

Varus and Valgus Deformities of the Foot in Cerebral Palsy

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Introduction

Deformities of the foot and ankle are common among patients with cerebral palsy. Equinus due to contracture of the gastrocnemius-soleus muscle is the most common: it has been estimated that some 20 to 25 per cent of all children with cerebral palsy will require surgery for this deformity (Basset and Baker 1966) and the results are predictably good. Varus and valgus deformities are less easily corrected surgically, and it is also less easy to explain their development.

An equinovarus deformity usually is attributed to overactivity of tibialis anterior or tibialis posterior in the presence of equinus (Perry and Hoffer 1977). Equinovalgus is explained by the 'bow-string' theory, which states that: 'in the presence of an equinus contracture the hindfoot is forced into the valgus position when the forefoot touches the ground. This occurs because of the bowstring effect of the triceps surae on the ankle and subtalar joints. The calcaneum then rotates under the talus, which then drops into a more vertical position on losing the support of the sustentaculum tali' (Tachdjian 1972). Two objections can be raised against this theory: (1) equinovalgus deformities are

seen in children who have never walked; and (2) hemiplegic children who are fully mobile seldom develop a valgus deformity, in spite of equinus commonly being present.

From clinical observation we have noted that whereas hemiplegia typically produces an equinovarus deformity, diplegia and quadriplegia are characterised by an equinovarus foot. This was confirmed in a retrospective study of 230 children who had had foot surgery at the Hospital for Sick Children, Toronto. When first seen, their ages ranged from birth to 17 years. Average follow-up was 11.4 years. 84 were classified as hemiplegic and 146 as diplegic or quadriplegic. 70 of the latter group were fully mobile, 50 were household ambulators and 80 were chairbound. Table I shows the pattern of deformity in

TABLE I
Pattern of deformity

Group	No. with equinus	No. with equinovarus	No. with equinovalgus
Hemiplegia	50	32	2
Diplegia/ quadriplegia	62	30	54

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the two groups. If either varus or valgus deformity was present, 94 per cent of affected hemiplegic patients were in varus, whereas for those with diplegia and quadriplegia, 64 per cent were in valgus.

We also noted that hemiplegic children often show signs of tibialis overpull, whereas those with diplegia or quadriplegia seldom do. This suggests a possible reason for the different pattern of deformity in the two groups: it seemed to us that the fundamental difference lay not in muscle contractures or mobility, but in the function of tibialis posterior. The aim of the present investigation was to test this hypothesis by electromyographically assessing the activity of the muscles around the ankle during locomotion, with particular reference to the tibialis posterior.

Patients

The children selected for investigation were attending either the Cerebral Palsy Clinic at the Ontario Crippled Children's Centre or the Orthopaedic Clinic at the Hospital for Sick Children, Toronto. The criteria for selection were that they had: (a) cerebral palsy; (b) a varus or valgus deformity of the hindfoot; (c) no operations on their foot or ankle, with the exception of elongation of the tendo-achilles. Informed parental consent was obtained and one parent of each child was present at the time of investigation. Six ambulatory patients with varus deformity and six with a valgus deformity were studied.

Method

The investigations were carried out in the Gait Laboratory of the Ontario Crippled Children's Centre. On arrival, after the child was made familiar with his surroundings, an examination of the locomotor system was performed. A photographic record of the foot deformity

and a video-recording of the child's gait were made. No attempt was made to impose a standard walking speed, either at this stage or later.

Dynamic gait electromyographic recordings of tibialis anterior, tibialis posterior, gastrosoleus and the peronei were made. Becton Dickinson disposable surface-electrodes were used for all muscles, except tibialis posterior, for which wire electrodes were used (25µm Trimel-coated platinum wire, prepared after the manner of Basmajian 1979). The wire was inserted into the muscle, using a 22-gauge needle, from an anterolateral approach. Correct placement was verified by muscle stimulation tests, while palpating the tibialis posterior tendon. Custom-built miniature pre-amplifiers were placed close to the skin-electrodes to minimise electrical interference. High-pass filters were used to cut out low-frequency signals (less than 40Hz). Data was recorded on Honeywell visicorder paper for visual analysis.

The whole procedure took about 90 minutes.

Results

The results are shown diagrammatically in Figures 1 and 2. It can be seen that activity was recorded in the tibialis posterior in all six patients with varus feet, but none was detected in five of the six with a valgus deformity. Abnormalities of phase occurred in other muscles tested, but in no constant pattern. It should be emphasised that, as is often the case in cerebral palsy, the phasic pattern of activity usually was superimposed on a background of constant electrical activity.

Discussion

Valgus deformity of the foot develops if the tibialis posterior tendon is cut or paralysed, for example by polio (Fried and Hendel 1957). To our knowledge, non-

function has not previously been described in patients with cerebral palsy. Certainly abnormalities in its phasic activity in the varus foot have previously been reported by Perry and Hoffer (1977). Using gait electromyography, they were able to formulate rational methods of treatment with predictable results for the 24 patients they studied.

Tibialis posterior appears to have a central rôle in the genesis of the valgus foot. From clinical observation and the data presented here, we would submit that

the bowstring theory, which relies on weight-bearing for the production of the valgus deformity, is no longer tenable. Similarly, we would consider spasticity in the peroneal muscles to be an unusual cause. Certainly it may be a secondary factor, but in the presence of a non-functioning tibialis posterior the deformity may be expected to progress even when the peronei are normal.

The valgus foot in cerebral palsy has many similarities to convex pes valgus. Drennan and Sharrard (1971) attributed

Patient	Age	Diagnosis	tibialis posterior	tibialis anterior	peronei	gastrocnemius
J.K. ♂	10	left hemi.				
C.P. ♀	16	right hemi.				
D.M. ♂	5	diplegia				
G.H. ♂	10	diplegia				
J.P. ♂	6	right hemi.				
D.J. ♀	4	left hemi.				
Normal Phasic Activity						

Patient	Age	Diagnosis	tibialis posterior	tibialis anterior	peronei	gastrocnemius
C.C. ♂	4	diplegia	no activity			
J.A. ♂	6	diplegia	no activity			
G.P. ♂	5	diplegia	no activity			
N.C. ♂	7	diplegia	no activity			
P.L.	7	diplegia	no activity			
G.T.	5	diplegia				
Normal Phasic Activity						

Fig. 1 (upper) varus feet and Fig. 2 (lower) valgus feet. Note activity in tibialis posterior. Each box represents from 0 to 100 per cent of gait cycle.

this deformity to muscle imbalance: a weak or non-functioning tibialis posterior being overpowered by strong dorsiflexors and evertors. This theory led Duckworth and Smith (1974) to transfer the peroneus brevis tendon to that of the tibialis posterior. We have used the same procedure for valgus feet of cerebral-palsied patients, since based on the results we have described, it appears to be a logical procedure. It is too early to report the results of these operations, but in the main they have been successful elsewhere (Sharrard, personal communication; Smith *et al.* 1976). So far, our results are encouraging. The main theoretical drawback to this procedure seems to be the

risk of late varus deformity, which has occurred in a few of Sharrard's series. We hope to minimise this risk by only using the procedure for children with no tibialis posterior function.

Acknowledgements: We thank the Conn Smythe Research Foundation for Crippled Children, which funded this work.

AUTHORS' APPOINTMENTS

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SUMMARY

Dynamic gait studies of children with varus and valgus foot-deformities due to cerebral palsy show that the activity in the tibialis posterior is important in the development of such deformities. Varus is associated with increased activity and valgus with decreased activity.

RÉSUMÉ

Déformations du pied en varus et valgus dans l'I.M.C.

Les études de la démarche dynamique d'enfants IMC présentant un pied varus ou un pied valgus montrent que l'activité du jambier postérieur joue un rôle important dans le développement de ces déformations. Le varus est associé à une activité accrue et le valgus à un déficit.

ZUSAMMENFASSUNG

Varus- und Valgusstellungen des Fußes bei Cerebralparese

Dynamische Ganguntersuchungen bei Kindern mit Varus- und Valgusstellungen der Füße durch Cerebralparese haben ergeben, daß die Funktion des M. tibialis posterior eine wichtige Rolle bei der Entstehung solcher Mißbildungen spielt. Die Varusstellung entsteht durch erhöhte Aktivität, die Valgusstellung durch herabgesetzte Aktivität.

RESUMEN

Deformidades en varus y en valgus del pie en la parálisis cerebral

Estudios dinámicos de la marcha en niños con deformidades del pie en varus y en valgus debidas a parálisis cerebral, muestran que la actividad del tibial anterior es importante en el desarrollo de estas deformidades. El varus esta asociado con una actividad aumentada y el valgus con una actividad disminuida.

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