POSTERIOR ILIOPSOAS TRANSPLANTATION
IN THE TREATMENT OF PARALYTIC DISLOCATION OF THE HIP

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Paralysis of the gluteal muscles of the hip, with active power still remaining in the flexor
and adductor muscles, presents one of the most serious orthopaedic problems in children.
With this distribution of paralysis, dislocation of the hip is almost inevitable, and it often
recurs despite tenotomy and osteotomy. Even if reduction of the paralytic dislocation is
finally secured the child may still be unable to walk.

Mustard (1952, 1959) showed that the iliopsoas tendon could be transplanted antero-
laterally in trying to compensate for abductor weakness, but in our experience this operation
failed to prevent recurrent dislocation when there was complete paralysis of gluteus medius,
minimus and maximus.

Posterior iliopsoas transplantation was tried in 1958 and at first the results were promising
(Sharrard 1959). Sufficient time has now elapsed for the method of operation to be improved
and for possible complications to be revealed. Some patients have now been under observation
long enough for the lasting value of the procedure to be determined. One hundred and fifty
operations have been performed in ninety-five patients (Table 1). The late results of forty-one

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operations in twenty-two patients followed up for periods of from two years to five and a half
years are available for detailed study.

Almost all the children had a meningomyelocele. The considerable increase in the number
of such children being brought for operation in the last eight years is related directly to advances
in the medical and surgical management of spina bifida cystica (Sharrard, Zachary, Lorber
and Bruce 1963) and of the hydrocephalus associated with it (Lorber 1961a and b), which have
reduced the mortality in the first year of life from over 90 per cent to less than 40 per cent.
Very many of those who survive are mentally normal, but more than one-third show dislocation
or subluxation of the hip at birth or during the first five years of life. Some need posterior
iliopsoas transplantation to restore stability at the hip, but it should not be performed on the
wrong type of case or for the wrong indications. An account of the paralysis and its relation
to the condition of the hip in meningomyelocele is therefore warranted before the operation
and its results are described.
PARALYSIS AND DEFORMITY IN MENINGOMYELOCELE

Paralysis or paresis of one or both lower limbs, with or without associated deformity, is present at birth in over 90 per cent of babies with thoraco-lumbar or lumbar meningomyelocele, and in over 50 per cent with lumbo-sacral or sacral meningomyelocele. A recent investigation showed that the degree of paralysis after the first month of life was related to the time of closure of the lesion (Sharrard, Zachary, Lorber and Bruce 1963). After closure within the first forty-eight hours of life there is often significant improvement in the paralytic state. Delaying closure, or allowing spontaneous healing of the defect, never produces improvement and the paralysis often becomes worse. Thus, to avoid errors in relating paralysis to deformity, all the patients now reviewed were those who had been operated upon during the first forty-eight hours of life and who might therefore be expected to have retained as much active musculature as possible. There were 281 such patients.

Seventy-eight children had no paralysis of either lower limb at birth and did not develop paralysis later, this number including all those with cervical and thoracic meningomyeloceles, some with thoraco-lumbar or lumbar meningomyelocele, and rather less than half of those with lumbo-sacral or sacral meningomyelocele. In none was there deformity at birth, nor did deformity develop later.

In twenty of the 203 children in whom one or both lower limbs showed some paralysis the distribution was irregular, there being either a scattered loss of function in one or more lumbar or sacral nerve roots or a mixed lesion of upper and lower motor neurones. In these children the deformity patterns were complex and they were excluded from the main analysis.

In the 366 lower limbs of the remaining 183 children the paralysis could be defined in terms of involvement of sacral, or of lumbar and sacral, nerve roots below a certain neurological level, with normal function above it. It was in these children that a study was made of the relationship between hip deformity and paralysis. Six groups were defined: 1) paralysis below the twelfth thoracic root; 2) paralysis below the first or second lumbar root; 3) paralysis
below the third or fourth lumbar root; 4) paralysis below the fifth lumbar root; 5) paralysis below the first sacral root; 6) no lower limb paralysis.

Each group was found to show a distinct pattern of deformity in the lower limb at birth and in early years associated with characteristic changes in the hip joints. The findings are summarised in Figure 1 which indicates the radiological state of the hip joints at the end of the first year of life. Figure 2 shows the root innervation of lower limb muscles to aid the reader in interpreting the analyses.

FIGS. 3 AND 4
Deformities at the age of 2 years. The right lower limb is completely paralysed (Group 1). The left lower limb is innervated by the first two lumbar roots only (Group 2).

FIGS. 5 AND 6
Group 3 paralysis of both lower limbs. Figure 5—Deformities at age of 3 weeks. Figure 6—Radiograph of hips at age of 9 months.
Group 1—In seventy-five limbs there was complete paralysis (Fig. 3). The hips were not dislocated at birth and did not dislocate later (Fig. 4). More than half developed a valgus deformity of the neck of the femur and some showed subluxation; but no dislocation was observed even in those who bore weight on the limb in later years.

Group 2—In seventy limbs there was innervation from the first, or the first and second lumbar nerve roots. There was moderate or strong active hip flexion and weak or moderate active hip adduction. All other muscles were paralysed. Apart from some fixed flexion there was usually no hip deformity at birth but progressive flexion and adduction deformity with valgus deformity of the neck of the femur developed in almost all during the first year of life (Fig. 3). At this time fifty-eight hips showed moderate or severe subluxation (Fig. 4) and eight were dislocated. If left untreated, some of the subluxated hips dislocated during the next three or four years.

Group 3—In eighty-seven limbs the upper three or four lumbar nerve roots were intact. The hip flexors were normal and the adductor and quadriceps muscles were strong or normal, but the abductors and extensors of the hip were completely paralysed except in a few patients in whom some fibres of the tensor fasciae latae were active. There was often gross deformity of the limb at birth with severe flexion, adduction and lateral rotation deformity of the hip, extension deformity of the knee and varus deformity of the foot (Figs. 5 and 28). In seventy-two limbs the hip was dislocated by the end of the first year, the dislocation having either been present at birth (Figs. 7, 15, 17, 19) or developed within the first month of life. The remaining thirteen hips were subluxated, moderately or severely, and when left untreated invariably progressed to complete dislocation (Figs. 6, 8, 26). Almost all showed some degree of valgus of the neck of the femur. A notable feature of the radiographs in these cases was that the acetabulum appeared to be normal and developed normally for at least the first year. It is for these hips that the term congenital paralytic dislocation is suggested.

Group 4—In twenty-seven limbs all the lumbar nerve roots were normal. The hip flexor, adductor and quadriceps muscles were normal. There was weak or moderate active abduction with paralysis of extension of the hip. The semitendinosus and semimembranosus muscles, the nerve root innervation of which corresponds with that of gluteus medius and minimus, were also acting. The deformity at birth and in later months was very like that in Group 2 with a slowly progressing flexion, adduction deformity (Fig. 9) leading to subluxation (Fig. 10) in twelve limbs, and to dislocation in seven limbs by the end of the first year. When left untreated, the subluxated hips dislocated later (Fig. 11) though some did not do so until the fifth or sixth year. Even if the hip did not dislocate, progressive fixed flexion deformity often developed. Valgus of the neck of the femur was present in one-third of these hips.
Group 4 paralysis. Figure 9—Deformities at age of 2 years. Figure 10—Radiograph of hips of another child aged 6 months, showing bilateral subluxation. Figure 11—Radiograph of hips of same child at age of 21 years, one year after transplantation of left iliopsoas. The left hip has remained reduced; the right has redislocated.

Group 5—In fifty-three limbs the only weakness of the hip was of extension. There was no deformity at birth except for mild fixed flexion in some infants; and the hip remained normal or at most developed a mild subluxation.

Group 6—In fifty-eight patients one limb was normal. No deformity or radiological abnormality was found or developed later in any of these limbs. It seems likely that if any of the dislocations in the other groups had been of the ordinary congenital type some would have occurred in the normal lower limbs. No child among more than 700 suffering from meningomyelocele seen during the last eight years has been found to have a subluxated or dislocated hip when the innervation of the limb was normal.

A word of caution is needed about children who when first seen have dislocation of the hip, possibly with other deformities, and at the same time complete paralysis of the limb. In many there has been delay in closure, or failure to close the spinal defect on the first day of life, or if operation has been done there has been serious wound infection. Normal nerve roots and spinal cord have thus been damaged, and muscles that were acting and were capable of producing deformity before birth have become paralysed. Posterior iliopsoas transplantation has no place in the treatment of these children.

THE PRINCIPLES OF POSTERIOR ILIOPSOAS TRANSPLANTATION

Tendon transplantation has two objects: the removal of deforming forces and the reinforcement or restoration of the action of a muscle that is weak or paralysed. In the lower limb removal of the deforming force is almost always the more important consequence of successful tendon transplantation. This is true also of iliopsoas transplantation. Although adductor predominance and contracture has been established as the primary cause of paralytic dislocation of the hip (Watson Jones 1926), iliopsoas action is an important secondary
deforming force and, as Somerville (1959) showed, the iliopsoas becomes a strong lateral rotator of the hip when there is valgus deformity of the femoral neck or when the hip is dislocated.

Posterior iliopsoas transplantation leaves sartorius, rectus femoris and pectineus as adequate flexors of the hip. By transferring the muscle posterior and lateral to the hip joint it becomes capable of extending as well as abducting it, thus balancing the activity of the remaining flexors and adductors. When the operation was first done it was not known how much power the iliopsoas might develop in a direction opposed to its normal action, or how it would function in walking. Since then experience has shown that, particularly when the transfer has been done before the age of four years, the muscle can abduct and extend the hip when the limb is off the ground and it can partake in the normal rhythm of muscle action in walking.

MATERIAL

One hundred and fifty operations were performed. The results of the first forty-one consecutive operations on twenty-two patients have been studied in detail. In the follow-up series the youngest child was aged ten months at the time of operation, the oldest was aged seven years and the mean age was three years. In the larger series the operation has been done on patients as young as four months old and as old as seventeen years.

All but one of the twenty-two children were suffering from paralysis secondary to a lumbar or lumbo-sacral meningomyelocele. The exception was a child with spastic tetraplegia and bilateral subluxation of the hips. Of the children with meningomyelocele nine had no hydrocephalus, four had moderate hydrocephalus and eight had severe hydrocephalus controlled by a ventriculo-cardiac shunt in seven and a theca-to-peritoneum shunt in one. The intelligence quotient was normal in all but one patient in whom the level was assessed at 90 per cent.

There were twenty-seven dislocated hips. Eleven hips were dislocated at birth, all in Group 3 (Figs. 7, 17, 19, 28). Sixteen hips showed subluxation at birth (Figs. 5, 6 and 10) going on to dislocation during the first two years of life (Fig. 8). Of these, thirteen were in Group 3 and three in Group 4.

Fourteen hips showed progressive subluxation but had not dislocated by the time the operation was done (Fig. 11, left side). All of these were in Group 4; the paralysis in the spastic child came into this group since there were spastic hip flexor and adductor muscles of normal power and weak abductor and extensor muscles with normal tone.

Only five of the twenty-two children—four with meningomyeloceles and the spastic child—were able to walk. All walked with flexed, adducted hips with considerable difficulty and leaning heavily on a walking aid. All had paralysis of Group 4 that was bilateral in four and unilateral in one. Seventeen children, including all those with unilateral or bilateral paralysis of Group 3 and one with bilateral paralysis of Group 4, were unable to walk, although nine of them were more than three years old and three were more than six years old.

CHOICE OF OPERATION FOR PARALYTIC DISLOCATION

Four operations are available for paralytic dislocation of the hip—adductor tenotomy, varus osteotomy, antero-lateral iliopsoas transplantation and posterior iliopsoas transplantation. The choice of operation or combination of operations depends on the degree of paralysis and deformity at the hip.

Adductor tenotomy—Adductor tenotomy alone or combined with excision of the anterior branch of the obturator nerve often suffices to correct progressive subluxation of the hip in cerebral palsy (Pollock and Sharrard 1958) when the imbalance between adductor and abductor power is not severe, but it is not adequate for the more severe imbalance associated with meningomyelocele. It is, however, essential that full passive abduction of the hips should be
obtained before any of the other three operations are done. Adductor tenotomy is sometimes needed to ensure this, and it is always needed before a paralytic dislocation can be reduced. In some cases subcutaneous tenotomy of the adductor longus and gracilis muscles may be adequate; in others, open tenotomy, sometimes with division of all the adductor attachments, is needed before full passive abduction can be obtained.

In this series, adductor tenotomy was performed at some time during the first eighteen months of life for all the eleven hips that were dislocated at birth. Reduction was achieved in six (Fig. 20) but failed in five (Fig. 17). Of the six that were reduced, three were subjected as soon as possible to posterior iliopsoas tendon transplantation and none of these redislocated (Fig. 21). The other three continued with abduction splintage and all of them dislocated again by the end of a year after reduction. These hips were reduced again after a second adductor tenotomy. After posterior iliopsoas tendon transplantation they stayed reduced. Of the five hips that were dislocated at birth and could not be reduced after adequate adductor tenotomy,

four were reduced at the time of posterior iliopsoas transplantation, when the psoas was separated from the lesser trochanter. One hip could not be reduced.

Adductor tenotomy was done in all sixteen hips subluxated at birth and later dislocating, and reduction was achieved easily in fifteen. Of these, seven were subjected to posterior iliopsoas transplantation and none subluxated or dislocated again (Fig. 12, left side). Eight were splinted in abduction. Five of these again became severely subluxated and three dislocated (Fig. 12, right side). All were reduced again by a second adductor tenotomy followed by tendon transplantation. The single hip that dislocated could not be reduced at the initial tenotomy was successfully reduced at the time of tendon transplantation.

Of the fourteen hips that were subluxated at the time of operation but had never been dislocated, only two required adductor tenotomy, and these were in the child with spastic tetraplegia. Partial division of the obturator nerve in addition to tenotomy was only done in the spastic child.

**Varus osteotomy**—The mechanism of paralytic dislocation of the hip and the place of varus osteotomy in its management was well reviewed by Somerville (1959) and Blundell Jones (1954, 1962). Adductor tenotomy and varus osteotomy as recommended by Blundell Jones will prevent or postpone dislocation in subluxated hips with paralysis of Groups 2 and 4 (Figs.

**Fig. 12**

Radiograph of hips of child shown in Figures 10 and 11, at age of 4 years, eighteen months after transplantation of right iliopsoas.
13 and 14), but with paralysis of Group 3 redislocation always occurs within two to four years even after adequate varus osteotomy unless posterior iliopsoas transplantation is done within that time. Varus osteotomy may nevertheless be used in infants with Group 3 paralysis if subluxation is progressing to dislocation or when a dislocation has been reduced before the child is old enough for iliopsoas transplantation (Figs. 15 and 16). It may also be needed for correction of bony deformity after iliopsoas transplantation (Figs. 18 and 21). External splintage can be avoided by using internal fixation with a miniature nail plate.

**Antero-lateral iliopsoas transplantation** (Mustard 1952)—This operation is indicated for dislocation of the hip caused by paresis or paralysis of gluteus medius and minimus in the presence of a working gluteus maximus. This pattern of paralysis rarely occurs other than in poliomyelitis. The operation was tried in four patients with dislocation associated with Group 3 paralysis. Two hips redislocated and two subluxated with recurrent flexion deformity.

**Posterior iliopsoas transplantation**—Severe muscle imbalance of the type seen in Group 3 paralysis is an absolute indication for this operation. Before the operation was used no child with paralysis of this group could walk without extensive apparatus including calipers with pelvic band and locking hip joints. In some, failure to obtain reduction after open adductor tenotomy was caused by a short iliopsoas tendon holding the femur up and laterally rotated (Fig. 17). Reduction is permitted by division of the tendon which can then be transplanted posteriorly at the same operation. Dislocation of the hip is less likely to occur early in limbs with Group 4 paralysis but inability to maintain extension of the hip makes walking difficult and, at best, the child walks with hips and knees flexed and is liable to develop recurrent flexion deformity at the hip and knee joint. Posterior iliopsoas transplantation improves the gait, allows pelvic support and hip hinges to be discarded and prevents recurrent flexion deformity.

**PREPARATION FOR OPERATION**

Any adduction deformity should be corrected by open adductor tenotomy and, if possible, the subluxation or dislocation of the hip should be reduced. Even in children up to the age of five the dislocation reduces more easily than does the congenital variety. When the dislocation is present at birth no attempt should be made to reduce it immediately. The splintage needed to maintain reduction interferes with the more important requirements for the care after the operations to close the meningomyelocele and—when necessary—to treat the
hydrocephalus. Once the child is thriving, open adductor tenotomy and reduction of the dislocation is indicated at any time after the third month (Figs. 19 and 20). Reduction by traction, frames or plaster is not advisable because of the possibility of serious results from pressure sores and vascular disturbance. A modification of the von Rosen splint is quite sufficient to maintain reduction with the hip in abduction and extension. If splintage has to be maintained for more than three months before iliopsoas transplantation, the splint should be left off during the day and reapplied only at night, or the hips will become fixed in the abducted position. In this respect the treatment differs from that in congenital dislocation, in which there is rarely any difficulty in restoring mobility even if splintage is maintained continuously for a year or more. Splintage just sufficient to maintain reduction should then be continued until the child is between one and two years old and the ideal time for tendon transplantation has been reached.

If, in spite of splintage, there is a tendency for the hip to subluxate during the second year, a varus osteotomy will maintain reduction for the next year or two (Fig. 16).

If adequate adductor tenotomy fails to reduce the dislocation the abducted position should still be maintained by splintage and combined reduction and tendon transplantation should be done as soon as the child’s general condition allows. The youngest child so operated on was four months old.

The child is admitted two or three days before operation to allow a thorough assessment of its general condition. In particular, the state of the hydrocephalus and of any controlling apparatus is examined and tests of renal function are done.

**TECHNIQUE OF OPERATION**

The plan of action of the operation is shown in Figures 22 to 25.

After induction of anaesthesia an intravenous saline infusion is begun. Blood can be given during and after the operation. Blood loss in small children is best determined by the method described by Alsop, Emery and Zachary (1963). The mean loss in this series in children between the ages of two and four has been 100 millilitres. The patient lies on an ordinary operation table slightly tilted to the opposite side. An incision is made along the anterior two-thirds of the iliac crest and follows the medial border of the sartorius in the upper half of the thigh. The dissection proceeds down to the deep fascia, often, in the case of meningomyelocele, through a very substantial fatty layer. Branches of lumbar nerves may be encountered at the posterior end of the incision and should be preserved. The iliac crest is defined in the upper half of the incision. In many young children the abdominal wall overhangs the iliac crest and must be dissected upwards to reveal it. The gluteal fascia is defined and
incised along the middle and posterior thirds of the iliac crest to show the underlying gluteus medius muscle which is usually atrophic or completely converted to fat. The fascia covering the tensor fasciae latae can usually be left untouched, unless there is any fixed flexion deformity that needs to be released. The outer surface of the ilium is exposed by removing the remains of the gluteus medius and minimus from it with a rugine, the particular aim being to expose the more posterior part of the bone through which the iliopsoas will later be transplanted. Packs are inserted to control any bleeding, and attention is then transferred to the dissection of the thigh.

The deep fascia is incised to expose the sartorius in its upper half. The lateral cutaneous nerve of the thigh is identified and should be preserved if possible since it is one of the nerves that is likely to have retained some intact sensory fibres. A small vessel that crosses the origin of the sartorius is divided. The origin of the sartorius from the anterior superior iliac spine can be left untouched unless there is a severe fixed flexion deformity. If flexion deformity of the hip is associated with extension deformity of the knee the tendon of origin of the rectus femoris may be divided. The lower border of the inguinal ligament is defined by blunt dissection and a layer of deep fascia distal to it is dissected away to expose the femoral nerve as it emerges from the pelvis. If any difficulty is experienced in discovering the femoral nerve the nerve supply to the sartorius can be traced up to meet it, or the femoral nerve can be found easily after the pelvis has been entered. The femoral nerve is defined and mobilised a little from its surroundings towards the lateral side. All its branches except one pass downwards or laterally. The branch that passes medially appears to be a sensory supply and can be divided if necessary.

The inner aspect of the false pelvis is now exposed by detaching the abdominal muscles from the anterior two-thirds of the iliac crest. In a young child it is convenient to detach the cartilaginous rim of the iliac crest to provide a firm base for suturing at the end of the operation. The whole of the abdominal wall and its contents, including the inguinal canal, can then be displaced upwards, the dissection following the plane between the iliacus and the extra-peritoneal fat and fascia. Only one small vessel passes between the two surfaces and requires division. Retraction allows the whole of the iliacus and the pelvic course of the femoral nerve and psoas muscle to be exposed.

The psoas muscle is followed distally and its tendon is defined as it passes over the hip joint. Distal to this the tendon dives back steeply towards the lesser trochanter between the

Fig. 17

Fig. 18

Varus osteotomy combined with transplantation of iliopsoas. Figure 17—Radiograph of hips of child with Group 3 paralysis, at age of 8 months. Bilateral dislocation unreduced after radical adductor tenotomy. Note the gross lateral rotation deformity. Figure 18—Same child at age of 2 years, one year after bilateral iliopsoas transplantation and varus osteotomy. Satisfactory reduction of right hip; persistent subluxation of left. Three years later the position was unchanged.
Paralytic dislocation treated by iliopsoas transplantation and varus osteotomy. Figure 19—Radiograph of hips of child with Group 3 paralysis, aged 6 months. Bilateral dislocation. Figure 20—Same child aged 15 months after bilateral adductor tenotomy and iliopsoas transplantation. This was followed by varus osteotomy on the left and "spontaneous osteotomy" on the right. Figure 21—Same child aged 2 years 3 months. Hips have remained reduced and the angles of the femoral necks are normal.
femoral nerve and femoral vessels. The hip is flexed and laterally rotated to bring the lesser trochanter forward. By careful retraction medially of the femoral vessels and laterally of the femoral nerve, it is possible in some limbs to reach and define the lesser trochanter without ligation of the lateral femoral circumflex vessels. In others these vessels should be very carefully dissected out, ligated and divided. The whole of the psoas tendon can now be seen. Only half of the tendon is attached to the lesser trochanter itself; the remainder separates off into a deeper layer after it has passed across the hip joint to be attached to the shaft of the femur. The lesser trochanter with its attached portion of psoas tendon is detached with a Smillie's meniscus knife in a young child, or with an osteotome in an older child. The deeper separate portion of the psoas tendon is then divided and the whole psoas tendon mobilised upwards into the pelvis, the bursa deep to it indicating the plane of separation. The fibres of the iliacus
that are inserted into the iliopsoas tendon are preserved but that part of the iliacus whose fibres proceed independently to be attached to the femoral shaft is cut at the level of the inguinal ligament.

Dissection proceeds up into the false pelvis. The femoral nerve is carefully mobilised from the iliacus and psoas, care being taken to preserve the nerve supply to the iliacus which usually arises by two branches, one given off soon after the femoral nerve enters the pelvis and the other about half way through its pelvic course. The distal branch may have to be dissected up to some extent from the main nerve. The hip is flexed to relax the femoral nerve so that the iliopsoas tendon and the attached portion of lesser trochanter can be passed beneath it to its lateral side. The origin of the iliacus is detached extra-periosteally from the inner aspect of the false pelvis by blunt and sharp dissection. It detaches easily, its origin being from the periphery of the pelvis, but it is important that it should be separated from the ilium posteriorly so that the whole of its origin is free. When this has been achieved, the whole false pelvis, the anterior aspect of the sacro-iliac joint, the brim of the true pelvis and the extra-peritoneal fat lateral to the fifth lumbar vertebra can all be seen. The iliacus has now been detached at both ends though it still retains all its nerve supply, and a sufficient blood supply, particularly on its deep surface, from branches of the iliolumbar vessels. In older children one branch from the vessels supplying the deep surface of the iliacus passes into the nutrient foramen on the inner surface of the iliac wing and this vessel needs to be divided and coagulated. Most of the anterior two-thirds of the iliac bone is now exposed on both sides.

With an angled osteotome a hole is made in the ilium immediately lateral to the sacro-iliac joint. The width of the hole should be slightly more than one-third of that of the iliac wing. It should be oval, its length being about half as much again as its width, and it should lie with its long axis in the longitudinal plane. Care must be taken to ensure that both cortical layers of the bone have been removed. The iliopsoas tendon and the whole of the iliacus muscle are then passed through the hole. In earlier operations the tendon with its attached fragment of lesser trochanter was passed through the hole first, but difficulty was sometimes encountered in passing the whole of the iliacus through without enlarging the hole. It was found that if the origin of the iliacus were passed through the hole first, it would go through easily and that the psoas muscle and iliopsoas tendon would readily follow. The whole of the iliacus now lies outside the pelvis but is still attached to its nerve and vessels which pass through the hole in the bone.

The new insertion of the iliopsoas tendon is to be the postero-lateral aspect of the greater trochanter. If necessary this part of the greater trochanter can be exposed through a separate posterior skin incision, but this has never been needed in any of the cases reviewed here. By passing a finger from the gluteal region distally and posteriorly into the bursa deep to the gluteus maximus tendon the postero-lateral aspect of the greater trochanter can be identified by touch. By reference to this point, the corresponding anterior aspect of the greater trochanter is exposed by dissecting through the fascia lata and a number of layers of fatty and fibrous tissue overlying the trochanter. A tunnel passing through the greater trochanter from front to back is made by awls and enlarged by Paton's burrs until it is big enough to receive the tendon. A strong silk suture is attached by clove-hitch to the fragment of lesser trochanter and to the iliopsoas tendon. A special instrument was designed to facilitate the passing of the tendon from behind forwards through the bone. This is an anaesthetist's metal sucker with its distal end partially amputated and bent through a right angle, the whole instrument acting as a cannula. This tendon cannula is passed through the bony tunnel so that its tip appears in the gluteal region. A piece of wire passed down the cannula is used to pull the suture attached to the tendon through the cannula. The end of the tendon with its fragment of lesser trochanter is inserted just into the end of the cannula and the suture wound round the finger grip of the cannula. In this way, tendon and suture are all fixed together in one piece. The cannula is pulled through the tunnel, guiding the tendon through the posterior
entrance to the tunnel and bringing it to the front of the greater trochanter. While this is being done the hip is abducted and extended in neutral rotation. In most cases the tendon will come right through to the anterior surface of the trochanter to which it can be fixed with several strong sutures. Failing this, the suture used to pull the tendon into the bony tunnel can be fixed to the tissues on the anterior aspect of the trochanter. The tendon must be sutured under as much tension as can be reasonably obtained. Care must be taken to ensure that the line of the tendon passes directly from the inside of the abdomen through the hole in the ilium to the greater trochanter.

When the iliopsoas tendon has been firmly fixed to the femur the origin of the iliacaus can be sutured to the ilium just below the iliac crest in the position corresponding to the origin of the glutus medius. In a young child it is convenient to use for this suture a trochar pointed needle that can penetrate the thin bone or cartilage of the iliac wing. After tendon fixation the hip should be moved gently in abduction and adduction and in flexion and extension to demonstrate that the psoas muscle is moving correspondingly inside the abdomen.

Closure is obtained by suturing the abdominal muscles and gluteal fascia back to the iliac crest. The space between the inguinal ligament and the pubic bone is closed by suturing the inguinal ligament to the ilio-pectineal line. Deep fascia, fat and skin are sutured. A plaster spica extending to the toes on the affected side is applied with the hip joints in full abduction and extension and in neutral or medial rotation depending on the degree of femoral anteversion present. In children with bladder paralysis, which includes almost all those with meningocele, an area above the pubis must be left exposed to permit bladder emptying by expression. Even so, the spica is likely to become softened by urine and it is a wise precaution to incorporate a bar between the front of the thigh pieces of the spica to prevent the plaster from collapsing at the end of the second week. Careful watch for plaster pressure must be kept. Since the feet in almost all patients with meningocele have sensory paralysis and often almost complete motor paralysis, it is advisable to incorporate the whole of the foot on the operated side in the plaster so as to avoid pressure on the heel or on the back of the tendo calcaneus.

All fixation can be discarded at three and a half weeks in children of two or three years, at four weeks in children of up to six years and at four and a half weeks in children of up to ten years. If the same operation has to be done on the opposite side, the second operation can be done after three weeks, or, if the child’s condition permits, on the same day.

CARE AFTER OPERATION

After operation a watch must be kept for any evidence of ileus, though none has developed in any patient operated upon so far. The intravenous saline infusion is maintained for the first forty-eight hours until the child resumes normal feeding. Penicillin and streptomycin have usually been given for the first week. It has been possible for many young children to be taken home in plaster on the tenth day.

After removal of the plaster the limb lies in abduction and extension to an extent depending on the angle of abduction that was necessary to allow the hip to be reduced. When considerable abduction is needed to maintain reduction there is usually severe valgus deformity of the femoral neck and varus osteotomy is indicated (Figs. 18, 20, 21). In three cases spontaneous greenstick fracture of the neck of the femur occurred during the days between the removal of the plaster and the intended osteotomy. In two of these the fracture occurred at the exact position at which osteotomy would have been done (Fig. 21).

Apart from varus osteotomy with or without rotation, some patients have required other secondary procedures to correct deformities, particularly at the foot, before walking could begin. Correction of severe varus deformities of the heel by soft-tissue division and skin elongation, section of the tendo calcaneus, soft-tissue correction and tendon transplantation
to the calf for calcaneus, quadriicepsplasty for genu recurvatum and hamstring tenotomy for flexion deformity of the knee have been needed in various patients. In only seven patients was there no other deformity to correct.

**FINDINGS AT OPERATION**

In all patients with meningomyelocele the clinical assessment of muscle activity proved to be correct. Psoas, iliacus, sartorius, pectineus, rectus femoris and vasti appeared macroscopically normal and the histological appearances of any biopsy specimens were normal. Tensor fasciae latae, gluteus medius and gluteus minimus showed appearances varying between complete fibro-fatty replacement and partial innervation that corresponded reasonably well with the clinical estimate of abductor activity and even more precisely with the condition of the hip joint. In every patient in whom dislocation had been present at birth these muscles showed complete fibro-fatty replacement. When the hip had been subluxated at birth and had later dislocated, any muscle fibres that were present showed histological evidence of denervation. When the hip had not dislocated but remained persistently subluxated, the tensor fasciae latae and gluteus medius showed a proportion of normally innervated muscle though gluteus minimus was almost completely denervated. Gluteus maximus was completely denervated in all children with meningomyelocele.

In fifteen cases in which the hip was reduced at the time of the transplant operation or in which the hip had been reduced after adductor tenotomy within a month preceding the operation, it was possible to study the mechanism of dislocation. Although adduction alone caused the hip to dislocate in some, lateral rotation appeared to play a very important part in almost all cases. The combination of lateral rotation, adduction and flexion caused the head of the femur to rotate spirally out of the acetabulum. The head of the femur left the acetabulum anteriorly and the continuation of the movement allowed it to displace upwards to lie in the characteristic position above and in front of the acetabulum. It was also noticeable in recent cases that the anterior capsule of the hip joint was loose and stretched and the fibres of the ilio-femoral ligament were attenuated.

The part played by the iliopsoas muscle in this mechanism is important. In the normal hip with an intact capsule and ilio-femoral ligaments and a normal angle to the neck of the femur, traction on the iliopsoas tendon causes flexion of the hip with perhaps a slight tendency to medial rotation. With fixed adduction and a valgus deformity of the femoral neck the psoas is a lateral rotator that aggravates or maintains the dislocation (Somerville 1959). In cases in which the hip could not be reduced after an adequate adductor tenotomy the iliopsoas tendon was found to be maintaining proximal displacement and lateral rotation. When the insertion of the tendon was detached, reduction was obtained by abduction and medial rotation.

In six patients the hip joint was opened to expose the acetabulum. No limbus obstructing reduction was found in any case. In all the younger patients the acetabulum appeared to be completely normal. In four hips in which there had been gradually increasing subluxation leading to dislocation, the roof of the acetabulum was partially deficient but, once the muscle shortening had been corrected, the head of the femur was stable in the acetabulum. The appearances suggested that the deficiency of the acetabular roof was secondary rather than primary.

The neck of the femur showed valgus deformity that sometimes was severe (Blundell Jones 1962) and, in any hip that had been completely dislocated, was usually combined with an increased angle of anteverision. Anteverision was much less marked in the hips that had not been dislocated, and in which there was some abductor power.

**TECHNICAL DIFFICULTIES**

Many of the difficulties that were experienced at first were caused by unfamiliarity with the detailed anatomy of the area. Only at three points has any real technical difficulty persisted:
1) The difficulty of exposing the lesser trochanter by an approach between the femoral nerve and vessels depends on the depth at which the trochanter lies. 2) It may be difficult to separate the origin of the iliacus muscle from the most posterior and medial aspects of the inner surface of the ilium. Sometimes the wing of the ilium is rather vertical and access to the false pelvis is restricted. If the iliacus is not fully detached it will not pass completely through the foramen in the next stage of the operation. To obtain a satisfactory exposure in these cases more of the iliac crest may have to be detached than usual. 3) The most persistent difficulty has been in the passage of the iliopsoas tendon through the greater trochanter from behind forwards. The point of entrance cannot be seen, and, if the usual methods for transferring a tendon through a bony tunnel are employed, the tendon is very likely to jam in the entrance. The use of the instrument described above has almost completely eliminated this difficulty. It should be possible on almost every occasion to bring the tip of the tendon with the attached piece of trochanter through to the anterior surface of the greater trochanter so that the tendon is fixed under sufficient tension. In one or two of the earlier cases in this series this was not achieved and in these rather less stability of the hip was obtained and strong active extension and abduction of the hip was not demonstrable.

Now that the technical difficulties have been overcome, the time for the operation is between one and a quarter hours and two and a half hours from induction of the anaesthesia to completion of the plaster spica.

RESULTS—WHOLE SERIES

For assessment of the immediate morbidity and mortality of the operation all 150 operations done between 1958 and 1963 are included. There have been two deaths directly related to the operation. The first, in a child of two, was caused by a virulent streptococcal infection that proved to have originated in the child's own throat. The second was in a girl of eight in whom combined reduction of the dislocation and posterior iliopsoas transplantation had been performed. Her condition remained very satisfactory for the first twelve hours, but she then showed steady deterioration with increasing signs of shock, and died. Permission for necropsy was refused.

Complications have been very few indeed. A subcutaneous haematoma with mild secondary infection developed after three of the operations in the early part of the series. In each case the wounds healed by second intention in about three weeks. In the last sixty operations no patient has developed this complication.

One child died two years after the operation of an unrelated broncho-pneumonia. This was the only patient in whom it was possible to obtain a necropsy dissection. This showed that the transplanted muscle was in good position. Histological sections confirmed that the fibres of the psoas and iliacus muscles were normal. The psoas tendon and muscle were free to move in the iliac foramen and the nerve and blood supply to psoas and iliacus had been satisfactorily preserved.

RESULTS—LATE REVIEW

Twenty-two patients operated upon more than two years ago have been reviewed to determine their ability to walk, the function present in the transplanted muscle and the clinical and radiological condition of the hip joint. With the exception of one child who died shortly after operation, all patients, representing forty operations, were reviewed.

Walking ability—All the children in this series are now walking. Most of those operated on before the age of four have become able to walk without any support on the limb or simply with double iron below the knee to support a flail foot. Many have progressed through use of a walking plough to tripod sticks, ordinary sticks and finally no external aids (Figs. 28 and 29).
A remarkable feature has been the ease with which every child has been able to walk upright and to maintain extension of the hips without difficulty. This contrasts even with the few who could walk before operation but with flexed hips. In most, a slight Trendelenburg gait is present. In a few there is a more marked Trendelenburg gait when weight is borne on one side and in these the common factor has been that the tendon was not attached to the greater trochanter under sufficient tension.

**Action in the transplanted muscle**—When the muscle has been transplanted in children between the age of two and four years and particularly in those children who have never previously walked, it seems that the transplanted muscle functions as a true gluteal replacement. “Re-education” of the muscle action is rapid and automatic and independent abduction and extension of the hip can be demonstrated. In all of them appearances suggest that the muscle is contracting to stabilise the pelvis when weight is borne on the limb. In older children accommodation to the new function of the muscle takes longer and does require some specific training. Even in those in whom independent activity of the muscle is difficult to demonstrate, the transplant appears to be able to act as an active tenodesis.

**Maintenance of reduction of hip**—In all but five hips the head of the femur remained satisfactorily reduced (Figs. 12, 21, 27). Four hips showed some subluxation that was present immediately after the operation and has not increased since (Fig. 18). One hip remains dislocated. Reduction has been maintained even in those in whom there was moderate valgus of the neck of the femur that was not corrected by osteotomy. Osteotomy after iliopsoas transplantation is now reserved for the hips in which a position of extreme abduction has in the first instance been necessary for reduction. In those in whom the operation has been done more than three years ago, there is reason to believe that valgus deformity of the neck of the femur may be showing some spontaneous correction possibly because of the combined effects of the pull of the transplant on the greater trochanter and the forces of weight bearing (Fig. 21).

A feature of the radiographs taken after operation is the large size of the foramen in the ilium (Figs. 12, 18, 27). This appearance arises, in part, because, in an antero-posterior
radiographic projection, the part of the ilium that is seen is mainly the postero-medial part of the bone through which the hole was made. The hole does, in fact, enlarge, possibly because of loss of part of the vascular supply to the bone (Figs. 18, 20, 21). However, in the case in which a necropsy examination was done the foramen was so well closed by a firm membrane that there was no likelihood of herniation of intestinal contents through it. There has been no herniation beneath the inguinal ligament.

In no hip has any fixed flexion deformity recurred. The range of passive abduction has varied between 50 and 90 degrees and the range of medial and lateral rotation has varied between 40 and 90 degrees in either direction. In some—usually in those in which there was marked increase in the angle of anteversion of the neck of the femur—a limited range of lateral rotation has made it necessary for a lateral rotation osteotomy of the shaft of the femur to be performed to prevent walking with persistent in-toeing.

![Figure 28](image1)

![Figure 29](image2)

**Fig. 28** Late results of iliopsoas transplantation. **Fig. 29**—Child with Group 3 paralysis of both lower limbs, aged 3 weeks. There is fixed flexion, adduction and lateral rotation deformity of both hips with dislocation. There is also fixed genu recurvatum and severe calcaneo-varus deformity. **Figure** 29—Same child aged 4 years, two years after bilateral iliopsoas transplantation. She can walk without any external aids.

**COMMENT**

The primary cause and problem in paralytic dislocation of the hip is unbalanced muscle force. It may be present in children with poliomyelitis, cerebral palsy or meningomyelocele. Valgus of the neck of the femur makes dislocation more likely but it, in turn, may be secondary to the absence of muscle pull on the greater trochanter. Although varus osteotomy alone may be sufficient to prevent redislocation in the presence of a severe valgus of the neck of the femur when the muscle imbalance is not too great, it is not adequate to prevent redislocation in children with complete gluteal paralysis and normal flexor and adductor muscles, a finding confirmed in Blundell Jones's (1962) series.

Posterior iliopsoas transplantation was initially devised as a measure of desperation to prevent recurrent dislocation of the hip. The important principle of removal of a deforming force and transplantation to produce a correcting force is that of other successful tendon transplantations in the lower limb. The ability of the transplanted muscle to stabilise the hip and to allow walking without the need for any external support was an unexpected result that has made the operation a rational procedure when gluteal abduction is present but weak.
and there is paralysis of gluteus maximus. In these patients the hip less often dislocates but recurrent flexion deformity is very likely to develop and the child almost always walks with the hips flexed and adducted.

The position with regard to dislocation of the hip in spastic paralysis is not yet so certain. Only one patient in this series has been followed for more than two years and, in any event, the number of patients with spastic paralysis in whom dislocation or subluxation of the hip cannot be prevented by adductor tenotomy and division of the anterior branch of the obturator nerve is small. In a few extreme instances dislocation recurs in spite of adequate adductor tenotomy in a child who has previously been capable of some walking or who appears to have sufficient intelligence to benefit. Posterior iliopsoas transplantation will prevent further dislocation but it is too early to assess what the functional result may be until more patients of this type have been treated.

SUMMARY

1. The indications for and technique of posterior iliopsoas transplantation are described with particular reference to paralytic dislocation and subluxation of the hip in children.
2. Experience of 150 operations in ninety-five patients and of the long-term results of forty-one operations are given.
3. Reduction of the dislocation has been maintained in every case even when there was complete paralysis of all gluteal muscles.
4. All the children are able to walk without the aid of hip splintage.

REFERENCES


