TRANSLANTATION OF THE HAMSTRING MUSCLES IN CEREBRAL PALSY

G. A. POLLOCK, EDINBURGH, SCOTLAND, and T. A. ENGLISH, HULL, ENGLAND

From the Princess Margaret Rose Orthopaedic Hospital, Edinburgh

The child suffering from spastic diplegia stands and walks with the hips and knees flexed and with equinus deformity at the ankles. This is an attitude which is a source of embarrassment to an intelligent child and to his friends, a handicap in walking, and often a bar to progress at school or at work. Adduction contractures at the hips are particularly distressing if the child is bedridden because they increase the difficulties of nursing (Pollock and Sharrard 1958, Lamb and Pollock 1962).

Eggers (1952) advocated transplantation of the hamstring tendons to the back of the lower femur. This operation relieved the tendency to flexion contracture of the knee while preserving the hamstrings' effect as hip extensors, and did not demand of them any antagonistic function.

In an earlier paper Eggers (1950) recommended division of the patellar retinacula to permit full extension of the knee. He found ultimately, however, that better results followed a combination of this retinacular release with transplantation of the hamstrings to the lower end of the femur.

Keats and Kambin (1962) claimed with reason that flexion deformity at the knee was caused primarily by muscle imbalance and led to stretching of the patellar tendon; for this reason he suggested that operations for taking up the slack patellar tendon (Chandler 1933, 1940) would have no permanently beneficial effect unless the imbalance was corrected at the same time. He found that his best results followed a combination of hamstring transplantation with Chandler's advancement of the patellar attachment more distally on the tibia (Roberts and Adams 1953, Baker 1956).

The present assessment of the results of the last ten years has led us to believe that careful selection of the cases is essential. The mental and physical capacity of the patient affect the success of the operation. An appraisal of the criteria for selection of cases seems particularly indicated because it is now considered that it may be justifiable to transplant the tendons into the extensor mechanism of the knee in higher grade spastic patients.

We have found that gradual stretching of the patellar retinacula by correction of the flexion contracture of the knee by serial plasters was usually as effective as surgical division. It had the great advantage of preserving the integrity of the quadriceps expansion. It did not increase the laxity of the patellar tendon when the knee was eventually straightened. Muscular imbalance was then corrected by transplantation of the hamstring tendons to the lower end of the femur (after Eggers).

This technique has remained fairly constant during ten years although in three recent operations the hamstring tendons have been reattached to the medial and lateral borders of the patella instead of to the femur. Baker and Hill (1964) recorded six cases in which medial rotation at the hip was corrected by transplanting the semitendinosus subcutaneously across the back of the femur to the front of the lateral femoral condyle; this operation was not used in our series.

MATERIAL AND METHOD

Transplantation of the hamstring muscles at their distal attachment was undertaken in thirty-one spastic patients of both sexes, all of whom were diplegic, except for one boy who was hemiplegic. The oldest patient was thirty-one and the youngest five years: most were
between the ages of eleven and seventeen years (Fig. 1). Fifty-four operations were performed: both legs were operated upon in twenty-three patients and only one leg in eight patients. The average duration of follow-up was five years, the longest ten years.

**Preliminary correction**—The flexion deformity at the knee was corrected as far as possible by preliminary manipulation under general anaesthesia, after which the limbs were immobilised in bilateral long-leg plasters, with the foot dorsiflexed to as near a right angle as possible. The two plasters, which were then separated by a wooden crossbar placed between the knees to maintain abduction of the hip, remained in position for two to three weeks. The weight of

![Graph](attachment:image.png)

**Fig. 1**

Transplantation of hamstring muscles. Age of patients at time of operation.

![Graph](attachment:image2.png)

**Fig. 2**

Analysis of muscles transposed.

the plasters when the patient was supine with the buttocks raised on a pillow helped to reduce the degree of fixed flexion at the hips.

**Operation**—If both legs were affected an interval of three weeks elapsed between operations. With the patient in the prone position and the limb exsanguinated, longitudinal S-shaped incisions were made over the lateral and medial groups of hamstring muscles in their lowest third. The semitendinosus and biceps tendons were transplanted in most cases (Fig. 2). In slightly less than half the cases the semimembranosus was transplanted too, and in seven cases the gracilis was also transplanted.
Experience showed that it was wise to leave one or more muscles to assist the gastrocnemii and popliteus to flex the knee, tension in the remaining muscles being adjusted by tendon lengthening if necessary. The transplanted tendons were laced into holes drilled in the lower femoral shaft and attached to themselves and to the surrounding periosteum, except in three recent cases in which the transfer was made to the lateral and medial borders of the patella. In eight limbs in which correction of the knee flexion deformity before operation was incomplete it was found necessary to detach the origins of the gastrocnemii in seven cases and the patellar retinacula in two; in one case posterior capsulotomy was performed in addition to the usual muscle transplantation. Plasters were retained for three weeks after operation, during which time the patients were taught hip extension exercises. When free of plaster the patients were taught to balance and to move with confidence in the swimming pool before walking with a ‘bonaped’ on dry land; in some cases calipers were helpful in the early months after operation.

Complications—No patient died in the early period after operation but the hemiplegic patient died two months after operation in status epilepticus. In one limb the femur fractured at the level of transplantation while still in plaster.

Recurrence of knee flexion contracture—Three knees became flexed after operation: two of them were in the case in which one femur fractured (Case 10, Fig. 3). The other contracture was gradual in onset and was fully corrected by tendon lengthening four years after the original operation (Case 19).

Limitation of knee flexion—This was present in three knees, resulting in inability to kneel on the affected leg. It occurred in two cases early in the series, when post-operative plasters were left on for six weeks, and it was in an attempt to reduce the incidence of this complication that the period was reduced to three weeks. For the same reason a departure was made from Eggers’s policy of transplanting all the hamstring muscles to the femur; in many cases one muscle, usually the semimembranosus, was left in support of the gastrocnemii and the popliteus.

ASSESSMENT AND RESULTS

The object of the operation was to improve the posture and general appearance of the patient as well as to increase his independence.

The final decision whether the patient was better, the same or worse after operation was based on the combined opinions (given independently) of the patient, the parent or regular attendant, the surgeon and the surgical assessor. Twenty-one patients were improved after
operation, five were unchanged and one was worse; it was too early for the decision to be made in four cases (Table I). These opinions took into account considerations of comfort, convenience, appearance and personality as well as the actual ability to walk and choice of walking aids. The measurement of walking ability was found to give the most useful quantitative assessment of individual results (Fig. 3).

*Hips*—The six patients whose walking was not improved after operation all had moderate or severe spasticity of hip muscles; some had unstable hips, and the thirteen patients with the best results had only mildly affected hip muscles. Our conclusion was that patients with severe hip involvement do less well after operation than the others. There was a definite improvement in hip extension after hamstring transplantation, and the average flexion deformity improved from 30 degrees before operation to 13 degrees after it; but some of this improvement is attributed to the plaster correction of the hip deformity, and to the long lever effect of a straighter knee which permits the limb weight to act at a greater distance from the hip.

**TABLE I**

<table>
<thead>
<tr>
<th>Opinion</th>
<th>Number of patients</th>
<th>Case numbers (See Figure 3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improved</td>
<td>21</td>
<td>2, 5, 6, 8, 9, 12, 13, 14, 16, 17, 18, 19, 20, 21, 22, 23, 24, 26, 27, 28, 29</td>
</tr>
<tr>
<td>Same</td>
<td>5</td>
<td>1, 4, 7, 10, 11</td>
</tr>
<tr>
<td>Worse</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Too early to assess</td>
<td>4</td>
<td>15, 25, 30, 31</td>
</tr>
<tr>
<td>Total</td>
<td>31</td>
<td></td>
</tr>
</tbody>
</table>

*Knees*—Fifty-two out of fifty-four knees that were operated upon showed improvement in range of extension. The average improvement was from 28 degrees short of full extension before operation to 5 degrees after operation. There was some improvement in extension in the seven spastic limbs which were not operated upon but which had plaster correction alone.

Knee extension power could not be measured accurately before operation because of the flexion contractures. A severe knee flexion contracture was not a contra-indication to operation provided that the general considerations were favourable. In the patients who improved in walking ability after operation, the power of extension was on average M.R.C. Grade 4.

Knee flexion range after operation was to more than a right angle in twenty-three knees, and was 60 degrees or less in nine knees.

*Apliances*—Thirteen patients wore long calipers before operation: eight discarded them afterwards and five retained them. Fifteen patients did not wear long calipers before operation: seven of these had no need of them afterwards, but four others used them for work or for walking long distances, and four unimproved patients were still not mobile enough to require them. Many patients wore calipers in the early months after operation but were able to discard them later.

**SELECTION OF PATIENTS AND FACTORS WHICH INFLUENCE RESULTS**

Operation was offered to all grades of spastic patient in whom there appeared to be some hope of improvement. The more specific indications which we have deduced from this survey were applied as they became evident.
In spastic patients general factors of personality, age, sex, balance and the involvement of arms and hips were thought to be important in affecting results. Mental capacity, foot deformities and unequal length of limbs were thought not to be of such specific importance. Our impression was that mental handicap in itself did not prejudice the results of operation nor act as a contra-indication, and that the operation was useful in these patients if the other general factors indicated a favourable outcome.

**Personality, sex and age**—It was noticed during treatment that improvement could be expected after operation in patients who showed a positive desire to get better in order to earn more, to become independent, to drive, dance, to be more attractive or to be less of a burden to their parents. It was our impression that this attitude was more prevalent in older boys and young men, and less common in girls and in young boys. Of the twenty-one patients who were improved after operation only one was a girl; the unimproved group of six patients included four girls (Cases 1, 3, 4 and 10). The average age of patients who were improved was sixteen years compared with eleven years in patients who were no better, though this distribution is affected by the fact that operation was offered to the more severely affected patients at an earlier age.

**Balance**—This was considered to be an important factor in prognosis. Four patients with no standing balance before operation but with good sitting balance were among those to gain most in independence or in improved ability, and the thirteen patients who derived most from the operation all had good or average balance when sitting. The patients who did not improve after operation all had poor balance.

After operation the improved mechanics allow the patient to apply his balancing ability to his legs as well as to his trunk. Practice in the use of his altered joint position and stretch reflexes is necessary for proficiency to improve, and both in this and in Eggers's series the greatest benefit was not apparent until a year after operation.

**Arms**—Improvement was limited in patients who could not use crutches, sticks or walking aids because of spasticity in their upper limbs. Normal arms are an effective means of balancing, and normal hand function is a stimulus to improve leg function in the pursuit of work and leisure. Correction of hand deformities by plaster, arthrodesis or tendon transplantation (Pollock 1962) should be done before the hamstrings are transplanted.

**Feet**—In this series the presence of foot deformity did not affect the outcome of hamstring transplantation.

**Inequality of leg length**—An average disparity of three-quarters of an inch was observed in eight patients, only one of whom had inequality of more than one inch. Four patients, all of whom were improved, found the inequality to be a minor handicap.

**DISCUSSION**

Operations on the locomotor apparatus of spastic patients are often regarded with pessimism. The question is whether it is worth while applying a limited mechanical rearrangement in the presence of derangements of mental capacity, balance and coordination. To prevent disappointment when an apparently sound mechanical procedure fails to produce the desired result, a strict assessment of the patient's general capabilities must be made. In a survey of fifty-four operations the general assessment of the patient was of the greatest importance in predicting the success of the proposed operation.

Although a mentally retarded child in an institution makes limited demands on his locomotor system, and may be unaware of his surroundings and uncritical of his appearance and actions, nevertheless a simple mechanical improvement such as the ability to stand up with only one assistant is a great advance from his attendant's viewpoint. The same result may be a complete failure in a sensitive girl who would like to be "like other girls" but who regards her practical improvement after operation as an insignificant advance towards
SUMMARY

1. A ten-year study of fifty-four operations for transplantation of the hamstring muscles in thirty-one spastic patients has been made.
2. Twenty-one patients were improved after operation, six were not improved, and in four the duration of follow-up was too short for proper assessment. One patient died from other causes.
3. Greatest benefit was not obtained until one year after operation.
4. The results varied considerably in different grades of spastic patient. Important factors affecting the results were age, sex, personality, balance and function of arm and hip. Hand and major hip operations should be carried out before hamstring transplantation.
5. The objectives of operation are discussed. These were most consistently achieved in older, more ambitious or more responsible males with good balance and with good arm and hip function.
6. Factors which were of less direct importance were mental capacity, minor degrees of limb length inequality, and foot deformities.
7. Operative correction of foot deformities should not be done before hamstring transplantation.
8. Serial plaster correction of the knee flexion deformity before operation is preferred to division of the patellar retinacula.
9. Transplantation of the hamstrings to the patella in spastics is under trial.

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REFERENCES


