

Tendon Transfers in Traumatic Foot

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A clinical review was performed of 11 cases of traumatic foot treated by tendon transfer. Among 11 patients, there were eight males and three females, ranging from four to 36 years of age. The anterior tibial tendon was used in six cases for tendon transfer and among these, split anterior tibial tendon was used in three cases in children. The posterior tibial tendon was used in two cases and the extensor digitorum longus tendon of the foot was in three cases.

In six cases of soft tissue injury where tendon transfer was impossible, microvascular free cutaneous flap transplantation was combined with the tendon transfer. Follow-up results were obtained from 25 months to nine years.

Excellent results were obtained in eight cases and satisfactory results in three cases. For the correction of function loss in traumatic foot, tendon transfers were a useful method for the recovery of active motion of the foot.

For the restoration of function loss in the traumatic foot, there are several methods of treatment such as tendon transfer, arthrodesis and tenodesis, but for recovery of the active motion of the foot, tendon transfer is the only useful method.

Key Words: Tendon transfer, traumatic foot

Among 11 patients, there were eight males and three females, and the mean age was 12 years, ranging from four to 36 years of age. The right foot was operated on in seven cases and the left foot in four cases.

Preoperative deformities of the foot were equinovarus in two cases, varus in six cases, and drop toe in five cases. The causes of the deformity were peroneal nerve palsy in five cases, peroneal muscle injury three cases, and extensor hallucis longus muscle injury in three cases.

In six cases where tendon transfer was impossible or postoperative adhesion was a problem due to the extensive soft tissue damage of the foot, a microvascular free cutaneous flap transplantation was combined with the tendon transfer.

Tendon transfer was performed at an average of 3.7 years, ranging from four months to 30 years, after the trauma. Follow-up results were obtained for an average of 3.5 years ranging from 25 months to nine years after the operation.

OPERATIVE PROCEDURES

The anterior tibial tendon was used in six cases, and among these, the technique of splitting the anterior tibial tendon was used in three cases. The posterior tibial tendon was used in the two cases and the extensor digitorum longus tendon of the foot in three cases. In the two cases of equinovarus deformity, the tendon of the tibialis posterior was exposed and divided at the insertion site, then rerouted through the tibiofibular interosseous membrane, subcutaneously to the dorsum of the foot, and attached to the third cuneiform bone.

In the six cases of varus deformity, the split anterior tibial tendon was used in the three cases whose muscle power was normal. The lateral half of the anterior tibial tendon was divided at the insertion site, then rerouted through the subcutaneous tissue

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and attached to the cuboid bone. In another three cases whose muscle power was good, the entire tendon of the tibialis anterior was divided at the insertion site, then rerouted through the subcutaneous tissue and attached to the third cuneiform bone.

In the three cases of great toe drop, the extensor digitorum longus tendon of the second toe was cut at the level of the extensor hallucis longus tendon injury, then a tendon-tendon attachment was performed between the distal end of the severed extensor digitorum longus tendon of the second toe and the ruptured distal stump of the extensor hallucis longus tendon. Extension of the second toe was not impaired due to the action of the short extensor instead of the severed long extensor.

Insertion sites of tendon transfer were the third cuneiform bone in five cases, the cuboid bone in three cases and tendon suture in three cases. There were two methods of bony attachment of tendon transfer.

One method was tendon attachment to a slit on the bone, and covering by the surrounding periosteum and joint capsule, which was used in five cases.

In another method, the Bunnel sutured tendon was inserted in the hole of the inserting bone, then extended to the sole and fixed with a button, and a pull-out wire was attached to the dorsum of the foot. This method was used in three cases (Table 1). The tension of the bone or tendon attachment of the tendon transfers was a little tighter in the position of knee flexion and provided enough dorsiflexion of the ankle.

The combined operation involved a microvascular free cutaneous flap transplantation due to the extensive soft tissue damage in six cases: two cases

among these were operated on three and four months previous to the tendon transfer respectively, and the free flap transplantation was combined with four cases when surgery was done simultaneously. Of the two cases of dropped great toe, a modified Jones operation was combined in the one case and tenodesis in the other case. In one case of severe contracture of the Achilles tendon, lengthening of the Achilles tendon was combined.

In the cases of joint stiffness, preoperative physical therapy was performed for as much recovery of the passive motion of the ankle and foot joints as possible.

A slightly overcorrected position was maintained postoperatively in a short or long leg plaster cast for six weeks in cases of bone attachment, or for three weeks in tendon-tendon attachment, the range of the motion was gradually established.

RESULTS

For evaluating of the results, the Srinivasan method was adopted the active dorsiflexion angle, range of motion of the ankle, and great toe. The total score was calculated by adding subjective feeling, walking ability, correction of the deformity and muscle power.

The active dorsiflexion of the joint was evaluated as grade 1 in cases of over 0 degree, grade 2 in cases with neutral position, and grade 3 in cases below the neutral position. The active range of motion of the joint was grade 1 in cases of over 25 degrees, grade 2 in cases of 10-25 degrees, and grade 3 in cases below 10 degrees. The angle was checked at a position of 90 degrees flexion of the knee with the foot at a freely dropped position. Table 2 shows the grades of active dorsiflexion and active range of motion, 9 cases belonged to grade 1 and 2 cases belonged to grade 2.

Table 1. Operative procedures

1. Tendon Used
a. Tibialis anterior
-Split: 3 cases
-Total: 3 cases
2. Insertion Site
a. Lateral cuneiform; 5 cases
b. Cuboid: 3 cases
c. Tendon: 3 cases
3. Insertion Method
a. Tendon to bone suture: 5 cases
b. Pull-out wire fixation: 3 cases
c. Tendon to tendon suture: 3 cases

Table 2. Grading of tendon transfer

Criterion for grading	Grade			Total
	1	2	3	
	No. of feet			
Active dorsiflexion angle	9	2	0	11
Range of active movement	9	2	0	11

Table 3. Correlation between active dorsiflexion and range of movement

Active movement grade	Active dorsiflexion grade			Total
	1	2	3	
	No. of feet			
1	8	1	0	9
2	1	1	0	2
3	0	0	0	0
Total	9	2	0	11

Table 4. Results of tendon transfer

Results	Cases
Excellent	8
Good	3
Poor	0
Total	11

As shown in the table 3, the relationship between the active dorsiflexion and active range of motion, and eight cases belonged to grade 1 in both categories.

Table 4 shows the total score of the subjective feeling, walking ability, correction of the deformity and muscle power. Excellent results were recorded in eight cases where more than three indices were acceptable and which also belonged to grade 1 according to active dorsiflexion and active range of motion. Good results were obtained in the three cases where two indices were acceptable. Of these, two cases showed decreased active dorsiflexion and range of motion due to postoperative adhesion and in one case which the posterior tibial tendon was used, there was a slight valgus deformity and limping.

All three cases of split anterior tibial tendon transfer showed excellent results and all six cases of microsurgical free vascularized flap transplantation combined with tendon transfer also showed excellent results (Table 5).

Postoperative complication were seen in two cases. One of these was a wound infection which soon healed and showed good results. The other was a case of detachment of the transferred tendon which was noted on the seventh postoperative day and was corrected by reoperation for inforcement

of the insertion site. Although this case called for a serond operation, the results were excellent.

DISCUSSION

In contrast of arthrodesis of the traumatic foot which more or less restricts the motion of the joint, tendon transfer has the advantage of giving excellent motion of the joint and walking ability.

Preoperative considerations in tendon transfers are the character and severity of deformities, cause and site of the injury, motion of the neighboring joints, selection of the transferred tendon, gliding route and insertion site, stability of the joint and adhesion after the operation.

Tendon transfers of the posterior tibial tendon to the dorsum of the foot were divided into two methods according to the gliding route; One was a circumtibial route which was simple but caused adduction with a in-toe-gait tendency and was cosmetically not satisfactory (Lim *et al.* 1972; Lipscomb *et al.* 1961), and the other was an interosseous route which had a slight adduction tendency in one case (Gun *et al.* 1957; Ihn *et al.* 1970; Warren, 1968; Watkins *et al.* 1954; Williams, 1976).

Postoperative conversion from the stance phase to the swing phase was imperative in tendon transfers of the posterior tibial tendon, and the majority of the patients did well subjectively but not in the rhythmic motion of walking (Bisla *et al.* 1976; Close *et al.* 1959; Peny *et al.* 1977). So reeducation was necessary for conversion of the posterior tibial tendon of the swing phase.

In the case of the varus deformity of the hindfoot, the anterior tibial tendon was used. Of these, the anterior tibial tendon in cases of normal muscle power was attached to the line of the fourth metatarsal bone. The anterior tibial tendon in cases of good muscle power was attached to the line of the second or third metatarsal bone (Hoffer *et al.* 1974). We used the split anterior tibial tendon in three cases of normal muscle power of the anterior tibial muscle and obtained excellent results and stability of the foot in all cases.

The results of tendon to bone (Clawson *et al.* 1970; Gunn *et al.* 1957; Watkins *et al.* 1954) and tendon to tendon attachments (Caryon *et al.* 1967; Srinivasan *et al.* 1968; Warren, 1968) were not comparable in this study because the tendon to tendon attachment was used only in the cases of extensor hallucis longus injury. In the method of tendon to bone attachment, pull-out wire fixation

Table 5. Patient presentation

Case number	Sex	Age (yrs)	Interval between trauma & op.	Deformity	Cause	Used tendon	Insertion site	combined operation	Results
1	M	7	4M	Dropped Great Toe	EHL Rupture	EDL	EHL		Good
2	M	9	7M	Dropped Great Toe	EHL Rupture	EDL	EHL	FCFT (3M before)	Excellent
3	M	36	30Y	Varus	PNP	TA	Lateral Cuneiform		Good
4	M	5	2Y	Varus	PNP	TA	Lateral Cuneiform	Modified Jones Op.	Excellent (Infection)
5	M	18	1Y	Equinovarus	PNP	TP	Lateral Cuneiform		Good
6	M	31	9M	Varus	PNP	TA	Lateral Cuneiform		Excellent
7	F	5	1Y	Equinovarus	PNP	TP	Lateral Cuneiform	FCFT, Heel Cord OP	Excellent (Reop.)
8	F	4	4M	Varus	PTI	STA	Cuboid	FCFT (4M before)	Excellent
9	M	6	1Y	Varus	PTI	STA	Cuboid	FCFT	Excellent
10	M	6	33M	Varus	PTI	STA	Cuboid	FCFT	Excellent
11	F	4	5M	Dropped Great Toe	EHL Rupture	EDL	EHL	Tenodesis FCFT	Excellent

EDL; Extensor digitorum longus, EHL; Extensor hallucis, TA; Tibialis anterior
 STA; Split tibialis anterior, TP; Tibialis posterior, PNP; Peroneal nerve palsy,
 FCFT; Free cutaneous flap transplantation, PTI; Peroneal tendon injury.

was used in three cases: of these, one case was reoperated due to rupture of the suture material on the sole on the seventh postoperative day.

In the case where extensive soft tissue injury was combined with function loss in the hand, microvascular free tendocutaneous flap transplantation from the foot would be used for recovery of the function (Kim *et al.* 1982), but the above procedure was impossible in the foot due to the unavailability of donors. Therefore microvascular free cutaneous flap transplantation combined with tendon transfer was a useful method in extensive soft tissue injury of the foot for the removal of scar contracture and prevention of postoperative adhesion.

CONCLUSIONS

1. For the recovery of function loss in the traumatic foot, tendon transfers were a useful method for the recovery of active motion of the foot.

2. For the correction of varus deformity of the hindfoot, split anterior tibial tendon transfer was an effective method in children with normal muscle power.

3. In the cases of extensive soft tissue injury where tendon transfers were impossible, microvascular free cutaneous flap transplantation combined with tendon transfer could improve the function of the foot.

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