnostakos K. Negative pressure wound therapy in the management of late deep infections after open reconstruction of achilles tendon rupture. *J. foot ankle Surg.* 2015; 54(1):2–6.
 40. Saku I, Kanda S, Saito T, Fukushima T, Akiyama T. Wound management with negative pressure wound therapy in postoperative infection after open reconstruction of chronic Achilles tendon rupture. *Int. J. Surg. Case Rep* 2017; 37:106–108.
 41. Wei F-C, Chen H-C, Chuang C, Noordhoff M. Reconstruction of Achilles tendon and calcaneus defects with skin-aponeurosis-bone composite free tissue from the groin region. *Plast Reconstr Surg*, 1988; 81(4):579–89.
 42. Huemer GM, Larcher L, Scholler Bauer T. The free gracilis muscle flap in Achilles tendon Coverage and re-costruction. *Plast. Reconstr. Surg* 2012; 129(4):910–919.
 43. Smit JM, Darcy CM, Audolfsson T, Hartman EHM, Acosta R. Multilayer reconstruction for defects overlying the Achilles tendon with the lateral-arm flap: long term follow up of 16 cases. *Wiley Periodicals* 2012; 32(6):438–44.
 44. Dabernig J, Shilov B, Schumacher O, Lenz O, Schaff J. Functional reconstruction of Achilles tendon defects combined with overlying skin defects using a free tensor fasciae latae flap. *Journal of Plastic, Reconstructive & Aesthetic Surgery* 2006; 59(2):142–7.
 45. Innocenti M, Tani M, Carulli C, Ghezzi S, Raspanti A, Menichini G. Radial forearm flap plus Flexor Carpi Radialis tendon in Achilles tendon reconstruction: Surgical technique, functional results, and gait analysis. *Micrisurgery* 2015; 35(8):608–14.
 46. Deiler S, Pfadenhauer A, Widmann J, Stütze H, Kanz KG, Stock W. Tensor Fasciae Latae Perforator Flap for

- Re-costruction of composite Achilles Tendon defects with skin and vascularized fascia. *Plast Reconstr Surg* 2000; 106(2):342-9.
47. Kim SW, Hong JP, Lee WJ, Chung YK, Tark KC. Single-Stage Achilles tendon reconstruction using a composite sensate free flap of dorsalis pedis and tendon strips of the extensor digitorum longus in a complex wound. *Ann Plast Surg* 2003; 50(6):653-7.
48. Papp C, Todoroff BP, Windhofer C, Gruber S. Partial and complete Reconstruction of Achilles tendon defects with the fasciocutaneous infragluteal free flap. *Plast. Reconstr Surg* 2003; 112(3):777-83.
49. Tiengo C, Sonda R, Monticelli A, et al. Achilles Tendon Region Defects: Delayed Composite Anterolateral Thigh Flap With Stripping of Fascia Lata: A Case Series. *Wound Manage Prev* 2020; 66(12):13-22.

Received: 19 November 2021

Accepted: 3 February 2022

Correspondence: Luca Di Lenarda
Orthopedics and Traumatology Unit, Cattinara Hospital -
ASUGI, Strada di Fiume 447 - 34149 Trieste, Italy
Phone: +39 3518842576
Fax: +39 0403994544
E-mail: lucadilenarda@gmail.com