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The Vulpius procedure for correction of equinus deformity in patients with hemiplegia

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Spasm or contracture of gastrocnemius causes an equinus deformity of the ankle in both cerebral palsy and hemiplegia. Its release is therefore required in the treatment of those patients who do not respond to conservative measures. The Vulpius procedure is a simple and effective method for the release of gastrocnemius and is particularly indicated when long periods of immobilisation of the foot and ankle are not desirable. We have used this procedure with good results to correct an equinus deformity in 230 adults with a cerebrovascular accident and various associated medical conditions. It is not only effective in cerebral palsy, but should be considered at an early stage in all adult patients with deformity of the ankle and foot in whom spasm of gastrocnemius is the major cause.

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Abnormality of the gait in adults who have hemiplegia is the result of equinus deformities of the ankle, decreased flexion or hyperextension of the knee and increased flexion of the hip. Spasm or contracture of gastrocnemius is the main cause of the equinus deformity,[1] correction of which is the most important factor in improving mobility.[2,3] In the past, various combinations of lengthening, transfer and release of tendons have been undertaken in an attempt to correct disorders of gait in patients with hemiplegia caused by either stroke or head injury.[2]

Since most of these patients are middle-aged or elderly, they frequently have other conditions such as hypertension, diabetes and ischaemic heart disease, and complicated surgery may not be appropriate. In order to obtain a rapid correction of the deformity and to allow early mobilisation, we have achieved good results using the Vulpius technique which is widely used in patients with cerebral palsy to correct deformities of the ankle and foot.[4-7] It is a simple and effective method of releasing spasm in gastrocnemius. Gage[8] recommended lengthening of gastrocnemius instead of tendo Achillis as the soleus muscle may be responsible for only a small part of the deformity. We have evaluated the outcome in terms of its technical simplicity and rapid return of activities of daily living. This is the first report of the use of this procedure in adult hemiplegic patients with contractures of the lower limb.

Patients and Methods

Between 1986 and 1999, 230 patients with cerebrovascular accidents underwent surgery for equinus deformities of the foot and ankle. There were 192 men and 38 women with a mean age of 67.7 years (46 to 78). They had been treated elsewhere during the acute phase of the stroke and had various associated conditions including hypertension (156), diabetes (98) and ischaemic heart disease (69). They received conservative treatment for between three and six months and, when no further significant improvement in gait was recorded, surgery was advised. Some patients were assessed by gait analysis, electromyography and nerve-conduction studies in order to confirm the priorities for surgical correction of the deformities.

In many patients, their general medical condition precluded complicated surgery such as tendon lengthening or transfer which may necessitate prolonged periods of immobilisation. They required minimally invasive procedures which allowed the early return of activities of daily living.

Surgery was undertaken using the technique of Vulpius with slight modifications. Tenotomy or lengthening of flexor digitorum longus and flexor hallucis longus was also used if there were hammer-toe deformities. Patients lay in a prone position without a tourniquet. Under local anaesthesia, a longitudinal incision of 4 cm was made. The aponeurosis of gastrocnemius and the fascia of soleus were excised and any remaining soft tissue which prevented correction of the deformity. Relief of spasm was assessed by passively dorsiflexing the ankle with the knee flexed and extended. If there were hammer-toe deformities the tendons of flexor digitorum longus and flexor hallucis longus were exposed through an incision distal to the medial malleolus

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and divided or lengthened. Although contractures of tibialis posterior are also responsible for a varus deformity of the hindfoot, it was preserved to maintain stability. Immobilisation in a plaster cast was not required although an elastic supporting bandage was retained for one week in order to prevent local swelling. Rehabilitation began on the first postoperative day. Either a knee-ankle-foot orthosis (KAFO) or an ankle-foot orthosis (AFO) was used to assist mobilisation.

Traditional KAFOs and AFOs are quite heavy, weighing between 900 and 1400 g. We used the Yunoko plastic AFO (Tokuda Prostheses Manufacturing Company, Kumamoto City, Japan) which weighs only 200 g.

The Brunnstrom system was used to classify the function of the legs during recovery of the hemiplegia.[9] It has six stages which record improvement in motor function of the hip, knee and ankle. Stage 1 is complete flaccid paralysis. As recovery begins, in stage 2, there may be minimal voluntary movement and spasticity begins to develop. In stage 3, voluntary control appears, although a full range of movement may not be obtained and spasticity progresses. Stage 4 is reached when it becomes possible to execute some combinations of voluntary movement outside the synergistic patterns and the spasticity begins to decline. In stage 5 more complicated combinations of movement are developed. Finally, in stage 6, spasticity has disappeared, movements of individual joints return and co-ordination approaches normal.[9]

Postoperative assessment and Brunnstrom scoring for the leg were carried out by physiotherapists and neurologists.

The preoperative and postoperative results were compared statistically using the non-parametric Mann-Whitney U test except where a paired *t*-test was used for the comparison of improvement in ankle dorsiflexion. A significance level of $p < 0.01$ was used for all comparisons.

Results

We analysed the results on the basis of aspects of functional outcome such as the use of braces, improvement of gait, increasing independence and changes in the Brunnstrom stages. Only patients for whom complete pre- and postoperative data were available were compared for each criterion.

Table I shows the change in the use of braces in the 230 patients. Fewer patients required complicated heavy braces and more were able to use simple lightweight braces. Of 33 patients using a KAFO preoperatively, 18 (54.5%) changed to a Yunoko-type plastic AFO and eight (24.2%) to a metal AFO. Two were able to walk without a brace. Of 134 patients using a metal AFO preoperatively, 101 (75.4%) changed to a plastic AFO and 18 (13.4%) were able to walk without a brace. Of 51 patients using a plastic AFO preoperatively, 11 (21.6%) were able to walk without a brace. Overall, 167 patients (72.4%) used a simpler brace or walked without one after operation.

According to the patient's ability to apply a brace, they were divided into three groups: those who needed help to apply the brace (the total support group), those who needed no help but took a long time to apply it (the partial support group), and those who applied it normally. This comparison was undertaken in 116 patients (Table I). Of 28 patients who needed help preoperatively, 21 (75%) were able to apply it normally. The number of patients who could apply the brace normally postoperatively increased from 48 (41.4%) to 73 (63%). Improvement in gait was considered in 146 patients in relation to their ability to walk with or without the support of parallel bars or a crutch or cane. There were significant improvements in each group (Table I).

Clonus of the ankle impairs co-ordination of movements of the foot during gait. It disappeared after excision of the aponeurosis of gastrocnemius with improvement in passive dorsiflexion of the ankle both with the knee flexed and extended (Table II).

Patients started rehabilitation in the acute phase of hemiplegia and those whose movements returned slowly underwent the Vulpius procedure so that an appropriate brace

Table I. The types of braces used, support required and Brunnstrom stage before and after surgery for correction of equinus deformity after a cerebrovascular accident. Figures in parentheses are numbers of patients

	Number of patients	
	Before surgery	**After surgery**
Braces used (230)		
KAFO	33	5
AFO (metal)	134	25
AFO	51	151
None	12	49
Support to apply braces (116)		
Total	28	8
Partial	40	35
None	48	73
Mobility support (146)		
Parallel bar	13	3
Multi-leg crutch	25	9
Single-leg crutch	94	116
Independent	12	16
Others	2	2
Brunnstrom stage (201)		
1	5	0
2	27	7
3	89	66
4	72	105
5	8	22
6	0	1

Table II. The mean (± SD) angles (degrees) of dorsiflexion of the ankle for 140 patients before and after surgery for equinus deformity after a cerebrovascular accident

	Ankle dorsiflexion	
	During knee extension	**During knee flexion**
Before surgery	1.5 ± 5.95	7.2 ± 4.74
After surgery	11.5 ± 5.04	16.5 ± 4.51

could be applied. The most benefit is obtained by surgery in Brunnstrom stages 3 and 4 (Table I). The improvement in the equinus deformity was maintained after operation in all patients. In eight patients there was insufficient correction of hammer-toe deformities. There were no instances of delayed wound healing or infection after operation.

Discussion

Dynamic derangement in the gait of adults with hemiplegia is caused by spasm and imbalance in the muscles of the affected leg. Although the hip and knee and their related muscles are also affected, the deformity which has the greatest effect on gait and mobility is an equinus deformity of the ankle.

Methods of treatment include lengthening of tendo Achillis, tendon transfer, nerve block or selective neurectomy. None of these, however, achieves satisfactory reliable results. The recovery of muscle function after acute hemiplegia is usually slow, unpredictable and incomplete, leading many physicians to recommend repeated manipulations of the joints of the leg. We have addressed this issue by using the Vulpius procedure to correct equinus deformities and allow early rehabilitation. It is most commonly used in the treatment of cerebral palsy in children. The aetiology of this type of upper motor neurone spasm is similar in adult hemiplegia. Meticulous excision of the gastrocnemius aponeurosis is equally effective in adult patients provided that the ankle has a normal passive range of movement. It may be carried out successfully under local anaesthesia and neither immobilisation of the leg nor bed-rest are required postoperatively. When compared with lengthening of tendo Achillis, there is no delayed or non-union of the tendon or increasing contracture because of immobilisation.

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