



FUNCTIONAL OUTCOME OF END-TO-END REPAIR AND FLEXOR HALLUCIS LONGUS AUGMENTATION IN TENDO-ACHILLES RUPTURE-A PROSPECTIVE STUDY

Orthopaedics

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ABSTRACT

Achilles tendon is one of the most commonly injured tendons in the human body. There are various factors that lead to its rupture. This can lead to restriction in movements. Surgical reconstruction is much more superior to conservative treatment. Transfer of flexor hallucis longus in Achilles tendon rupture is a newer procedure with not much studies regarding its functional efficacy. In this study we attempt to evaluate the functional outcome of end to end repair and flexor hallucis longus augmentation in tendo-achilles rupture. 20 patients with Achilles Tendon rupture admitted between June 2021 and November 2022 were recruited into the study. All patients were operated with end to end repair and Flexor Hallucis Longus (FHL)tendon augmentation. Functional outcome was analyzed using American Orthopaedic Foot and Ankle Society (AOFAS) Ankle-Hindfoot Score. All patients were followed up to 6 months post-operatively. Outcome was assessed by AOFAS Ankle-Hindfoot (AHS) score. The mean preoperative score of 48.0 improved to 77.9 at final follow-up out of a total 100 points. We achieved excellent functional outcome in 10%, good outcome in 80% cases and moderate outcome in 10% cases. No re-ruptures were noted. Superficial infections were noted in 2 cases which was managed with oral antibiotics. ankle stiffness was found in 1 case which was managed with physiotherapy. The study concluded that in ruptures of Achilles tendon, FHL augmentation to calcaneum with interference screw fixation and end to end repair of Achilles tendon is a reliable technique with good functional outcome.

KEYWORDS

Achilles tendon rupture, Flexor hallucis longus augmentation, End to end repair.

INTRODUCTION

Achilles tendon rupture, a catastrophic injury and frequent tendinous lesion, affects 18 out of every 100,000 persons.^[1] Despite its strength, the Achilles tendon is one of the most commonly injured tendons in the human body.^[2] The tendon is frequently injured through a combination of inherent and extrinsic factors. Ageing, male sex, and obesity are intrinsic characteristics that have been linked favourably to Achilles tendon damage. The use of fluoroquinolones and local corticosteroids are examples of extrinsic influences.^[3]

A meta-analysis was published in 2002 by Bhandari and colleagues in relation to the treatment of acute Achilles tendon ruptures. The rupture of the muscle is usually found in middle aged men, especially untrained and recreational athletes. Many causes, such as violent dorsiflexion of the plantar flexed foot, as in a fall from a height, direct blow to the contracted tendon in a road traffic accident, industrial-accidents, spontaneous ruptures contribute to the rupture. The main function of the tendon is to provide plantar flexion. A number of factors are associated with the rupture of the tendon. They mainly include local and systemic corticosteroids, peritendinous injections and degenerative changes in tendon. As the tendon weakens normal physiological loads also cause the tendon to weaken and rupture.^[3]

The correct diagnosis of the rupture is usually missed in around 25% patients at initial presentations. The main way to diagnose the rupture is with thorough proper history taking, clinical examination and imaging techniques. Clinically, edema and swelling like symptoms may be noted. Also, in many cases a palpable gap may be observed along the tendon proximal to its insertion. Ultrasound imaging is the best technique for its examination whereas magnetic resonance imaging can act as a secondary diagnostic feature. Initially the rupture goes undiagnosed in many cases. Partial ruptures are rare.^[4]

Physical examination findings include a palpable deformity, weak plantar flexion strength, and passive ankle dorsiflexion. There is always a positive Thompson and Matles' test result. As a result of recent technical developments, it is now possible to diagnose and predict the outcomes of Achilles tendon problems much more accurately. The critical zone is a region with less vascularization that can be seen in magnetic resonance imaging.

Two to six centimetres from insertion is where most Achilles tendon rips happen. Over time, there has been a sharp rise in Achilles tendon ruptures. Cast mobilisation and functional bracing are frequently used in non-operative therapy. Patients are instructed to gradually reducing plantar flexion to neutral over the course of six weeks.^[5]

Surgical reconstruction is much more superior to conservative treatment. Surgical treatment mainly includes treating the Achilles tendon rupture either by open, mini open or minimally invasive approach. To close the gaps or serve as a link between them, a range of operations, including V-Y plasty, gastrocnemius soleus fascia turn down grafts, and local tendon transfers, including flexor hallucis longus, flexor digitorum longus, and peroneus brevis, are frequently employed. Conventional and conservative treatment are ineffective in many cases and in such cases a gap is formed between retractile tendon stumps.

Compared to the Flexor digitorum longus and peroneus brevis (PB) tendons, the Flexor hallucis longus tendon has the following advantages. (1) It provides greater plantarflexion than the Flexor digitorum longus and Peroneus Brevis tendons and is the second strongest tendon after the gastrosoleus. (2) The Achilles tendon is closer to the axis of contraction than the Flexor digitorum longus and Peroneus brevis tendons. (3) The gastrosoleus complex and the Flexor Hallucis Longus Tendon fire together. (4) It is situated close to the Achilles tendon anatomically.^[6]

There are also many additional materials utilised, such as alloplasts, synthetic materials like Dacron weave, carbon fibre, and Marlex mesh. After the triceps surae, the flexor hallucis longus is the strongest plantar flexor of the ankle. Its line of contraction resembles the Achilles tendon in certain ways.^[7]

Transfer of flexor hallucis longus in Achilles tendon rupture is a new procedure and is widely accepted. The procedures or surgeries performed earlier did not yield satisfactory results in terms of plantar flexion. The present study was conducted to predict the outcome of patients presenting with Achilles tendon rupture with end-to-end repair treated with flexor hallucis longus augmentation with special emphasis on regaining strength of plantar flexion.

Aims And Objectives

Aim: To report the functional outcome of management of patients presenting with Achilles tendon rupture and treated by end-to-end repair and Flexor hallucis longus augmentation

Objectives:

1. To study demographic parameters of cases with Achilles tendon rupture.
2. To report their outcome with particular attention on the ankle plantar flexion.

MATERIALS AND METHODS

The present study is a hospital-based interventional prospective study conducted in the department of Orthopaedics of a tertiary care centre for a duration of 18 months (June 2021 - November 2022). The patients admitted with tendo-achilles rupture going to be operated by end-to-end repair and flexor hallucis longus augmentation in a tertiary hospital, were enrolled in the study after obtaining their consent. The study was approved by the Ethical Committee of the Medical College. Sample size was taken as 20 cases.

Inclusion Criteria:

1) Patient aged 18 -70 years. 2) Traumatic tear of tendoachilles. 3) Degenerative tear of tendoachilles. 4) Chronic tear where end to end repair is possible. 5) Ability to walk before trauma.

Exclusion Criteria:

1) Patients age <18 years and >70 years. 2) Chronic tear where end to end repair is not possible. 3) Insertional tear. 4) Unwillingness to participate. 5) Preinjury status non ambulatory. 6) Associated fractures.

Methodology

Patients fulfilling above inclusion and exclusion criterias were enrolled in the study. Documentation of demographic and clinical parameters was done in predesigned case record sheet. Relevant clinical examination and routine blood investigations were conducted. Pre- operative assessment was done before surgery. Skin condition over the affected limb was checked. After deciding fitness for surgery, patient was then taken up for end-to-end repair and flexor hallucis longus augmentation of Achilles tendon rupture in prone position under appropriate anaesthesia. Time interval between injury and operation were noted for each patient.

Intra-operative blood loss and anaesthesia complications were noted. Time required for completion of surgery was noted. Post- operation patient was assessed for immediate/early/late pain. Any infection or swelling after surgery were noted. Follow up examination was done on 1st, 3rd, 6th months from surgery. On follow-up assessment of patients was done using AOFAS score and following findings were noted: ankle range of motion, calf muscle strength and endurance using the heel rise test.

Operative Procedure: -

1] Patient was positioned prone after appropriate anaesthesia and scrubbing, painting and drapping done under all aseptic precaution.



Fig 1. Patient Position

2] Midline incision was taken over the Achilles tendon, paratendon was carefully opened and the ruptured tendon was exposed.



Fig 2: Incision

3] Further dissection was done to localise the Flexor Hallucis Longus (FHL) tendon.



Fig 3. Flexor Hallucis Longus (FHL) tendon localised

4] Flexor Hallucis Longus (FHL) Tendon is then stripped from the insertion distally and harvested for transfer to the calcaneum.



Fig 4. Flexor Hallucis Longus (FHL) tendon stripped

5] Hagelund deformity if any was excised. Bed for transfer of FHL to calcaneum prepared. Under fluoroscopy, guide wire was passed in the calcaneum. Calcaneum was drilled with appropriate size drills and reamers to create tunnel for fixation of FHL tendon in it.



Fig 5. Interference screw placement under fluoroscopy

6] End to end repair of ruptured Achilles tendon is done with Bunnell's or modified Kessler's suturing technique

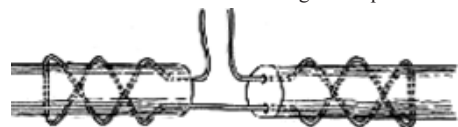


Fig 6 Bunnell's Suture

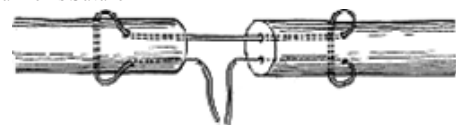


Fig 7 Modified Kessler's Suture

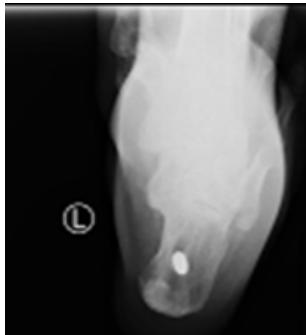


Fig 8 End to end repair of Tendo - Achilles

- 7] Paratenon of Tendo Achilles sutured carefully. Skin closure was done in layers with appropriate suture materials and sterile dressing was done.

**Fig 9.** Skin closure

Post-operative Images: -

**Fig 10:** Calcaneum- Axial view**Fig 11:** Calcaneum lateral view

Post Operative Protocol

In our facility, a below knee slab was originally applied for two weeks over the dorsum of the foot with the ankle in an equinus position. After two weeks, the sutures were taken out, and the slab was kept in place for a further six weeks while the ankle was gradually dorsiflexed every 2 weeks. After eight weeks, foot exercises and moderate weight bearing were introduced. The physical therapy was continued until the ankle could move well.

Post-operative Clinical Images:

**Fig 12.** A] Heel Rise

B] Matles Test

Functional Assessment Post Operatively-

The Functional Outcome Is Evaluated By: -

- 1] Healing of the skin wound over the Tendo-Achilles region.
- 2] Ability to both plantar flex as well as dorsi flex the ankle joint.
- 3] Ability to heel rise.
- 4] Patient's ability to walk and to stand on toes.
- 5] Thorough assessment was done using American Orthopaedic Foot and Ankle Society (AOFAS) Ankle-Hindfoot Score.

The patients were evaluated by American Orthopaedic Foot Ankle Society (AOFAS) Ankle-Hindfoot scale. It is a 100points score with 40 points for pain, 50 points for function and 10 for alignment. Functional evaluation by AOFAS ankle-hind foot scale was done in i. Pre-injury status by evaluating contralateral normal side; ii) Postoperative state at maximum follow-up of 6 months. Overall result was graded as excellent if return of function at final follow-up was >85% of pre-injury score; good if 70 to to <85% of pre-injury level; moderate if 55 to <70 and poor if score was <55% of pre-injury score.

Ankle-Hindfoot Scale (100 Points Total)		
Pain (40 points)		
None		40
Mild, occasional		30
Moderate, daily		20
Severe, almost always present		0
Function (50 points)		
Activity limitations, support requirement		
No limitations, no support		10
No limitation of daily activities, limitation of recreational activities, no support		7
Limited daily and recreational activities, cane		4
Severe limitation of daily and recreational activities, walker, crutches, wheelchair, brace		0
Maximum walking distance, blocks		
Greater than 6		5
4-6		4
1-3		2
Less than 1		0
Walking surfaces		
No difficulty on any surface		5
Some difficulty on uneven terrain, stairs, inclines, ladders		3
Severe difficulty on uneven terrain, stairs, inclines, ladders		0
Gait abnormality		
None, slight		8
Obvious		4
Marked		0
Sagittal motion (flexion plus extension)		
Normal or mild restriction (30° or more)		8
Moderate restriction (15°-29°)		4
Severe restriction (less than 15°)		0
Hindfoot motion (inversion plus eversion)		
Normal or mild restriction (75%-100% normal)		6
Moderate restriction (25%-74% normal)		3
Marked restriction (less than 25% normal)		0
Ankle-hindfoot stability (anteroposterior, varus-valgus)		
Stable		8
Definitely unstable		0
Alignment (10 points)		
Good, plantigrade foot, midfoot well aligned		15
Fair, plantigrade foot, some degree of midfoot malalignment observed, no symptoms		8
Poor, nonplantigrade foot, severe malalignment, symptoms		0
Total =		100
American Orthopaedic Foot and Ankle Society		
From: http://www.aofas.org/14a/pages/index.cfm?pageid=3494		

Figure 13 - Ankle hindfoot scale

RESULTS

As per inclusion and exclusion criteria, 20 patients were included in this study, 5 were females and 15 were males, with mean age 53.55±5.84 years, with maximum age of presentation was 65yrs and minimum age of presentation was 43yrs.

Out of 20 patients, 9 patients had left sided tear and rest 11 had right sided tear.

Comorbidities were not seen among 13 study subjects. 2 subjects were having diabetes mellitus, 4 subjects were hypertensive and only 1 subject was having hyperthyroidism.

Based on mode of injury, industrial accident was seen in only 2 subjects, 4 subjects had road traffic accident, 4 subjects had spontaneous rupture and 10 subjects had fall from height.

Delay from time of injury to surgical intervention was observed to be 1 week in 2 subjects, 3 subjects had it after 2 weeks, 2 subjects had it after 3 weeks and 13 subjects had it after 3 days

In our study after 6 months follow-up, AOFAS Score was observed to be moderate in 2 study subjects (10%), good in 16 study subjects (80 %) and excellent in 2 subjects (10%).

Increase in the mean AOFAS score from preop stage (48) to 1 month (59), 3 months (69) and 6 months (77) was observed.

At the preoperative and one-month stages of our study, none of the study subjects had heel rise; however, at 3 months follow up heel rise was present in 15 subjects and at 6 months it was observed to be present in 18 subjects.

Out of 20 study subjects, 17 subjects were not found to have any post operative complication, 1 had ankle stiffness and 2 subjects had superficial infections. Ankle stiffness was managed with physiotherapy and superficial infections were treated with oral antibiotics.

Based on above observations, Flexor Hallucis Longus augmentation with end-to-end repair for Achilles tendon rupture, had a good functional outcome indicated by AOFAS score.

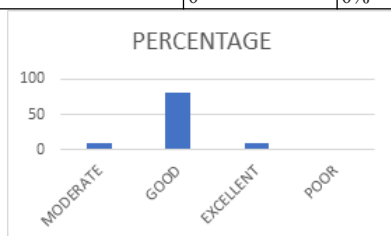
Table No 1: - Mean AOFAS Score

	Mean	N	Std. Deviation	Std. Error Mean	Mean difference from preop stage	Std deviation	P value
Preop	48.00	20	2.656	.594	-	-	-
1 month	59.25	20	4.051	.906	-11.250	3.432	<0.001
3 months	69.55	20	5.978	1.337	-21.550	5.266	<0.001
6 months	77.90	20	6.735	1.506	-29.900	6.373	<0.001

Graph No 1: - Mean AOFAS Score

Table No 2: - Functional Outcome

FUNCTIONAL OUTCOME AT 6 MONTHS FOLLOW UP	NUMBER OF PATIENTS	PERCENTAGE
EXCELLENT	2	10%
GOOD	16	80%
MODERATE	2	10%
POOR	0	0%



Graph No 2: - Functional outcome

Table No 3: - Heel Rise

	Preop		1 month		3 month		6 month	
	Freq uenc y	Per cent	Frequ ency	Per cent	Frequ ency	Per cent	Frequ ency	Per cent
ABSENT	20	100	20	100	5	25.0	2	10.0
PRESE NT	0	0.0	0	0.0	15	20.0	18	90.0
Total	20	100	20	100	20	100.0	20	100
P value	-	-	-	-	0.001	-	0.001	-

Graph No 3: - Heel rise

DISCUSSION

There are several ways to treat an Achilles tendon rupture, including open surgery, non-operative techniques, and percutaneous sutures. In comparison to open surgical repair, closed methods had a higher rate of re-rupture.

In our investigation, traumatic tears were observed on the left side in 9 patients and the right side in 11 subjects out of 20 study participants. This is consistent with research by **Sayed et al.**^[8] in which 3 cases involved the left side and 6 cases involved the right side.

In our investigation, 2 participants experienced industrial accidents, 4 had a traffic collision, 4 had spontaneous rupture and 10 had a tear due to fall from a height. This is consistent with a study by **Nagakiran et al.**^[9] in which falls were identified as the common mechanism. This is consistent with research by **Siddigari et al.**^[10] that found ruptures are frequently caused by fall from stairs.

In our study after 6 months follow up, AOFAS Score was observed to be moderate in 2 study subjects (10%), good in 16 study subjects (80 %) and excellent in 2 subjects (10 %). The mean AOFAS score in our study increased from the preoperative stage (48) to 1 month (59), 3 months (69), and 6 months (77). Studies with similar scenarios are discussed. According to a study by **Nagakiran et al.**,^[9] the ankle-hindfoot score increased to 50.71, 83.5, and 91.14 at 6 weeks, 3 months, and 6 months, respectively. According to research by **Yeoman et al.**,^[11] the average AOFAS before surgery was 51.4 (range 26–87), 79.8 (range 64–94) after three months, and 91.9 (range 77–100) at six months.

According to a study by **Wegrzyn et al.**,^[12] the mean pre-operative AOFAS score increased from 64 to 98 points (90 to 100) at the most recent follow-up. According to the study by **Sayed et al.**,^[8] mean AOFAS increased from 65 (range, 50-80) preoperatively to 91.5 (range, 88-95) at the most recent follow-up. **Aniruddha et al.**'s^[13] study revealed that the average pre-operative AOFAS score was 57.47. (SD 5.98, range 46-66). The average AOFAS score following surgery was 96.71. (SD 3.57, range 93-100). 39.35 was the average improvement. This improvement was really noteworthy ($p < 0.001$). At the preoperative and one-month stages of our study, none of the study subjects had heel rise; however, at 3 months follow up heel rise was present in 15 subjects and at 6 months it was observed to be present in 18 subjects.

According to the research done by **Athar et al.**,^[14] the patients were able to perform a single leg heel rise for an average of 13.7 seconds at the last follow-up, demonstrating a strong recovery of push-off strength during walking. This is consistent with the **Rastogi et al.**'s^[15] study, in which all patients were capable of performing single-leg heel lifts a year following surgery. This is consistent with the research done by **Aniruddha et al.**,^[13] where all patients bar one were capable of

performing a single leg heel lift.

In our study, out of 20 participants, 17 participants had no complications, 1 participant had ankle stiffness, and 2 participants had infections. Ankle stiffness was managed with physiotherapy and superficial infections were treated with oral antibiotics. This is consistent with a study by **Sayed et al.**^[8] in which there were no significant postoperative complications. This is consistent with the research done by **Wegrzyn et al.**,^[12] which found no significant issues or complications. This is consistent with the **Athar et al.**^[14] investigation, which found that there were no significant complications. One patient experienced a superficial infection that improved after switching medicines.

CONCLUSION

Achilles tendon rupture is common in adult population who are more prone to trauma leading to sudden dorsiflexion of ankle or even spontaneous ruptures. More common in males as compared to females. Treating a ruptured Achilles tendon can be exceedingly difficult based on the nature of tear and associated surrounding soft tissue injury. Flexor Hallucis Longus augmentation with end-to-end repair for Achilles tendon rupture is safe, simple and effective method. By this method, we achieved good mobilization of the ankle with fewer complications. With this method, consistent good functional outcome can be obtained. The challenges include harvesting FHL tendon and proper paratenon closure of the Achilles Tendon while performing end to end repair.

Hence, we conclude that Flexor Hallucis Longus augmentation and end to end repair had good functional outcome in Tendo- Achilles rupture cases, with consistently reproducible results.

Additional number of cases and long-term analysis should be used to support the results that are reported here.

The current study's limited sample size was one of its limitations. Future research that includes more instances and has a longer period of follow-up could offer better proof.

Conflict Of Interest:-

On behalf of all authors, the corresponding author states that there is no conflict of interest.

REFERENCES

1. Nyyssönen, T., Saarikoski, H., Kaukonen, J. P., Lühje, P., & Hakovirta, H. (2003). Simple end-to-end suture versus augmented repair in acute Achilles tendon ruptures: A retrospective comparison in 98 patients. *Acta Orthopaedica Scandinavica*, 74(2), 206–208.
2. Del Buono, A., Chan, O., & Maffulli, N. (2013). Achilles tendon: Functional anatomy and novel emerging models of imaging classification. *International Orthopaedics*, 37(4), 715–721.
3. Egger, A. C., & Berkowitz, M. J. (2017). Achilles tendon injuries. *Current Reviews in Musculoskeletal Medicine*, 10(1), 72–80.
4. Tarantino, D., Palermi, S., Sirico, F., & Corrado, B. (2020). Achilles tendon rupture: Mechanisms of injury, principles of rehabilitation and return to play. *Journal of Functional Morphology and Kinesiology*, 5(4), 95.
5. Mahmoud, S., & Zaki, R. A. (2015). Internalized stigma of mental illness among schizophrenic patients and their families (Comparative study). *Journal of Education and Practice*, 17.
6. Coughlin, M., & Mann, R. (1999). *Surgery of the foot and ankle* (Vol. II, 7th ed.). Mosby.
7. Ahemad, M. A. A., Abdul, N. M., & Syed, M. A. (2018). Chronic insertional Achilles tendon ruptures treated by suture anchor repair and augmentation with flexor hallucis longus tendon transfer. *International Journal of Research in Orthopaedics*, 4(2), 227.
8. Bekkam Siddigari, D. K. R., Mondem, A., & K. B VMR. (2019). A comparative study of reconstruction of chronic tendo Achilles rupture with flexor hallucis longus and peroneus brevis. *Journal of Evidence Based Medicine and Healthcare*, 6(9), 653–657. <https://doi.org/10.18410/jebmh/2019/136>
9. Benitez, J., Mansur, H., & Castro, I. (2018). Evaluation of the results of flexor hallucis longus tendon transfer for chronic Achilles tendinopathy. *Scientific Journal of Foot & Ankle*, 12(3), 240–246. <https://doi.org/10.30795/scijfootankle.2018.v12.825>
10. Jahir Hussain, K. (n.d.). A retrospective study to analyse the functional outcome of various procedures to treat tendo Achilles injuries (Doctoral dissertation, Stanley Medical College, Chennai).
11. Rastogi, D., Mahindra, M., Ullah, S. W., Kumar, S., & Singh, S. K. (2022). Management of chronic Achilles tendon tear by reverse gastrocnemius turnover flap and augmentation with FHL tendon – A case series. *Asian Journal of Medical Sciences*, 13(8), 167–172. <https://doi.org/10.3126/ajms.v13i8.44372>
12. Lui, T. H. (2011). Whole length flexor hallucis longus transfer with a minimally invasive approach: Technique tip. *Foot & Ankle International*, 32(7), 730–734. <https://doi.org/10.3113/FAL.2011.0730>
13. Xu, Y., Li, C., Xiang, F., Deng, Y., Lu, X., & Wei, D. (2020). Flexor hallucis longus tendon transfer through a single incision in the treatment of chronic Achilles tendon rupture with large defect. *In Review*. <https://doi.org/10.21203/rs.3.rs-17168/v1>
14. Malik, P., Singh, S., Singh, O., Tiwari, M., Gupta, N., & Sood, M. (2021). Tendo-Achilles injury: An observational study in a tertiary care hospital. *Journal of Acute Disease*, 10(6), 242. <https://doi.org/10.4103/2221-6189.330742>
15. Mao, H. (n.d.). Neglected Achilles tendon rupture treated with flexor hallucis longus transfer with two turnover gastrocnemius fascia flaps and reinforced with plantaris tendon.