

Comparative Study of Functional Outcome of Posterior Tibialis Tendon Transfer to Middle Cuneiform Bone and Anterior Tibialis Tendon with Other Techniques for Management of Foot Drop

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Abstract

Background: Injury of the Common Peroneal Nerve leads to Foot Drop and causes disability in the gait of the patient. The common cause of Common Peroneal Nerve injury is trauma, which is either a penetrating injury at the line of its course or fracture of the upper part of fibula, and sometimes due to iatrogenic injury during orthopedic surgery. The disability of the patient includes loss of dorsiflexion, ankle eversion, and toes extension. During normal walking, the heel strikes the ground, so normally, the ankle remains in slight extension or natural position, and in the swing phase, an active extrusion of toes and ankle up to the ground, but in Foot Drop during heel strike, the patient slaps his foot on the ground and in the swing phase the patient drags it along the ground, so compensatory, the patient flexes hip more than the normal to lift the entire foot off the ground, i.e. the stepping gait. The target of our technique is to restore the dynamic dorsiflexion of the foot and normal toe-heel gait. There are various procedures and techniques used to correct Foot Drop; among them, tendon transfer is tendon or tendon-to-bone transfer. **The Aim of the Study:** In our study, we transferred the Posterior Tibialis Tendon to both the Middle Cuneiform bone and the Anterior Tibialis Tendon as an alternative technique for managing Foot Drop. The aim of this study is to compare the functional outcomes of Posterior Tibialis Tendon transfer to these two sites, using the criteria described by Carayon *et al.* **Patients & Methods:** The present study is prospective study conducted in the Department of Plastic and Reconstruction Surgery at Al-Wahda Teaching Hospital, Thamar-University, and the Plastic Surgery Department in the 48 Model Hospital. The patients included thirty patients from May 2015 to May 2024. All the patients were male, and their ages ranged from fifteen to forty years old. The patients were classified according to the techniques used for reconstruction into the following groups: Group (1): Transfer of Posterior Tibialis Tendon to Anterior Tibialis Tendon and Flexor Hallucis Longus Tendon by dividing the Posterior Tibialis Tendon longitudinal and tying by Pulvertaft weave method by non-absorbable suture. Group (2): The technique used for reconstruction of Foot Drop in this group is the transfer of Posterior Tibialis Tendon to the 2nd Metatarsal bone by tying the tendon around the Metatarsal bone. Group (3): The Posterior Tibialis Tendon is inserted into the Middle Cuneiform bone by making a hole in the superior surface of the Cuneiform bone to the planter surface of the foot and tied by Prolen or Ethicon in the planter side of the same bone (tendinosis). The tendon elongation by tendon graft from the Plantaris muscle tendon or Palmaris Longus Tendon. The other side is inserted into both the Posterior Tibialis Tendon and Flexor Hallucis Longus. **Results:** The final record after post-operative follow-up for 24 months, we have noted that: In group (1), the results were excellent in two cases (20%), good in three cases (30%), moderate in two cases (20%), and finally poor results in two cases (20%). In the same group, two cases were complicated by surgical site infection and treated with antibiotic and observation, and the infection subsided. Regarding patient satisfaction, there were five cases out of ten patients (50%) who were unsatisfied, and all five cases underwent reoperation after one year by another technique. For group (2), after 24 months of follow-up, post-operatively, the majority of patients in group (2) were excellent and good according to the Carayon scale. Six patients out of ten had excellent results (60%). Also, there were two cases out of ten (20%) with good functional outcomes, only one patient out of ten patients had a moderate functional outcome (10%), and one case out of ten patients with poor outcomes (10%). Regarding post-operative infection of the same group, there was only one case complicated by surgical site infection. Eighteen cases out of ten patients were satisfied (80%). Regarding re-operation, there were two patients out of ten patients (20%), redo the operation after two years. In group (3), there were seven patients out of ten patients with excellent results (70%). Also, there were two cases out of ten patients (20%) with good functional outcomes, no cases in moderate (0%), and one case had poor results (10%). There was only one case complicated by post-operative infection which was a surgical infection at the site of connection of the Posterior Tibialis Tendon with Anterior Tibialis and Flexor Hallucis Tendon, which we managed by debridement and redo the operation after six months by the same technique. **Conclusion:** In our study, group 3, most of the patients had excellent results (70%), and combination tendon to tendon and tendon to the bone have an advantage over the other techniques with a lower complication rate, such as the durability of restoring the function of dorsiflexion of the ankle and never recurrent, and also no need for further use of a splint with a good balanced foot. In the third group, all the patients were satisfied, and all the patients followed up for more than two years with excellent function outcomes with no drawbacks and only one case needed to re-operation in all the three groups.

Keywords: Tendon transfer; Tendon to tendon transfer; Tendon to bone transfer; Combination technique to bone and tendon; Foot Drop.

1. Introduction

Injury to the Common Peroneal Nerve leads to Foot Drop and make disability in gait of the patient. The common cause of Common Peroneal Nerve palsy is trauma, which either penetrating injury at the line of its

course or fracture of upper part of fibula, and sometimes due to iatrogenic injury during orthopedic surgery [1]. The disability of patients includes loss of dorsiflexion, ankle eversion, and toes "extension" [2]. The success rate of nerve repair has increased with recent advances in microsurgery, but in our country, there is a lack of facilities, low experiences in

microsurgical surgery and most patients presented in our hospital with permanent Foot Drop [3].

During normal walking, the heel strikes in the ground, the ankle remains in slight extension or natural position, and in swing phase, an active extrusion of toes and ankle in up to the ground [1]. But in Foot Drop, during heel strike, the patient slaps his foot on the ground, and in the swing phase he drags it along the ground [3]. In compensatory, the patient flexes his hip more than normal to lift the entire foot off the ground, i.e., the stepping gait [1]. Most authorities prescribe the use of an ankle-foot splint to prevent plantar flexion more than the natural as a temporary solution and conservative management [1]. The target of our technique is to restore the dynamic dorsiflexion of the foot and normal toe-heel gait. Various procedures and techniques have been used to correct Foot Drop. Tendon transfer is the most commonly performed procedure with its different dorsal attachment sites on the foot, i.e., tendon-to-tendon or tendon-to-bone transfer.

The aim of most authoritative studies is to reconstruct the dynamic Foot Drop of patients and restore the normal toe-heel gait [1,3]. The options for restoring a normal toes heel gait are available including tenodesis, arthrodesis and tendon transfer [4]. Dynamic tendon transfer is considered the golden standard [5], but other methods such as arthrodesis, are considered static [4]. Tendon transfer restores the dorsiflexion of the foot and allows near-normal functional activity and prevents the equinovarus deformity caused by Tibialis Posteriors Tendon [6].

2. Aim of the Study

The aim of our study was comparative study of the functional outcome of Posterior Tibialis Tendon transfer to both Middle Cuneiform bone and Anterior Tibialis Tendon as an alternative to the other techniques for management of foot drop by using the criteria described by Carayon *et al.* [7].

3. Patients and Methods

A prospective study was conducted at the Department of Plastic and Reconstruction Surgery, Al-Wahda Teaching Hospital, Tamar University, and Plastic Surgery Department in 48 Model Hospital. The patients included thirty patients from May 2015 to May 2024. All the patients are male, ranging from fifteen to forty years old.

3.1 Carayon Scale

Table 1: Carayon Scale [7].

	Excellent	Good	Moderate	Poor
Active Dorsiflexion	>15	5 – 15	No Active dorsiflexion	The presence of planter flexion that prevents ankle motion, minimal dorsiflexion
Active Plantar Flexion	>30	15 – 20	Drop Foot Totally Corrected	
Active Rom	>40	20 - 30	Plantar Flexion is Possible up to 10 degrees	

3.2 Surgical Techniques

We are using three different attachment sites for Tibialis Posterior Tendon in the dorsum of the foot. The first one is the transfer of the Posterior Tibialis Tendon to the Tibialis Anterior Tendon and Flexor Hallucis Longus-Tendons. The second technique is to transfer the Posterior Tibialis Tendon to the 2nd Metatarsal bone, which we looped the Posterior Tibialis Tendon around the 2nd Metatarsal " a modification of classic Barr's procedure [8]. The third attachment sites is a new technique in which we are combination of transfer and insertion of the Posterior Tibialis Tendon to the Middle Cuneiform bone and to Anterior Tibialis Tendon with Flexor Hallucis Longus Tendon, which we split the Posterior Tibialis Tendon longitudinal into two halves, the first half is inserted into Middle Cuneiform bone and the second

half is inserted through the Anterior Tibialis Tendon and Flexor Hallucis Longus Tendons.

Due to the insertion point of the Posterior Tibialis and its axis, any tension on this tendon results in dorsiflexion and also inversion. In our technique, to prevent this drawback, we split the tendon longitudinally into two parts. One half is sutured to the Middle Cuneiform bone, and the other half is passed through the Anterior Tibialis Tendon and Extensor Hallucis Longus Tendon by using a tendon graft. The route of tendon transfer is intraosseous, and the fixation site at the foot of dorsum such as tendon to tendon or tendon to bone which is still debatable in most of literature [3, 5]. And also tendon Achilles elongation is performed to increase the range of dorsiflexion [5]. The patients were classified according to the techniques used for reconstruction into the following groups:

Group (1): Transfer of Posterior Tibialis Tendon to Anterior Tibialis Tendon and Flexor Hallucis Longus Tendon by dividing the Posterior Tibialis Tendon longitudinally and tying by the Pulvertaft weave method by non-absorbable suture.

Group (2): In this group, the technique used for reconstruction of Foot Drop is transfer of Posterior Tibialis Tendon to 2nd Metatarsal bone by tying the tendon around the Metatarsal bone. The Posterior Tibialis Tendon transfers through the intraosseous route. When the Posterior Tibialis Tendon is brought to lateral side the leg through the intraosseous, lengthening of Posterior Tibialis Tendon is necessary to overcome the insufficient length and finally the tendon is denuded circumferentially around the 2nd Metatarsal.

Group (3): In this group, the Posterior Tibialis Tendon is inserted into the Middle Cuneiform bone by making a hole in the superior surface of the Cuneiform bone to the planter surface of the foot and tied by Prolene or Ethicon in the planter side of the same bone (tendinosis). The tendon elongation is done by tendon grafting from the Plantaris muscle tendon or Palmaris Longus Tendon.

In all the groups of patients, the route of Posterior Tibialis Tendon passes through the intraosseous route to reach to the dorsum of foot, then subcutaneous route in the dorsum of foot. All the patients' groups underwent tendon Achilles lengthening by Z-plasty.

3.3 Post - Operative Follow Up

In all the patients in the three groups, the ankle was kept at full dorsiflexion at the time of fixation by below-knee splinting for six weeks postoperatively. In all patients' groups, active dorsiflexion was initiated after six weeks and light weight bearing on the operated limb within the splint during the next six weeks. By the end of 12 weeks duration, the splint or cast was removed and replaced by an artificial cast gradual weight bearing is now allowed. Preoperative and post-operative passive and active range of motion should be assessed using the criteria of the scoring scale of Carayon *et al.* In each case, the following were fulfilled:

- Complete history.
- Complete medical examination.
- Preoperative active and passive motion of the affected limb.
- Post-operative active and passive limb.
- Preoperative and postoperative photography.
- Follow up for 6 months, 18 months, and two years.

4. Results

In each case, the following parameters were fulfilled:

- 1- preoperative passive and action motion according to the Carayon criteria scale.
- 2- Post-operative infection.
- 3- Post-operative recurrent Foot Drop.
- 4- Patients' satisfaction.

A total of thirty patients were included in our study. All the patients were male, and they were divided into three groups according to the technique used for the reconstruction of the Foot Drop.

Group (1): Ten patients underwent surgery by transferring and fixing the Posterior Tibialis Tendon to the Anterior Tibialis Tendon and Flexor Hallucis Longus Tendon, as listed in Table 2.

Group (2): Ten patients underwent surgery by transferring the Posterior Tibialis Tendon and fixed to 2nd Metatarsal bone (see Table 3).

Group (3): Ten patients underwent surgery by transferring the Posterior Tibialis Tendon to the Cuneiform bone and to the Anterior Tibialis Tendon and Flexor Hallucis Longus Tendon by using a tendon graft (see Table 4).

All the patients were male. At six months post-operatively, the majority of patients in group 2 and group 3 showed excellent to good

results according to Carayon scale described by Garayon *et al.* [7]. However, the patients in group one less than the other groups. The final recorded after post-operative follow up for 18 months, it was noted that, in **Group (1)**, the results were excellent in two case (20%), good in three cases (30%), moderate in 2 cases (20%), and finally poor results in two cases (20%). In the same group, there are two cases complicated by surgical site infection and treated by antibiotics and observation, and the infection subsides. Regarding patient satisfaction, there were 5 cases out of ten patients (50%) who were unsatisfied, and all five cases underwent reoperation after one year by another technique, as shown in Figure 1.

Table 2: Ten patients underwent surgery by transferring and fixing the Posterior Tibialis Tendon to Anterior Tibialis Tendon and Flexor Hallucis Longus Tendon.

No	Carayon Scale				Infection	Patient Satisfaction	Re-operation
	Excellent	Good	Moderate	Poor			
1	+					+	-
2	-	+				+	-
3	-		+		+	-	+
4	-	+				+	-
5	-	-	+			-	+
6	+					+	-
7	-	+				+	-
8	-		-	+	+	-	+
9	-		-	+		-	+
10	-			+		-	+

Table 3: Ten patients underwent surgery by transferring the Posterior Tibialis Tendon and fixing to 2nd Metatarsal bone.

No	Carayon Scale				Infection	Patient Satisfaction	Re-operation
	Excellent	Good	Moderate	Poor			
1	+			-	-	+	-
2	+			+	-	+	-
3			+	-	+	+	+
4	+			-	-	+	-
5	-	+		-	-	+	-
6	+			-	-	+	-
7		+		-	-	+	-
8	+			-	-	+	-
9	+			-	-	+	-
10	-	-	-	+	-	-	+

Table 4: Ten patients underwent surgery by transferring the Posterior Tibialis Tendon to both the Cuneiform bone and to the Anterior Tibialis Tendon and Flexor Hallucis Longus Tendon by using a tendon graft.

No	Carayon Scale				Infection	Patient Satisfaction	Re-operation
	Excellent	Good	Moderate	Poor			
1	+		-	-	-	+	-
2	+		-	-	-	+	-
3		+	-	-	-	+	-
4	+		-	-	-	+	-
5	+		-	-	-	+	-
6		+	-	-	-	+	-
7	+		-	-	-	+	-
8			-	+	+		+
9	+		-	-	+	+	-
10	+		-	-	-	+	-



Figure 1: The pre-operative cases (A and B) and post-operative cases (C) of the same case used the technique in Group (1).

Group (2): After 24 months follow up, post-operatively, the majority of patients in group 2 were excellent and good according to the scale of Carayon. Six patients out of ten with excellent results (60%). Also, two cases out of ten (20%) had a good functional outcome, and finally, only one patient out of ten patients had a moderate functional outcome (10%), and one case out of ten patients had a poor outcome (10%). Regarding the post-operative infection of the same group, there is only one case complicated by surgical site infection. There were eight cases out of ten patients who were satisfied (80%). Regarding re-operation, there were two patients out of ten patients (20%) after two years as shown in Figure 2.

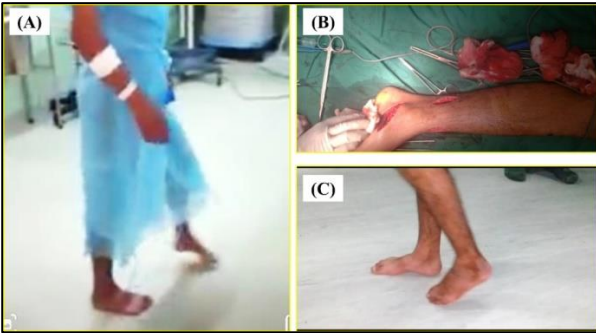


Figure 2: The pre-operative cases (A and B) and post-operative cases of the same case (C) used the technique in Group (2).

Group (3): Seven patients out of ten had excellent results (70%). Also, there were two cases out of ten (20 %) with a good functional outcome, zero cases in moderate [0%], and one case with poor results (10%). Only one case was complicated by post-operative infection, which was a surgical infection at the site of connection of the Posterior Tibialis Tendon with the Anterior Tibialis and Flexor Hallucis Tendon. This was managed by debridement and redo the operation after two years by the same technique as shown in Figure 3.



Figure 3: The pre-operative case (A) and post-operative case of the same case (B) used the technique in Group (3).

5. Discussion

The traumatic injury of the Common Peroneal Nerve remains the most common cause of Foot Drop, as it is more prone to trauma due to its location [1]. Some patients use the ankle-foot brace to prevent the drop foot, but most patients can't tolerate it. The surgical option for the management of patients with Foot Drops is tendon transfer, because it provides dynamic correction of Foot Drop and restores a normal toe-heel gait. Some patients undergo a static operation such as ankle arthrodesis. The repair of the Common Peroneal Nerve by microscopic surgery is very important when the patients present early and facilitation such as equipment was available from a good, experienced surgeon. However, most patients were presented in the late stages with permanent and irreversible nerve repair [9]. Tibialis Posterior Tendon transfer is the gold standard in the management of Foot Drop. Multiple sites insertion of the Tibialis Posterior Tendon on the dorsum of the foot.

In our study, we used three techniques for the insertion of the Posterior Tibialis Tendon. In the 1st group of patients, we used the Posterior Tibialis Tendon transfer and insertion to the Anterior Tibialis Tendon and the Flexor Hallucis Longus Tendon. In the 2nd group, we used the Posterior Tibialis Tendon transfer and insertion to the 2nd Metatarsal bone as we looped the tendon around the second Metatarsal bone. For the 3rd group of patients, we used the Posterior Tibialis Tendon transfer and insertion to the Middle Cuneiform bone, and the other half of the Posterior Tibialis Tendon was inserted into the Anterior Tibialis Tendon, and the Flexor Hallucis Longus Tendon.

The post-operative results of all three techniques were evaluated within six weeks and two years according to the Carayon Scoring Scale. A total of 30 patients were evaluated for 6 months and two years for all the patient groups. At six months postoperatively, the results of all the groups were similar, with approximately 90% of patients having excellent and good results. After one year, significant differences in dorsiflexion were noted between the three groups, and the most deteriorated outcomes occurred in group 1. This agrees with most authorities [5,10].

In group 1, Posterior Tibialis Tendon insertion to the Anterior Tibialis Tendon, most patients return to wearing ankle foot supporting casts, with low success of long duration, as we agree with Watkins *et al.* [10] and Hove and Nilsen [11]. The authorities Ober [12], Hove & Nilsen [11], and Krishnamurthy [13] tried to prove that Posterior Tibialis Tendon is enough for restoration of dorsiflexion, the drawback of this study is that the Posterior Tibialis Tendon pulled with time and highly recurrent with a poor balance of foot and some patients were complicated by rupture of Posterior Tibialis Tendon. In our results with the same technique in group 1, there were only two cases out of ten patients with excellent results and the recurrent rate, after two years, was very high, with up to 50% of patients undergoing redoing the operation by other technique.

Watlani *et al.* [10], Codivilla [17], and Mayer [1] mentioned that the results of transfer the Posterior Tibialis Tendon to 2nd Metatarsal bone with excellent results in more than 80% of patients. They were the pioneers of the Posterior Tibialis Tendon transfer to dorsum of the foot through the intraosseous and then looping around the 2nd Metatarsal shaft. The procedure was augmented by lengthening of Posterior Tibialis Tendon to reach the 2nd Metatarsal bone [12,16,17]. Compared to our results with the same surgical technique in group 2, 60% of patients had excellent results, which is near the outcome of Watlani *et al.* [10]. All the differences in 20% of patients may be due to poor patient education regarding follow-up and poor obedience to the command. The drawback of this technique is an imbalance between varus and valgus, and there's two cases unsatisfied with gait, and most of patients wearing below knee splint assistant.

In the current study (the group 3), the most of patients with excellent results 70% and combination tendon to tendon and tendon to bone have advantages over the other techniques with less complication rate such as the durability of restoring the function of dorsiflexion of the ankle and never recurrent, and also no need for further use of splint, with good balanced foot. Also, in group 3, all the patients were satisfied and all the patients followed up for more than two years with excellent function out come with no draw back and no need to re-operation only in one case of patients in group 3. This is in good agreement with Ober and his coworkers [12,14,18], which they mentioned that the technique using combination insertion sites of bone and tendon are important for

equilibrium and avoid the varus or valgus in groups 1 and 2 with a lower complication rate.

In our study, we achieved functional restoration, by transferring both tendon and bone. The only disadvantage was the multiple scars on the foot and the long operation time. Also, we modified the tendon transfer to the bone by inserting the Posterior Tibialis Tendon to bone and the tendon as combination techniques to reach the excellent results, durability and restore the Foot Drop permanently with good balance gait. This modification in our study (in group 3) to overcome the disadvantage the previous procedures in groups 1 and 2.

6. Conclusion

In our study, group 3, most of the patients had excellent results (70%), and the combination of tendon to bone and tendon and tendon which have advantages over the other techniques, with lower complication rates such as durability, restoring the function of dorsiflexion of the ankle and never recurrent, and also no need for further use of a splint with good balanced foot. In the third group all the patients were satisfied, and all the patients followed up for more than two years with excellent function outcomes with no draw-back and only one patient underwent re-operation in all the group 3.

Human ethics

Consent was obtained by all the participants in our study by the ethical review committee.

Data Availability

The datasets used and analyzed during the current study are available from the corresponding author upon reasonable request.

Conflict of Interest

The authors declare no conflict of interest.

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