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Early postoperative active mobilisation versus immobilisation following tibialis posterior tendon transfer for foot-drop correction in patients with Hansen's disease

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Summary After tibialis posterior tendon transfer surgery for foot-drop correction, the foot is traditionally immobilised for several weeks. To test the feasibility of early mobilisation after this procedure in patients with Hansen's disease, 21 consecutive patients received active mobilisation of the transfer starting on the 5th postoperative day. Transfer insertion strength was enhanced by Pulvertaft weave. The results were compared with a historical cohort of 21 patients receiving 4 weeks of immobilisation. The primary outcomes were active dorsiflexion, active plantar flexion and total active motion at the ankle, tendon-insertion pullout and time until discharge from rehabilitation with independent walking without aid. Assessments at discharge from rehabilitation and the last clinical follow-up at more than 1 year were compared between both groups. The Student's *t*-test was used to compare data between the groups, and 95% confidence interval of the difference between groups was determined. A *p*-value of 0.05 was considered statistically significant. The average follow-up was 22 months for both groups. There was no incidence of insertion pullout of the tendon transfer in either group. In addition, there was no difference in active dorsiflexion angle between the groups at discharge (mean difference: 2.2°, $p = 0.22$) and final assessment (mean difference: 2.3°, $p = 0.42$). The plantar flexion angles were similar in both groups at discharge (mean difference: 0.5°, $p = 0.86$) and final assessment (mean difference: 0.5°, $p = 0.57$). In addition, there was no difference in total active motion between the groups at discharge (mean difference: 2°, $p = 0.54$) and final assessment (mean difference: 1°, $p = 0.49$). The patients were discharged from rehabilitation with independent walking at 44.04 ± 7.9 days after surgery in the mobilisation group compared to 57.07 ± 2.3 days in the immobilisation group. This

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indicates a significant difference in morbidity (mean difference: 13 days, $p < 0.001$) between the two groups. In summary, this feasibility study indicates that early active mobilisation of tibialis posterior transfer in patients with Hansen's disease is safe and has similar outcomes to immobilisation with a reduced time to independent walking, warranting the design of a controlled clinical trial to further substantiate this.

Foot-drop deformity is common in Hansen's disease and is often associated with compromised plantar sensation. Ankle—foot orthosis (AFO) is often used to treat foot-drop deformity in peripheral nerve injuries and intervertebral disc prolapse but has limited use for foot-drop in Hansen's disease as majority of patients in endemic countries are manual or agriculture workers habituated to bare-feet walking. Anterior transfer of the tibialis posterior tendon, therefore, is often used for foot-drop correction as this allows walking without an orthosis. Patient education for care of the anaesthetic foot along with tendon transfer provides appropriate care and rehabilitation for irreversible common peroneal nerve neuritis in Hansen's disease.

Three to four weeks of postoperative immobilisation of a tibialis posterior transfer is the conventional practice.[1—7] The morbidity for foot-drop correction with tibialis posterior transfer then extends to 8—10 weeks.[5,7] We recently demonstrated the advantages of early postoperative active mobilisation following thumb opposition transfer[8] and claw deformity correction.[9] The same concept may also be applicable in tendon transfer for foot-drop correction, although forces at the transfer insertion are higher in this situation. Increasing the strength of insertion by a Pulvertaft weave[10] enabled active tendon-transfer mobilisation.

In this study, we present data from a prospective trial on early active mobilisation after tibialis posterior transfer for foot-drop correction (mobilisation group). Results of the mobilisation group were compared with a retrospective cohort of similar transfers followed by the standard protocol of immobilisation in a cast for 4 weeks (immobilisation group). The purpose of the study was to assess the safety of early active mobilisation for tibialis posterior transfer by an objective method to identify transfer insertion pullout and compare the results with immobilisation of the transfer.

Material and methods

In the prospective trial, 21 consecutive foot-drop deformities (Figure 1a) in patients with Hansen's disease operated by the first author from June 2004 to May 2005 were included in the study. The inclusion criteria for the study were irreversible common peroneal nerve paralysis of more than 1 year and completion of multi-drug therapy for treatment of Hansen's disease. The exclusion criteria were clawed toes requiring additional surgery, neuropathic changes, bone fracture, bone absorption in the foot and active plantar ulcers.

After foot-drop correction using anterior transfer of the tibialis posterior tendon, patients in the mobilisation group received early active mobilisation from the 5th postoperative day. Historical records of 81 tibialis posterior transfers with conventional 4 weeks of immobilisation operated by the first author prior to the trial were reviewed. Data from 21 patients with inclusion criteria similar to the mobilisation group and follow-up of more than 1 year were used for the immobilisation group. The first author operated on all patients at the same institution. The two groups are comparable in relation to age, gender and duration of paralysis (Table 1). Each patient in the mobilisation group was explained the proposed change in the postoperative protocol and informed consent was obtained. Institutional review committee approval was obtained for the trial.

Surgical procedure

Patients were operated under anaesthesia using wide local infiltration of 1% lidocaine with 1:10 000 adrenaline and without the use of a tourniquet. The surgical technique for both groups is similar to that described by Srinivasan et al.,[2] except for the technique of insertion. The tibialis posterior tendon was detached from its insertion to the navicular bone, retrieved in the lower leg and split in the middle up to the musculotendinous junction into an anterior and posterior part. Each slip was then transferred to the foot separately along the circum tibial route passing anterior to the ankle and superficial to the extensor retinaculum. Closed tendoachilles lengthening was performed if passive ankle dorsiflexion was less than 20° with extended knee. The limb was put in a prefabricated splint that maintains the knee in 60° flexions and the ankle in 20° dorsiflexion to ensure standardisation of tendon-transfer tension. One slip of the transferred tendon was inserted into the tendons of extensor digitorum longus with maximum tension, and the second slip was inserted into extensor hallucis longus tendon in neutral tension. In the immobilisation group, the transfer slip was passed transversely once through the recipient tendon, sutured at the points of entry and exit with monofilament 2/0 nylon and finally tied distally to the recipient tendon. In the mobilisation group, the transfer was inserted using a Pulvertaft weave[10] to increase the strength of attachment. The points of entry and exit were sutured using 2/0 Ethibond (Johnson & Johnson).

For postoperative pain relief in the mobilisation group, the foot was supported by a below-knee posterior splint in full dorsiflexion. In the immobilisation group, a below-knee cast was applied in full dorsiflexion for 4 weeks. The patients in both groups were allowed non-weight-bearing crutch walking from the second postoperative day. A walking heel was applied to the cast in the immobilisation group, and the patients were allowed partial weight-bearing

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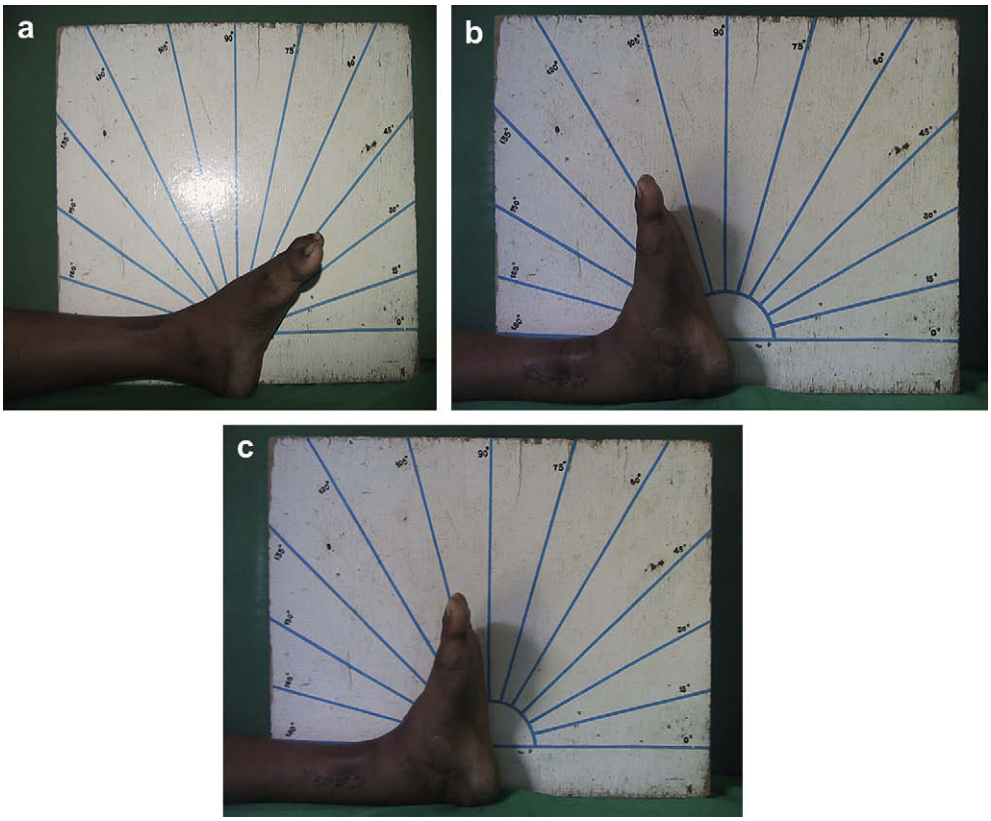

Figure 1 (a) Preoperative status of foot drop. Tibialis posterior transfer for foot-drop correction and early postoperative active mobilisation: postoperative status at discharge from rehabilitation (b) Active dorsiflexion (c) active plantar flexion.

with crutches from the 5th postoperative day. In the mobilisation group, the supporting slab was removed for therapy on the 5th postoperative day. The postoperative rehabilitation was institution-based and under supervision of a therapist trained specifically for the care of paralysed hands and feet.

Rehabilitation protocol

The rehabilitation therapy protocol was similar in both the groups, except that the therapy was started and the transfer was actively mobilised on the 5th postoperative day in the mobilisation group and at the beginning of the 5th postoperative week in the immobilisation group. As a result, the treatment protocol in the 2nd to 5th postoperative week in the mobilisation group corresponded with the 5th to 8th postoperative weeks in the immobilisation group. The therapy programme consists of once-a-day active dorsiflexion exercises in the 1st week of therapy (postoperative week 2 in the mobilisation group and week 5 in the immobilisation group), gentle active plantar flexion exercises in the 2nd week of therapy, partial weight bearing within parallel bars in the 3rd week of therapy, full weight bearing and gait training in the 4th week of therapy. The limb was supported after therapy in a posterior splint in full dorsiflexion for 3 weeks and thereafter only at night for 3 months. The patients in both groups were discharged from rehabilitation with good transfer contraction and independent walking without any aids. Unrestricted activities were allowed 3 months after discharge from rehabilitation. Clinical review was recommended once a month for 3 months; then every 3 months for a year, followed by once a year.

Table 1 Descriptive data for the early mobilisation and Immobilisation groups at baseline

Variables	Mobilisation	Immobilisation	*p* value
	$n = 21$	$n = 21$	
Age (years)	31.6 ± 11.7	36.7 ± 11.9	0.174
Gender (M;F)	17:4	20:1	—
Duration of paralysis (years)	4.6 ± 3.3	6.8 ± 4.4	0.070
Duration of follow-up (months)	22.2 ± 8.3	22.7 ± 8.0	0.831

Values are mean $\pm$ SD. The *p*-values indicates the significance level of the *t*-test comparing both groups.

Outcomes assessment

The primary goal of early active motion is to obtain an earlier discharge from rehabilitation with successful foot-drop correction. The main risk of early mobilisation is tendon-transfer rupture and insertion pullout. Therefore, primary outcome measurements are active ankle dorsiflexion angle of the foot beyond neutral, plantar flexion,

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total active motion of ankle from flexion to extension, incidence of transfer pullout and time until discharge from rehabilitation with independent walking.

The integrity of tendon-transfer insertion in the mobilisation group was monitored by measuring active dorsiflexion, plantar flexion and total active motion of the foot on daily basis for the first 2 weeks of therapy and then at the end of each week. A sudden or progressive reduction of dorsiflexion and total active motion would indicate rupture or impending insertion pullout. The ranges of motion measurements were recorded using a hand-held goniometer with the patient in a sitting position with the knee in 90° flexion.

Adverse effects of wound infection, transfer laxity, persisting foot-drop gait and inversion or eversion deformity were recorded. Morbidity was scored — defined as the time required from the day of surgery to discharge from rehabilitation with patient walking independently without any aids.

Data analysis

Outcomes of both groups were compared at discharge from rehabilitation (discharge assessment) and at the last clinical review (follow-up assessment). The Student's *t*-test was used to compare data between the groups and the 95% confidence intervals (CIs) of the difference between the groups were calculated. Statistical analysis was performed using SPSS software for Windows (version 12.0.1 SPSS, Chicago, IL, USA). A *p*-value of 0.05 was considered statistically significant.

To compare the results of the present study with published reports, the outcome measure introduced by Srinivasan et al.[2] was used, which also focusses on active dorsiflexion angle and total active motion of ankle between dorsiflexion and plantar flexion. In this measure, results are graded into three categories. For active dorsiflexion, the three different grades are:

Grade 1 (Good): active dorsiflexion beyond neutral,
Grade 2 (Fair): active dorsiflexion to neutral and
Grade 3 (Poor): unable to achieve active dorsiflexion to neutral.

For total active motion of ankle, the three different grades are:

Grade 1 (Good): total active motion equal to or more than 25°,
Grade 2 (Fair): 15°—20° and
Grade 3 (Poor): equal to or less than 10°.

Results

In each group, 21 patients were available for discharge assessment. Nineteen patients in the mobilisation group (Table 2) and 21 patients in the immobilisation group were available for follow-up assessment, with mean follow-up of 22.2 ± 8.3 and 22.7 ± 8.3 months, respectively. The reason for loss to follow-up in the mobilisation group was that one patient died of an unrelated cause 6 months after operation and the other could not be traced after the first follow-up review.

Table 2 Results of 19 patients with early active motion protocol at the last follow-up assessment

	Hosp. No	Age	Duration of palsy in years	Morbidity in days	Follow-up in months	Active Dorsiflexion in degrees
1	1939	25	1.6	42	36	25
2	1938	20	2	44	12	25
3	1935	36	2	44	13	20
4	1933	25	12	44	30	20
5	1941	50	2	41	12	25
6	1932	14	5	41	26	20
7	2014	45	4	40	31	15
8	2022	22	1	51	31	20
9	2011	46	8	38	24	20
10	2019	33	7	50	12	5
11	2015	35	1.6	53	22	20
12	2026	15	3	37	26	Nil
13	2030	25	5	37	26	12
14	1949	28	6	40	19	15
15	2037	20	1.6	40	12	10
16	1988	22	5	69	17	5
17	2016	39	3	39	31	30
18	2042	45	5	40	31	2
19	2049	45	1.6	57	30	20

The patients in both groups were able to actively dorsiflex the foot (Figure 1b) beyond neutral at discharge. At follow-up, one patient in each group lacked dorsiflexion beyond neutral. There was no difference in the active dorsiflexion angle, plantar flexion angles (Figure 1c) and total active motion between the groups at discharge and final follow-up assessment (Table 3).

There was no incidence of insertion pullout of the tendon transfer in either group. Patients were discharged from rehabilitation with independent walking at 44.04 ± 7.9 days (range: 37—69 days) after surgery in the mobilisation group compared to 57.07 ± 2.3 days (range: 53—63 days) in the iImmobilisation group. This indicates a significant difference in morbidity (mean (SD): 13 days, $p > 0.001$; 95% CI: 16.8—9.5) between both groups. The duration required for therapy in the mobilisation group was 40 ± 7.6 days compared to 29 ± 2.3 days for the immobilisation group (mean (SD): 9.8, $p < 0.001$; 95% CI: 6.3—13.3).

Comparison of the results of the present study with published reports based on the outcome measure introduced by Srinivasan et al.[2] demonstrates that satisfactory (good + fair) active dorsiflexion for the study group is similar to that reported by Richard[6] and Yeap et al.[15] Srinivasan et al.[2] reported higher failures in active dorsiflexion but significantly better total active motion compared to the study group and the results reported by Richard.[6] Early mobilisation of tendon transfer for foot-drop correction produces results similar to those following immobilisation of the transfer (Table 4).

Adverse effects

Two patients in the mobilisation group had deterioration of active dorsiflexion angle following unprotected full weight bearing in the 3rd week of therapy. Daily record of

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Table 3 Comparison of active dorsiflexion, active plantar-flexion and total active motion of the early mobilization and immobilization groups at discharge and last follow-up

	Group	Mean in degrees	SD	SEM	t − test	95% C.I	
					p values	Lower	Upper
ADF (D)	MOB. $n = 21$	14.9	7.44	1.6	0.220	5.9	1.4
	IMMOB. $n = 21$	17.14	3.5	0.8			
APF (D)	MOB. $n = 21$	5.0	5.36	1.2	0.860	2.9	2.5
	IMMOB. $n = 21$	5.24	3.02	0.7			
TAM (D)	MOB. $n = 21$	9.9	3.73	0.8	0.054	4.0	0.0
	IMMOB. $n = 21$	11.9	2.72	0.6			
ADF(L)	MOB. $n = 19$	15.21	10.61	2.4	0.421	3.5	8.1
	IMMOB. $n = 21$	12.9	6.59	1.4			
APF (L)	MOB. $n = 19$	0.37	7.45	1.7	0.566	3.2	5.7
	MMOB. $n = 21$	0.9	6.32	1.4			
TAM (L)	MOB. $n = 19$	14.84	5.47	1.3	0.498	2.0	4.1
	IMMOB. $n = 21$	13.81	3.82	0.8			

ADF: Active dorsiflexion, APF: Active plantar flexion, TAM: Total active motion , D: At discharge, L: Last follow-up, SD: Standard deviation, SEM: Standard error of mean, Mob: Early mobilisation group, Immob: Immobilisation group.

dorsiflexion and total active motion enabled detection of the impending tendon-insertion pullout. Restricting plantar flexion for 2 weeks with continuous use of the posterior supporting slab and isometric exercises restored good dorsiflexion at discharge. One patient in the mobilisation group was lost to follow-up after discharge and had a recurrence of foot-drop deformity at 26 months follow-up (Patient no. 12 in Table 2). One patient with irregular follow-up in the immobilisation group had no active dorsiflexion above neutral and total active motion of 10° at 19 months follow-up. This could be due to either elongation of the muscle-tendon complex as a result of inadequate contraction of the transfer or stretching at the transfer insertion.

Table 4 Comparison of both groups as well as comparison with published reports in the literature using the outcome grading as described by Srinivasan et al.[2]

Outcomes	Dorsiflexion			Total active motion at ankle		
Grading	Good	Fair	Poor	Good	Fair	Poor
Mobilisation group ($n = 19$)	18	0	1	2	13	4
Immobilisation group ($n = 21$)	20	0	1	1	13	7
Srinivasan[2] ($n = 39$)	22	12	5	15	15	4
Yeap[16] ($n = 18$)	15	3	0	—	—	—
Richard[6] ($n = 39$)	37	0	2	2	15	22

Discussion

The purpose of the study was to investigate if early postoperative active motion for rehabilitation of tibialis posterior transfer for foot drop correction in patients with Hansen's disease is feasible and will have similar outcomes in reduced time compared to immobilisation of the transfer. The results suggest that early active motion following foot-drop correction is safe, without the increased risk of tendon-insertion pullout, and has similar outcomes to immobilisation with the added advantage of earlier independent walking compared to immobilisation. Findings of this study suggest that the standard practice[1–7] of immobilisation following tibialis posterior transfer may not be needed, provided the therapist and patients follow the recommended protocol of early active mobilisation rigorously. Further investigations are necessary to establish if patients return to work earlier in the mobilisation group to determine the economic benefits of early mobilisation of tendon transfers to the foot.

In recent years, there has been a move away from the practice of immobilisation towards early active motion following tendon transfers.[8,9,11–14] Rath has demonstrated that early active motion after opposition[8] tendon transfer

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and after claw hand correction by pulley insertion[9,11–13] in patients with Hansen's disease is safe and has no increased incidence of tendon-insertion pullout, while obtaining similar outcomes compared to immobilisation. Silfverskiold and May,[14] in a prospective trial using synthetic mesh reenforcement for early active mobilisation for tendon transfer to hand, demonstrated significantly improved results along with quicker rehabilitation. This study indicates that the concept of immediate active motion developed for hand tendon transfers can be safely applied to foot tendon transfers, provided the insertion is strong enough to tolerate the stress of early weight bearing. A mean reduction of 13 days in morbidity with early mobilisation for foot-drop correction is considerably less compared to the reduction of 22 days in morbidity with early mobilisation in tendon transfers to the hand.[9,13] This is partly due to beginning of early mobilisation for foot drop on 5th postoperative day compared to the 2nd postoperative day for tendon transfers to the hand. The decision was made by the therapist more or less arbitrarily on the presumption that pain threshold and swelling would allow co-operation of the patient to begin movement on the 5th day following foot-drop correction. Future trials may investigate the possibility to even further reduce the morbidity by beginning the mobilisation protocol earlier.

It has been suggested in the literature that there are beneficial effects of stress during mobilisation on tendon healing,[15] suggesting that an early motion protocol for tendon transfer may accelerate healing and improve outcome. In this study, we did not find a difference in outcome between the two groups. However, it should be noted that this is a relatively small study with a control group based on historical records. Future randomised controlled clinical trials are necessary to further investigate this outcome.

In addition to the historical control group, we compared the result of foot-drop correction with early motion protocol with published reports in the literature.[2,6,16] Table 4 shows that the outcome of both mobilisation and immobilisation groups included in the study protocol of tibialis posterior transfer shows similar results to outcomes reported in the literature. None of the published studies, except Soares,[7] mentions morbidity following foot-drop correction. Soares[7] reported that the rehabilitation after tendon transfer for foot drops was completed by 10 weeks (70 days). In the present study, rehabilitation was completed by an average of 57 days after surgery for the immobilisation group compared to 44 days for the mobilisation group. At present, the average time from beginning of postoperative therapy until discharge from rehabilitation is 40 days for the mobilisation group compared to 29 days for the immobilisation group. In the future, morbidity may be reduced further as therapists gain experience with early active motion protocol and are able to complete postoperative rehabilitation in similar time to immobilisation. Our experience with early mobilisation protocol following claw-deformity correction of the hand in large number of patients has demonstrated that after a steep learning curve for the therapists, the average time from beginning postoperative therapy until discharge from rehabilitation is similar to both the mobilisation and immobilisation group.[9,13]

The present study has a number of limitations. The study is a comparison of a prospective trial with a historical control group. Excluding patients with less than 1 year follow-up in the immobilisation group is likely to filter out failures as patients with unsatisfactory outcomes have higher instances of poor follow-up. Randomised controlled trials in future can investigate the changes with early mobilisation versus immobilisation, and track their differences over equal period on a more extensive set of outcome measures.

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Conflict of interest/funding

None.

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