LENGTHENING OF THE CALCANEAL TENDON IN SPASTIC HEMIPLEGIA BY THE WHITE SLIDE TECHNIQUE

A LONG-TERM REVIEW

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For equinus deformity in spastic hemiplegia, correction by the White slide technique has been studied in a group of 35 patients followed up for 14 to 20 years. It is a simple, effective method of lengthening the calcaneal tendon, and is free from significant complications with an acceptable rate of recurrent deformity. The majority of patients achieved a heel-toe gait.

The most common deformity in children with spastic hemiplegia is equinus of the ankle, defined as limitation of passive dorsiflexion beyond the neutral position. This may be a dynamic deformity caused by an exaggerated stretch reflex in the calf muscles, or a fixed one, due to contracture of the triceps surae. In either case, the result is a characteristic tip-toe or toe-heel gait, which is clumsy, inefficient, and may cause excessive wear on shoes. Many forms of conservative treatment and more than 12 operations have been described for the correction of this deformity (Tachdjian 1985; Rang, Silver and de la Garza 1986).

We now report the long-term results of a uniform method of treatment for this deformity in spastic hemiplegia due to cerebral palsy. Our study differs from previous ones in that it focuses on one specific pattern of spasticity treated by one surgical procedure with follow-up to near skeletal maturity.

MATERIAL AND METHODS

From 1970 to 1977 at The Hospital for Sick Children, Great Ormond Street, 58 children with spastic hemiplegia had a White slide elongation of the calcaneal tendon (White 1943). Children with other patterns of

spasticity, or significant valgus or varus deformities were not included in the series.

The records of all these patients were reviewed and 35 of them were re-examined at nine to 16 years (mean 13 years) after operation. We were unable to re-examine 23 patients, but records of follow-up for a mean period of three-and-a-half years were available. Fifteen of the patients had originally been referred from overseas or outside London. Of these 23 there is record of only one recurrence and no major complications.

The specially examined group of 35 included 18 males and 17 females; 20 had a right hemiplegia, and 15 a left hemiplegia. The mean age at operation was 6 years 9 months (range 3 to 15 years) and at follow-up was 20 years 4 months (range 14 to 28 years). The mean follow-up was 13 years 4 months (range 9 to 16 years).

The parents of the specially reviewed patients were asked to complete a short questionnaire regarding their satisfaction with the result. The patient's gait was observed and classified as toe-toe, toe-heel, flat-foot, or heel-toe (Grant, Feldman and Lehman 1985). A toe-toe gait was defined as failure of the heel to strike at all, even when the patient walked slowly. With a toe-heel gait, the toe strikes first, and the heel strikes later. A flat-foot gait is one in which the foot is placed as a unit, heel and toe striking simultaneously. The aim of treatment is to achieve the normal heel-toe pattern. Some patients had a different gait with shoes, and without. In these cases, the better gait (in shoes) was recorded.

The lower limbs were then examined and a number of special parameters recorded. The passive range of ankle movement was measured with a goniometer, with the knee extended. Muscle power was tested and graded on the MRC scale and in addition, calf muscle strength was assessed by asking the patient to stand on one foot and repeatedly rise on the toes. If the number of repetitions achieved on the spastic side was more than

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half the number on the normal side, this was graded as "plus", and if it was less than half, "minus". Dorsiflexion was graded as selective, automatic or absent. Selective dorsiflexion is present if the patient can voluntarily dorsiflex the ankle throughout the passive range permitted by the heel cord, with the knee extended. Automatic dorsiflexion was assessed by the "confusion test", in which hip flexion against resistance produces involuntary ankle dorsiflexion. The leg lengths and calf diameters were measured with a metal tape, and the leg length discrepancy and calf wasting recorded.

Fig. 1

Fig. 2

Figure 1 - Skin incisions. Figure 2 - The two transverse partial tenotomies are shown. Distally, the anterior fibres have been cut, and proximally, the medial fibres. The foot has been dorsiflexed to produce a sliding elongation in continuity.

Management of equinus. Equinus deformity was treated when it caused a persistent toe-toe or toe-heel gait. Secondary indications were excessive shoe wear, genu recurvatum or rocker-bottom foot. Dynamic equinus was managed by repeated passive stretching of the calcaneal tendon and physiotherapy, with the emphasis on gait training and dorsiflexion exercises. When a fixed contracture developed, or when the ankle would only come to the neutral position with excessive pressure, surgical lengthening of the heel cord was performed by the White slide technique, (White 1943). The decision to operate was made only after several out-patient visits and assessment by both surgeon and physiotherapist.

Surgical technique and post-operative care. Slide lengthening of the heel cord is performed by two partial

transverse tenotomies of the calcaneal tendon, one proximal and the other distal and is based on the 90° rotation of the tendon fibres in the lower third of the leg. The tendon is exposed through two 1.5 to 2 cm posteromedial incisions - one close to the heel, and the other 5 cm more proximal (Fig. 1). With the tendon stretched by passive dorsiflexion of the ankle, the anterior two-thirds of the fibres are divided at the distal incision, protecting the skin and soft tissues with a curved dissector. At the proximal exposure the medial half to two-thirds of the tendon is then progressively divided maintaining pressure until a definite yield point is reached (a useful mnemonic for the incisions is DAMP: distal, anterior; medial, proximal). The medial fibres slide on the lateral, and this effects a lengthening in continuity, with a thinned out portion of the tendon distally, and a square medial gap at the proximal incision (Fig. 2). The elongation produced by firm dorsiflexion of the hindfoot is continued until the foot lies passively in a neutral position, and 5° to 10° of passive dorsiflexion can be obtained. The incisions are closed in layers with a subcuticular skin suture, but the tendon is not repaired. The leg is immobilised in a below-knee walking cast with the ankle in the neutral position for a period of three or four weeks. Patients leave hospital after one to two days, and are encouraged to weight-bear in the plaster as soon as they are comfortable, usually within two or three days.

The cast is removed in out-patients, or more commonly during a short admission to hospital for intensive physiotherapy. A plastic moulded night splint is supplied, and normally used for a period of six months post-operatively. The children were followed up regularly and those who were slow to gain selective dorsiflexion, or who showed signs of recurrent contracture, had physiotherapy with repeated passive stretching of the tendon and continued use of a night splint for as long as two years after surgery. Recurrence of fixed equinus was treated by open "Z" lengthening of the calcaneal tendon.

RESULTS

Parents assessment. Parental satisfaction with the treatment was high (Table I); 86% reported that gait had been improved, and 60% that shoes were not worn out so rapidly on the affected side.

Gait pattern and muscle strength. Before operation all patients had a toe-toe or toe-heel gait. At review, 19 patients had a heel-toe gait, 14 had a flat-foot gait, and two had a toe-heel gait (Table II). The strength of plantarflexion was MRC Grade 4 in all patients, though the six patients who had needed repeat tendon lengthening showed MRC Grade 4 minus. On the toe rising test 22 were graded as plus and 13 as minus. Selective control of dorsiflexion was present in nine patients pre-operatively, and in 24 patients at review. In the two patients with a persistent toe-heel gait, dorsiflexion could

not be elicited, even with the confusion test. All patients with a heel-toe gait had selective dorsiflexion.

Recurrent deformity and range of ankle movement. No patient had a calcaneus deformity, but six patients had developed recurrent fixed equinus, and had been treated by an open "Z" lengthening of the calcaneal tendon – a re-operation rate of 17%. In two patients a third operation was required. The mean age at first operation of patients who needed re-operation was 4 years 5 months, significantly younger than the mean of 7 years 7 months for those who had needed only a White slide ($p < 0.01$). Patients with recurrence of equinus all had a detailed in-patient assessment and muscle charting by a physiotherapist before repeat surgery. In four of these patients, selective control of dorsiflexion was absent.

Limitation of dorsiflexion was a common finding (Table III). In 15 patients, there was residual fixed equinus (43%), and in seven patients this was over 10° , but it was not always associated with a poor gait. It was particularly well disguised in female patients wearing high-heeled shoes. In 17 patients, the recorded range of passive dorsiflexion decreased during the adolescent growth spurt by more than 10° .

Leg length discrepancy and calf wasting (Fig. 3). Shortening of the spastic leg varied from zero to 4 cm (mean $1.8 \text{ cm} \pm 0.9 \text{ cm SD}$). Three patients used a shoe raise, but no patient had had a leg equalisation procedure. Calf wasting varied from one to 9 cm (mean $4.8 \text{ cm} \pm 1.7 \text{ cm SD}$); it was significantly greater in patients who had had a repeat tendon lengthening. Mean calf wasting in patients after a White slide only was 3.8 cm, and in patients with one or more open "Z" lengthenings was 6.3 cm ($p < 0.01$).

DISCUSSION

The aim of operation for the correction of equinus deformity of the foot is a well developed longitudinal arch, balanced muscle function in a brace-free and painless leg with a heel-toe gait and an adequate push-off (Keats 1970). This ideal is rarely achieved because the primary disorder is a central one and the site of surgery is peripheral. However, if parents are advised that relative improvement, rather than a normal gait, is the aim of treatment the majority will be satisfied (Table I).

The heel cord may be lengthened by percutaneous complete tenotomy, open "Z" lengthening, or a slide technique in which some continuity of the tendon fibres is maintained. Control of the tendon ends is poor after percutaneous tenotomy and this has been condemned by most surgeons, except for non-ambulant patients (Keats 1970; Lloyd-Roberts 1971). Open "Z" lengthening gives a reasonably low rate of recurrence of equinus deformity but has a significant rate of calcaneus deformity (Garbarino and Clancy 1985). Slide techniques have a higher rate of recurrent equinus, but calcaneus deformity

Fig. 3

A typical result at maturity: shortening of the affected leg is 1.5 cm, calf wasting is 3.5 cm. The foot is plantigrade and the gait is heel-toe.

Table I. Subjective assessment of results in 35 cases

	Gait	Shoe wear
Greatly improved	9	4
Improved	21	17
No change	5	14
Worse	0	0

Table II. Pre-operative and post-operative gait in 35 cases

	Pre-operative	Late review
Toe-toe	9	0
Toe-heel	26	2
Flatfoot	0	14
Heel-toe	0	19

Table III. Range of passive movement in 35 cases

Range in degrees	Pre-operative	Late review
Dorsiflexion		
10 to 20	0	2
0 to 10	0	18
Plantarflexion		
0 to 10	8	8
10 to 20	11	5
20 to 30	10	2
30	6	0

can be completely avoided, as in this series. Recurrent equinus is easy to treat after slide lengthening because there is little scarring. Calcaneus deformity is much more disabling than equinus and is virtually irreversible. The criteria for assessing recurrent equinus should be based on the need for further surgery; undue emphasis on obtaining a full range of passive dorsiflexion at the ankle is unwarranted. In our series 43% of patients had some limitation of ankle dorsiflexion, but only two had a toe-heel gait. These two patients had a "steppage gait" due to completely inactive dorsiflexors. In more than half the patients the range of passive dorsiflexion decreased during the adolescent growth spurt.

Fig. 4

Scheme of treatment options.

In spastic limbs the longitudinal growth is reduced (Staheli, Duncan and Schaefer 1968; Ziv et al. 1984). Muscle is affected more than bone, which results in a tendency to recurrent contracture during periods of rapid growth (Truscelli, Lespargot and Tardieu 1979). In an adolescent patient a full range of dorsiflexion should not be the aim of management (Sharrard and Bernstein 1972). It is better to preserve push-off than to produce calcaneus deformity, particularly in a short limb. Repeated heel cord lengthening may be necessary in some cases, but this is always associated with further weakening and wasting of the calf muscles. Recurrent equinus is clearly related to the patient's age at the time of operation in this, as in other series. Early surgery is not advised in cerebral palsy as the delayed maturation of the

central nervous system characteristic of this condition may produce variable and unpredictable results. In the younger patient with severe dynamic equinus, we now prefer one or two periods in a "tone-reducing" cast, rather than early surgery (Sussman and Cusick 1979). A scheme of management is given in Figure 4.

Postoperative bracing is a contentious issue. Some recommend prolonged bracing (Banks and Green 1958; Tachdjian 1985), others use no splintage after the first six weeks (Sharrard and Bernstein 1972; Lee and Bleck 1980). Between these two extremes a logical, though unproven middle ground, can be defined. It would seem reasonable to use a night splint for the first six months when the scar tissue is maturing and contracting. After this, provided that selective dorsiflexion is present, braces are unnecessary. Patients without selective dorsiflexion should probably continue to use night splints.

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