

TECHNICAL NOTE**Tenodesis in Flail Foot: A New Surgical Technique**

Omid Salkhori, MD; SM Javad Mortazavi, MD; Mohammad Ayati Firoozabadi, MD

Research performed at Department of Orthopedic Surgery, Imam Khomeini Hospital Complex, Tehran University of Medical Sciences, Tehran, Iran

Received: 11 June 2024

Accepted: 4 August 2024

Abstract

Flail foot is a condition characterized by a significant weakness in ankle dorsiflexion, resulting in limited or no active mobility in the ankle. To address this issue, we described a novel approach called tenodesis, which has been developed for ankle joint stabilization. This technique utilizes the patient's tendons to minimize potential complications. The primary focus of this method is to preserve ankle passive dorsiflexion, thereby maintaining the foot in a neutral position, helping prevent foot drop, reducing the risk of neuropathic ulcers, and keeping joint proprioception. Furthermore, maintaining passive ankle dorsiflexion is particularly important in societies where activities such as squatting are integral to daily life. The study aims to introduce a new surgical technique for flail foot.

Level of evidence: V**Keywords:** Flail foot, Peroneal neuropathy, Tenodesis, Tibial neuropathy**Introduction**

The adult paralytic foot is a common clinical condition that can result in significant disability. Paralysis in the lower extremities can lead to foot drop, cavovarus, and equinovarus deformities, as well as flail foot.¹

Flail foot is characterized by severe weakness in ankle dorsiflexion, plantar flexion, and intrinsic foot muscles, resulting in little to no active movement in the ankle or foot.² The understanding of its causes and treatment options continues to evolve, with various neurologic, genetic, and traumatic conditions being potential factors.¹

Treatments for flail foot range from non-surgical options, such as orthotic devices, to surgical interventions, such as subtalar arthrodesis, triple arthrodesis, and pantalar fusion.²⁻⁵ This study aims to introduce a new surgical technique for flail feet that does not involve fusion.

Surgical Technique

The study included six patients (four males and two females), with a mean age of 32 years (ranging from 22 to 43 years). The patients suffered from various conditions, such as polio, multiple sclerosis, and Charcot-Marie-Tooth disease, each presenting with flail feet. They were treated using a novel technique by a specialized orthopedic surgeon at Imam Khomeini Hospital Complex in Tehran, Iran.

The patient was positioned supine on the operating table

with a tourniquet on the upper thigh. A 5-7 cm incision was made to expose the lower and anterior aspects of the leg, allowing the visualization of the peroneus brevis and tibialis anterior tendons and the distal tibial bone. Two additional 1.5 cm incisions were made over the navicular and the base of the 5th metatarsal bones to facilitate the identification of the tendons [Figure 1 a, b].

The tibialis anterior and peroneus brevis tendons were carefully divided at their musculotendinous junctions and retracted into the distal incisions [Figure 1 c, d]. Subcutaneous tunnels were created to guide the proximal tendon ends to the wound over the tibia [Figure 2].

Transverse parallel holes were drilled into the meta-diaphyseal junction of the tibial bone using a 4.5 mm drill bit, 1 cm apart and 1 cm anterior to the cortex. The tendons were passed through these holes, with the tibialis anterior going through the lateral holes and the peroneus brevis through the medial holes [Figure 3]. The ends of the tendons were sutured to each other on the anterior surface of the tibia using non-absorbable thread to ensure proper tension [Figure 4].

The patient's wounds were meticulously closed with absorbable sutures in layers, and a below-knee cast was applied for six weeks postoperatively. Following cast removal, a soft-lined rigid ankle-foot orthosis was worn for an additional six weeks before being discontinued. During

Corresponding Author: Mohammad Ayati Firoozabadi, Joint Reconstruction Research Center (JRRC), Tehran University of Medical Sciences, Tehran, Iran

Email: dr.mohammad.ayati@gmail.com



THE ONLINE VERSION OF THIS ARTICLE
ABJS.MUMS.AC.IR



the period of wearing the cast, the patient was able to walk and bear weight as advised. The patient was prescribed Aspirin 80 mg twice daily for six weeks and started occupational therapy sessions after cast removal to aid in rehabilitation.

All patients, with a two-year follow-up, expressed satisfaction with the procedure and did not experience any foot drop. They are currently receiving occupational therapy to improve their condition further.

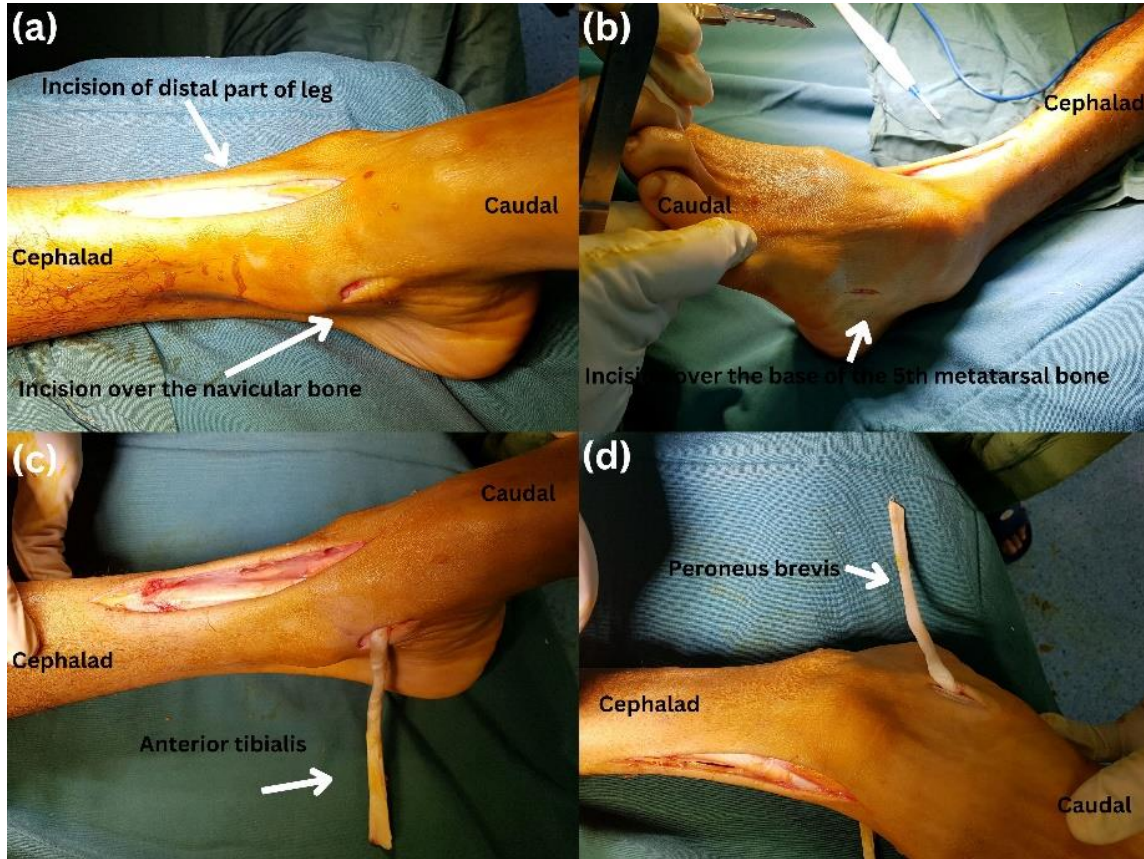


Figure 1. Incisions about 5-7 cm over the distal and anterior of the leg and the navicular bone in the medial of the foot (a) and the base of the 5th metatarsal bone in the lateral of the foot (b). The divided tendons were retracted into the distal wounds; anterior tibialis of medial (c) and peroneus brevis of lateral (d)

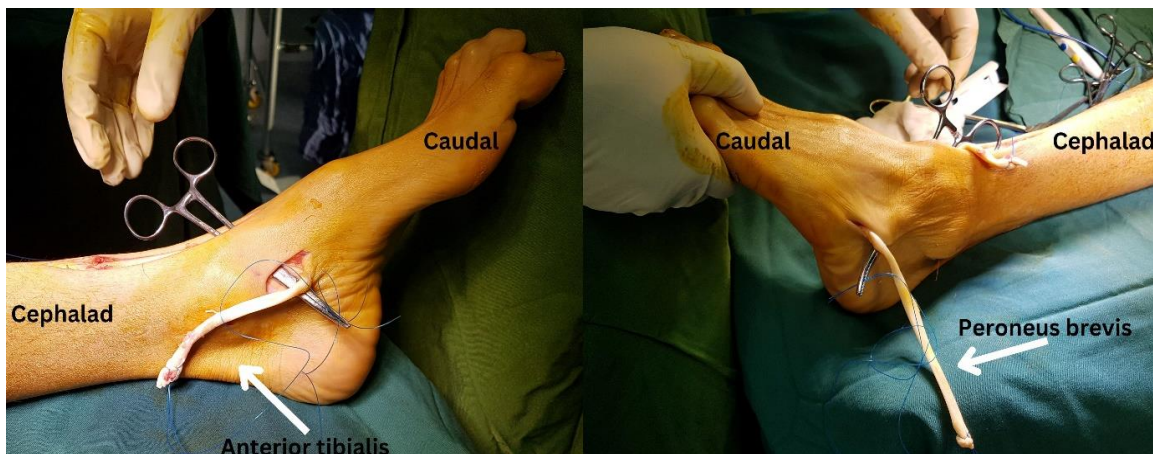


Figure 2. The subcutaneous tunnel is created using mosquito forceps, through which the tibialis anterior (a) and peroneus brevis (b) tendons pass to the proximal side

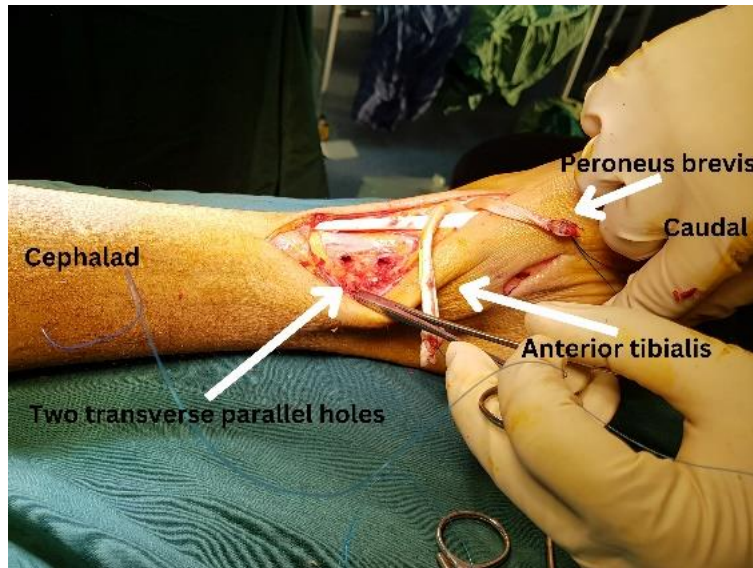


Figure 3. Two transverse parallel holes a distance of 1 cm from each other and 1 cm of the anterior cortex of the tibial bone were drilled in the meta-diaphyseal junction by a 4.5 mm drill bit and the ends of the tendons were threaded through these holes, with the tibialis anterior passing through the lateral holes and the peroneus brevis passing through the medial holes



Figure 4. The tendons' ends were sutured to each other on the anterior surface of the tibial bone, using a non-absorbable thread with appropriate tension, respectively

Discussion

Tenodesis is a procedure where one end of the tendon is stitched to the bone. In this surgical technique, we detach the proximal part of the tendon from the tibialis anterior and peroneus brevis muscles and attach it to the tibia bone. Securing the tendon to the bone on both ends without any muscle attachment maintains the foot in the correct position without causing issues with the lever arm. This approach prevents tendon loosening and foot drop both during the surgery and in the long term. Consequently, the likelihood of recurrence is decreased with this procedure.

The current treatment options for patients with flail feet are primarily limited to orthoses and arthrodesis.²⁻⁵ Although there is a surgical technique involving tenodesis using a neoligament, it is important to note that this method has only been documented in a single case and is not widely practiced.⁶

In the Bridle procedure outlined by Rodriguez,⁷ the tibialis posterior is transferred to the dorsum of the foot via the interosseous membrane, with an anastomosis to the anterior tibial tendon and a rerouted peroneus longus in front of the lateral malleolus. The posterior tibial tendon is inserted into

a tunnel in the second cuneiform bone and anastomosed within itself. However, there is a risk of tendon loosening and decreased dorsiflexion over time with this tendon transfer technique. In cases of flail foot where all muscles distal to the knee are paralyzed, tendon transfer is not a viable solution. In our approach, we utilize the tibialis anterior and peroneus brevis tendons, keeping the distal ends attached to their respective heads, while tenodesis is performed on the proximal ends of the tibia.

We have devised a novel technique for stabilizing the ankle joint known as tenodesis. This approach utilizes the patient's tendons instead of allograft to minimize potential complications. To date, we have implemented this method successfully in six patients. While arthrodesis is another effective option for ankle joint stabilization, it presents certain drawbacks, including a heightened risk of neuropathic ulcers and restrictions in daily activities.^{8,9}

On the other hand, our approach prioritizes the preservation of passive dorsiflexion of the ankle, maintaining the foot in a neutral position, aiding in preventing foot drop, lowering the risk of neuropathic ulcers, and preserving joint proprioception. Furthermore, safeguarding passive ankle dorsiflexion is vital in cultures where squatting is integral to daily activities. Our method is reserved for cases where the joint is still intact and is not suitable for young, active individuals engaged in strenuous activities.

In the tenodesis technique that incorporates a neo-ligament, an allograft is utilized.⁶ However, there may be challenges with the allograft integrating properly into the bone due to inadequate blood supply. Our approach emphasizes preserving the tendon insertions to uphold their blood supply and facilitate better integration. While allografts are not commonly used in the treatment of flail feet, the potential risks of infection and loosening remain uncertain. Studies examining the outcomes of anterior cruciate ligament reconstruction with allografts have indicated a heightened risk of loosening and infection.¹⁰ In contrast, our method presents a lower risk of infection and loosening.

Finally, it is important to mention that in patients with a flail foot, the foot is entirely paralyzed, rendering tendon transfer or nerve transfer unfeasible. The objective of this surgical procedure is to correctly align the foot in the coronal and sagittal planes to mitigate foot drop, gait issues, and skin breakdown, consequently enhancing short-term and long-

term results as well as the patient's quality of life.

Conclusion

The tenodesis technique we have utilized can serve as a valuable alternative to arthrodesis, effectively managing diverse complications related to limited flexibility and reduced occurrence of neuropathic ulcers in patients with flail feet. Ultimately, this approach enhances the overall quality of life for these individuals.

Acknowledgement

N/A

Authors Contribution: Authors who conceived and designed the analysis: Seyed Mohammad Javad Mortazavi and Omid Salkhori/ Authors who collected the data: Omid Salkhori/ Authors who contributed data or analysis tools: Mohammad Ayati Firoozabadi/ Authors who performed the analysis: Mohammad Ayati Firoozabadi/ Authors who wrote the paper: Seyed Mohammad Javad Mortazavi, Mohammad Ayati Firoozabadi, and Omid Salkhori

Declaration of Conflict of Interest: The author(s) do NOT have any potential conflicts of interest for this manuscript.

Declaration of Funding: The author(s) received NO financial support for the preparation, research, authorship, and publication of this manuscript.

Declaration of Ethical Approval for Study: Our institution does not require ethical approval for reporting this study.

Declaration of Informed Consent: The authors declare that there is NO information (names, initials, hospital identification numbers, or photographs) in the submitted manuscript that can be used to identify patients.

Omid Salkhori MD ^{1,2}

SM Javad Mortazavi MD ^{1,2}

Mohammad Ayati Firoozabadi MD ^{1,2}

1 Joint Reconstruction Research Center, Tehran University of Medical Sciences, Tehran, Iran

2 Department of Orthopedic Surgery, Imam Khomeini Hospital Complex, Tehran University of Medical Sciences, Tehran, Iran

References

- Matuszak SA, Baker EA, Fortin PT. The adult paralytic foot. *J Am Acad Orthop Surg.* 2013; 21(5):276-85. doi: 10.5435/JAAOS-21-05-276.
- Ansart MB. Pan-arthrodesis for paralytic flail foot. *J Bone Joint Surg Br.* 1951; 33(4):503-507. doi:10.1302/0301-620x.33b4.503.
- Fulford G, Cairns T. The problems associated with flail feet in children and their treatment with orthoses. *J Bone Joint Surg Br.* 1978; 60(1):93-95. doi:10.1302/0301-620X.60B1.627586.
- Natarajan M. Pan-talar arthrodesis for post-polio flail foot. *Singapore Med J.* 1967; 8(3):214-21.
- Gharehdaghi M, Rahimi H, Mousavian A. Anterior ankle arthrodesis with molded plate: technique and outcomes. *Arch Bone Jt Surg.* 2014; 2(3):203.
- Joseph B. Management of a flail foot in cauda equina syndrome by neoligament tenodesis: A case report. *Foot Ankle Int.* 2006; 27(1):60-3. doi: 10.1177/107110070602700111.
- Rodriguez RP. The Bridle procedure in the treatment of

- paralysis of the foot. *Foot Ankle*. 1992; 13(2):63-9. doi: 10.1177/107110079201300203.
8. Maynard MJ, Weiner LS, Burke SW. Neuropathic foot ulceration in patients with myelodysplasia. *J Pediatr Orthop*. 1992; 12(6):786-8. doi: 10.1097/01241398-199211000-00016.
 9. Watts DT, Moosa A, Elahi Z, Palmer AJ, Rodriguez-Merchan EC. Comparing the results of total ankle arthroplasty vs tibiotalar fusion (ankle arthrodesis) in patients with ankle osteoarthritis since 2006 to 2020-A systematic review. *Arch Bone Jt Surg*. 2022; 10(6):470-479. doi: 10.22038/ABJS.2021.55790.2778.
 10. Hulet C, Sonnery-Cottet B, Stevenson C, et al. The use of allograft tendons in primary ACL reconstruction. *Knee Surg Sports Traumatol Arthrosc*. 2019; 27(6):1754-1770. doi: 10.1007/s00167-019-05440-3.

