J.S. Yeap · R. Birch · D. Singh

Long-term results of tibialis posterior tendon transfer for drop-foot

Accepted: 4 January 2001 / Published online: 3 March 2001
© Springer-Verlag 2001

Abstract Twelve patients with drop-foot secondary to sciatic or common peroneal nerve palsy treated with transfer of the tibialis posterior tendon were followed-up for a mean of 90 (24–300) months. In 10 patients the results were ‘excellent’ or ‘good’. In 11 patients grade 4 or 5 power of dorsiflexion was achieved, although the torque, as measured with a Cybex II dynamometer, and generated by the transferred tendon, was only about 30% of the normal side. Seven patients were able to dorsiflex their foot to the neutral position and beyond. The results appeared to be better in men under 30 years of age with common peroneal palsies. A painful flatfoot acquired in adulthood does not appear to be a significant long-term complication despite the loss of a functioning tibialis posterior tendon.

Résumé 12 patients avec pied tombant secondaire à une paralysie sciatique et traités par transfert du tendon tibial postérieur ont été suivis en moyenne 90 mois (24–300). Chez 10 patients les résultats étaient ‘Excellent’ ou ‘Bon’. Chez 11 patients une force de dorsiflexion de grade 4 ou 5 a été atteinte, bien que le couple produit par le tendon transféré, mesuré avec un dynamomètre et le Cybex II n’était que de 30% de la valeur du côté normal. 7 patients étaient capables de relever leur pied en position neutre et au-delà. Les résultats ont paru meilleurs chez les hommes de moins de 30 ans avec paralysie du sciatique poplité externe. Un pied-plat acquis douloureux ne paraît pas être une complication à long terme en dépit de la perte de l’action normal du tendon tibial postérieur.

Introduction

Drop-foot is a disabling condition and in spite of improvements in nerve repair and grafting, 64% of repair and grafting of sciatic nerve [3] and 46–54% of common peroneal nerve [3, 10, 21] palsies fail to restore functional dorsiflexion. Ankle-foot orthoses (AFO) or braces are often poorly tolerated.

In 1937, Mayer [13] credited Putti with the description of transferring the tibialis posterior tendon through the interosseous membrane to the dorsum of the foot to restore foot dorsiflexion. Watkins et al. [20] in 1954 achieved ‘excellent’ or ‘good’ results in 24 out of 25 patients by using this technique. Gunn and Molesworth [7] found a ‘satisfactory’ result in 49 out of 53 patients.

Pinzur et al. [17] modified the technique, transferring tibialis anterior and posterior tendon to a neutral dorsiflexion point on the dorsum of the foot. Carayon et al. [2] in 1967 described a dual transfer whereby the tibialis posterior tendon was sutured to the tibialis anterior tendon while the flexor digitorum longus tendon was sutured to extensor hallucis longus and extensor digitorum longus tendon. They achieved ‘excellent’ or ‘good’ results in 22 out of 31 patients. Srinivasan et al. [19] in 1968 split the tibialis posterior tendon into ‘two’ tails. The medial tail was inserted into the tendon of extensor hallucis longus and the lateral tail into the tendons of extensor digitorum longus and peroneus tertius. The Bridle procedure [14], a tritendon double-end-weave anastomosis between tibialis posterior, tibialis anterior and peroneus longus tendon was used by Prahinski et al. [16] to treat 10 soldiers.

Ober [15] in 1933 described the superficial route whereby the muscle belly lies in contact with the tibia. Lipscomb and Sanchez [11] in 1961 combined this with a triple arthrodesis.

The present study assessed the results of the various modifications of tibialis posterior tendon transfer for patients with traumatic common peroneal or sciatic nerve palsy. Tibialis posterior tendon dysfunction is now a well-recognized cause of an adult acquired flatfoot de-

J.S. Yeap (✉)
Faculty of Medicine and Health Sciences,
University Putra Malaysia, Aras 8, Grand Seasons Avenue,
No 72 Jalan Pahang, 53000 Kuala Lumpur, Malaysia
e-mail: jsyeap@hotmail.com
Tel.: +60-3-26987780, Fax: +60-3-26491826

R. Birch · D. Singh
Royal National Orthopaedic Hospital, Stanmore,
Middlesex HA7 4LP, UK

formity [9, 12] and we therefore looked specifically for this potential long-term complication.

Patients and methods

The study was retrospective; of 25 identified cases, 19 had been operated on more than 2 years previously. Of these, 12 were clinically examined, 2 responded to a questionnaire, 3 could not be traced, one had died and one declined to participate. Only the 12 patients (7 males, 5 females) clinically examined with more than 2 years follow up are reported here. Their characteristics are presented in Table 1.

The mean duration of postoperative follow up was 90.4 months (25 months–25 years). The mean age of the patients at the time of surgery was 28.4 years (12–61 years).

The site of distal tendon attachment was decided by a careful preoperative assessment of the power of the various groups of muscles although the method was also dependent on surgeon preference. Lengthening of the Achilles tendon was performed first, if the foot could not easily be passively dorsiflexed to 10° beyond neutral (only 1 patient required a lengthening procedure). The steps at operation included: detachment of the tibialis posterior tendon from the navicular bone through an incision over the insertion of tibialis posterior tendon on the medial aspect of the foot; mobilization of the muscle through the calf from a posteromedial incision; then passage of the tendon through a generous window in the interosseous membrane through an anterior incision. The tendon was then passed deep to the extensor retinaculum into the dorsum of the foot. The fourth incision, if required, would depend on the predetermined distal attachment. Where the tendon transfer was a split transfer to tibialis anterior and peroneus longus, which was the most commonly used method in this report, a lateral incision posterior to the lateral malleolus can be utilised and the peroneus longus tendon was identified. At this stage, the previous wounds are closed before proceeding. Keeping the foot dorsiflexed slightly beyond the neutral position, the tibialis posterior tendon was then secured to the predetermined distal attachment. At the end of the procedure, the foot must be balanced and in at least a neutral position. Hemostasis was secured and a below-knee plaster applied with the foot kept in a neutral position for a period of 6 weeks.

All the patients were examined by the same independent observer (JSY) and the following assessments were made. The patients were asked to rate the results of their surgery using a non-numerical grading system where the categories were 'excellent, good, fair or poor'. They were also asked whether they needed an orthosis and if so, when and how frequently and whether they could wear normal shoes. Any additional comments regarding their foot or the surgery were noted.

The muscle strength of dorsiflexion, plantarflexion, inversion and eversion of both feet was measured using the Medical Research Council (MRC) grading [6] and by the Cybex II Isokinetic dynamometer. With the patient lying supine and the knee extended, the ranges of active dorsiflexion and plantarflexion of the ankle were measured using a flexible strain-gauge goniometer in 10 patients. In 2 patients, a manual goniometer was used and these were measured to the nearest 5 degrees.

The patient's gait, with their shoes on, was evaluated visually to assess whether the transferred tendon was functioning actively during the swing phase of the gait. Electromyographic studies were not performed.

The development of a valgus hindfoot was looked for and Harris-Beath footprints of both feet were performed to assess the arch of the foot for evidence of flatfoot and forefoot abduction [18].

Any other complications from the surgery were noted from the patient's case notes and by direct questioning of the patients.

Table 1 Characteristics of the patients in the study

Patient	Age at surgery (years)	Sex	Duration of follow up (months)	Date	Mechanism of injury	Level of	Type of tendon injury transfer
1	28	Female	81	1990	RTA (pedestrian hit by car)	SCN level	TP to TA and PL + closed achilles tendon lengthening
2	26	Male	56	1987	RTA (pedestrian hit by car)	CPN level	TP to TA and PL
3	26	M	62	1989	RTA (head injury + fracture R tibial plateau + L femur)	SCN level	TP to TA and PL
4	28	M	79	1990	Fell over 10 foot fence – dislocated knee	CPN level	TP to TA and PL
5	54	F	38	1992	Primary THR	SCN level	TP to TA and PL
6	12	F	58	1988	Idiopathic?Unrecognized trauma	CPN level	TP to TA and PL
7	56	F	66	1953	Idiopathic?Unrecognized a traum	CPN level	TP to TA and PL
8	20	M	69	1991	Rugby injury (varus force)	CPN level	TP to TA and PT
9	21	F	25	1994	Osteosarcoma proximal fibula (50% anterior part of CPN divided. Radiotherapy)	CPN level	TP to TA and PT
10	34	M	84	1990	Fell from ladder	SCN level	TP to TA and EDL
11	22	M	300	1972	Fell down a flight of stairs (varus injury)	CPN level	TP to dorsum of foot
12	14	M	168	1983	Excision of proximal fibula haemangioma (recovery of superficial branch)	CPN level	TP to TA only

RTA, Road traffic accident; SCN, sciatic nerve; CPN, common peroneal nerve; TP, tibialis posterior; TA, tibialis anterior; PL, peroneus longus; PT, peroneus tertius; EDL, extensor digitorum longus

Results

The detailed results of the patient rating on surgical outcome are presented in Table 2. The overall results in terms of patient satisfaction on the outcome of surgery were 6 excellent, 4 good and 2 fair. There were no poor outcomes.

Out of 12 patients, 10 did not have to use an orthosis; 1 used a splint constantly and 1 used a spring-loaded caliper sparingly. All 12 patients were now able to wear normal shoes. Of the 4 women aged under 50 years in this study, 3 were not able to manage shoes with heels due to their limited range of plantarflexion and weakened ankle stabilizers. Six of 12 patients had a preference for wearing boots or shoes with ankle support. Only patients with grade 4 or 5 dorsiflexion were able to wear any type of shoes they wished.

The detailed results of muscle power are presented in Table 2. The muscle power for dorsiflexion and plantarflexion on the normal foot was grade 5 in all patients. Grade 4 or 5 muscle power of dorsiflexion of the operated foot was achieved by 11 patients. However, despite grade 5 power of dorsiflexion clinically, Cybex showed that the strength afforded by an active tibialis posterior could never match that of the normal side.

Detailed results of the range of movement of the foot are presented in Table 2. Seven of 12 patients were able to dorsiflex their foot to neutral position and beyond (Fig. 1). The mean arc of movement for the operated foot was 18° (4–25°), while the normal side was 45° (40–63°).

All the patients except 1 (patient 10) who had only a grade 3 strength of dorsiflexion, showed active dorsiflexion during the swing phase of the gait. Nevertheless, none showed a completely normal gait.

Only 4 of 12 patients developed a slightly flatter medial longitudinal arch on the footprints and 1 patient had an

Fig. 1 This patient was able to dorsiflex the ankle to neutral position and beyond. The degree of dorsiflexion was only a little less than the normal foot

arch that appeared flatter on inspection but a normal footprint. None had forefoot abduction but 1 patient exhibited a valgus hindfoot. These changes were minor and in no way resembled those of patients with flatfoot and were not painful and therefore of no clinical significance.

Pain was present and persisted in 1 patient (no. 9). Two patients (no. 1 and 5) underwent further surgery. Patient 1 had an exploration to tighten the tendon transfer and this was followed by strong recovery of her tibialis anterior. The transfer was then undone but her foot still tended to invert and she went on to have a triple arthrodesis. In patient no. 5, the transfer was tightened with a good outcome.

Table 2 Results of patient rating on surgical outcome, assessment of muscle strength and range-of-movement of the ankle

Patient	Outcome rating	MRC grading of power				Cybex machine (unit of torque – Nm)								Range-of-movement (degrees)			
		DF	PF	Inv	Ever	DF		PF		Inv		Ever		DF		PF	
						R	L	R	L	R	L	R	L	R	L	R	L
1*	Good	5	5	–	–	(12)	2	(28)	19	(5.5)	–	(12)	–	(–22)	–1	(27)	15
2	Excellent	4	5	1	4	(27)	4	(61)	52	(15)	0	(19)	7	(–13)	–1	(31)	22
3	Good	4	5	4	4	(28)	11	(47)	30	(22)	4	(15)	2	(–13)	–1	(31)	22
4	Excellent	5	5	4	4	(34)	12	(42)	42	(22)	20	(27)	19	(–15)	–2	(22)	9
5	Good	4	5	3	1	0	(12)	4	(24)	0	(4)	0	5.5	0	(–10)	10	(20)
6	Good	4	5	4	3	(22)	3	(31)	22	(9)	2	(12)	1	(–19)	13	(44)	38
7	Excellent	4	5	4	1	(7.5)	3	(19)	14	(7)	1	(7.5)	0	(–15)	5	(30)	20
8	Excellent	5	5	5	3	(20)	14	(53)	53	(24)	19	(19)	4	(–17)	–8	(17)	14
9**	Fair	4	5	3	4	–	–	–	–	–	–	–	–	1	(–16)	26	(30)
10	Fair	3	5	2	0	(24)	1	(61)	23	(14)	0	(11.5)	0	(–15)	9	(26)	13
11	Excellent	5	5	4	5	(24)	8	(41)	37	(15)	12	(26)	14	(–12)	–4	(30)	17
12	Excellent	4	5	4	4	(31)	10	(62)	52	(20)	15	(23)	18	(–16)	–1	(24)	22

DF, dorsiflexion; PF, plantarflexion; Inv, inversion; Ever, eversion. Figures in *italics* indicate the operated side and figures in parentheses indicate the normal side. *Patient had previously undergone a triple arthrodesis. ** Patient could not attend the clinic where the

Cybex machine was situated. 0 degree refers to the neutral position. A +ve value indicates the foot was in a plantarflexed position. A –ve value means the foot was in a dorsiflexed position.

Discussion

Tibialis posterior tendon transfer gave an overall excellent or good result in 10 patients as judged by patient satisfaction, although 2 of these patients underwent more than 1 operation. There appeared to be a correlation between patient satisfaction and the muscle power and degree of active dorsiflexion achieved.

Of the 8 cases of common peroneal nerve palsy, there were 6 excellent, 1 good and 1 fair result. Of the 4 cases of sciatic nerve palsy, there were 3 good and 1 fair result. These suggest that while injury at the sciatic nerve level is not of itself a contraindication to surgery, the results may not be as good compared to the common peroneal nerve level. This may be due to subclinical weakness of tibialis posterior and the Cybex II Isokinetic dynamometer may have a role to play in detecting the presence of such weakness before surgery. This may provide a more realistic expectation on the outcome of surgery for both the patient and the surgeon.

The best results were found in male patients under 30 years of age with a common peroneal nerve lesion. All 5 of these patients achieved grade 4 or 5 dorsiflexion and were able to dorsiflex to beyond neutral. All rated the outcome as excellent.

The results from the Cybex showed that despite very good power of dorsiflexion clinically, the torque generated often only amounted to 30% of the normal side. In sciatic nerve injuries, there was a significant difference in the power of plantarflexion despite grade 5 power on clinical examination. The transfer however, does not affect the strength of plantarflexion significantly in those with common peroneal nerve palsy.

De Marchi et al. [4] concluded that there was no deterioration in function with time in patients who had the distal attachment to the cuneiform, while Prahinski et al. [16] commented that function deteriorated in time due to the tendon stretching out. We are not able to comment on this phenomenon, except to report that one patient felt that dorsiflexion was weaker following her pregnancy, and another felt this following a recent fall.

How does the tendon transfer actually work? The excursion of tibialis posterior tendon, being a unipennate muscle, is only 2 cm while that of tibialis anterior between 3 to 5 cm [1]. As the tendon is fixed in dorsiflexion while the foot is normally in plantarflexion, and the passive arc of movement on the operated side is always less than the normal side, this suggests that tenodesis must play a role. De Marchi et al. [4] showed continuous activity in tibialis posterior on EMGs during the entire gait, with 2 activity peaks. One of these peaks coincided with ankle dorsiflexion during the swing phase and became more apparent with time following surgery. We noted visually the active dorsiflexion of the foot during the swing phase. The patient with the strongest power of dorsiflexion in this study had dorsiflexion of 14 Nm, had an arc of movement of 22° and competed in a triathlon, while that of the poorest result had only 1.0 Nm and an arc of movement of 4°. These results suggest that in an

optimally functioning transfer, the role of voluntary contraction of tibialis posterior is of greater importance than the tenodesis effect.

The interosseous route was preferred to the subcutaneous route even though it is more technically demanding because it is more direct and produces less pronation and can achieve greater dorsiflexion [5]. However, clinically, Hall [8] reported that the subcutaneous route gave greater dorsiflexion. This difference in laboratory and clinical findings may be due to formation of adhesions. Earlier commencement of passive movement may reduce adhesions and improve the outcome. The tendon was passed deep to the extensor retinaculum to prevent a bowstring effect, as this is biomechanically advantageous.

One of the limitations of this study, despite the single route taken by the tendon, is that there were several sites for the distal site of attachment of the tendon, making interpretation of the results difficult. We make no recommendations as to where the distal site of attachment should be but feel that this is likely to be largely determined by the existing muscular balance. The other limitation was that we had a follow-up rate of only 64%, which may not provide a true picture of the outcome.

We conclude that tibialis posterior tendon transfers as a group produced 83% excellent or good results in terms of patient satisfaction with the outcome of surgery. It can therefore be recommended to patients who would prefer to discard an ankle-foot orthosis. The results are likely to be more successful if the nerve lesion causing the drop-foot was at the common peroneal level rather than at the sciatic level and in men aged less than 30 years. A painful acquired flatfoot deformity does not appear to be a significant long-term complication following the transfer.

References

1. Biesalski K, Mayer L (1916) Die Physiologische Sehnenverpflanzung. Verlag von Julius Springer, Berlin
2. Carayon A, Bourrel P, Bourges M, Touze M (1967) Dual transfer of the posterior tibial and flexor digitorum longus tendons for dropfoot – a report of 31 cases. *J Bone Joint Surg [Am]* 49:144–148
3. Clawson DK, Seddon HJ (1960) The results of repair of the sciatic nerve. *J Bone Joint Surg [Br]* 42:205–212
4. De Marchi F, Malerba F, Montrasio Alfieri U, Ferrarin M, Rabuffetti M (2000) Tibialis posterior tendon transfer through the interosseal membrane in paralysis of the common peroneal nerve. *Foot Ankle Surg* 6:19–25
5. Goh JC, Lee PY, Lee EH, Bose K (1995) Biomechanical study on tibialis posterior tendon transfer. *Clin Orthop* 319:297–302
6. Guarantors of Brain (1986) Aids to the examination of the peripheral nervous system. Bailliere Tindall, London, pp 32–43
7. Gunn DR, Molesworth BD (1957) The use of tibialis posterior as a dorsiflexor. *J Bone Joint Surg [Br]* 39:674–678
8. Hall G (1977) A review of drop-foot corrective surgery. *Lepr Rev* 48:185–192
9. Johnson KA, Strom DE (1989) Tibialis posterior tendon dysfunction. *Clin Orthop* 239:196–206

10. Kim DH, Kline DG (1996) Management and results of peroneal nerve lesions. *Neurosurgery* 39:312–319
11. Lipscomb PR, Sanchez JJ (1961) Anterior transplantation of the posterior tibial tendon for persistent palsy of the common peroneal nerve. *J Bone Joint Surg [Am]* 43:60–66
12. Mann RA, Thompson FM (1985) Rupture of the posterior tibial tendon causing flat foot – surgical treatment. *J Bone Joint Surg [Am]* 67:556–561
13. Mayer L (1937) The physiological method of tendon transplantation in the treatment of paralytic drop-foot. *J Bone Joint Surg* 19:389–394
14. McCall RE, Frederick HA, McCluskey GM, Riordan DC (1991) The Bridle procedure: a new treatment for equinus and equinovarus deformities in children. *J Pediatr Orthop* 11:83–89
15. Ober FR (1933) Tendon transplantation in the lower limbs. *New Engl J Med* 209:52–59
16. Prahinski JR, McHale KA, Temple HT, Jackson JP (1996) Bridle transfer for paresis of the anterior and lateral compartment musculature. *Foot Ankle Int* 17:615–619
17. Pinzur MS, Kett RPT, Trilla M (1988) Combined anteroposterior tibial tendon transfer in post-traumatic peroneal palsy. *Foot Ankle* 8:271–275
18. Rose GK, Welton EA, Marshall T (1985) The diagnosis of flatfoot in the child. *J Bone Joint Surg [Br]* 67:71–78
19. Srinivasan H, Mukherjee SM, Subramaniam RA (1968) Two-tailed transfer of tibialis posterior for correction of drop-foot in leprosy. *J Bone Joint Surg [Br]* 50:623–628
20. Watkins MB, Jones JB, Ryder Jr CT, Brown TH (1954) Transplantation of the posterior tibial tendon. *J Bone Joint Surg [Am]* 36:1181–1189
21. Wood MB (1991) Peroneal nerve repair – surgical results. *Clin Orthop* 267:206–220