QUADRICEPSPLASTY

THE TREATMENT OF STIFF KNEE FOLLOWING TRAUMA

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THERE are some joints, such as the wrist, ankle and tarsus, in which stiffness is compatible with excellent function, and even the effects of an arthrodesis may be masked almost beyond recognition. In the knee joint, however, any serious limitation of movement is a very considerable handicap, the effects of which can neither be disguised nor overcome. The patient is debarred from a considerable range of occupations and recreations; he may have to change both his job and his hobbies, and he is constantly being embarrassed by all the people who fall over his outstretched leg in buses, theatres, cinemas and the like, many of whom in their ignorance do not hesitate to upbraid him for a clumsy and inconsiderate fellow.

Such stiffness may follow either disease or trauma. When it is the result of infection or arthritis, attempts at restoring movement are not only disappointing but dangerous, and if any surgery at all is called for because of pain, instability or progressive deformity, it is usually better to do an arthrodesis. When it follows trauma, however, the outlook is almost completely reversed and the most gratifying results can be obtained, even in the stiffest and most unpromising knees, by the operation of quadricepsplasty. This is in fact one of the most rewarding operations in the orthopaedic surgeon's repertoire, but one gets the impression that it is also one of the most neglected, simply because its possibilities are not sufficiently appreciated. Since Bennett's original paper in 1922 and Thompson's classic contribution in 1944, the subject has received very little attention in the literature, though such reports as have appeared have been consistently favourable (Judet, 1959; van Nes, 1962; Nicoll, 1963; Hesketh, 1963).

This neglect of a good operation is all the more perplexing when one reflects on the

enormous amounts of time, energy and ingenuity that have been spent, for the most part unprofitably, on the stiff hip. Moreover, the type of stiff knee most amenable to surgery occurs predominantly in young, fit and otherwise active people, so it should not lightly be accepted either by surgeon or patient. The problem is bound to increase in the future as the mounting toll of road accidents pursues its apparently inexorable course. These high velocity injuries produce exactly the kind of fracture that can result in a stiff knee, and it is therefore important that the operation of quadricepsplasty, which has such rewarding possibilities, should be more widely known. The object of the present paper is to present an analysis of 38 cases operated on during the past 16 years, the results of which have been most encouraging.

Causes

The causes of stiff knee requiring quadricepsplasty in the present series are shown in Table 1.

TABLE 1
CAUSES OF KNEE STIFFNESS (38 PATIENTS)

Cause	Number of patients
Fracture of femoral shaft	
Normal union 9	26
Delayed union 9	
Non-union requiring grafting 8	
Fracture of femoral condyles ...	2
Fracture-dislocation of knee ...	2
Fracture of tibial plateau	3
Synovectomy	2
Hip conditions	3
Total ...	38

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FIG. 1.—Superimposed radiographs showing the excursion of the patella between full extension and 130° of flexion.

By far the commonest cause is fracture of the femoral shaft, particularly if this is in the lower half of the bone and is complicated by severe soft tissue damage, comminution or delayed union. In the present series, 26 cases (70%) followed fractures of the femur and 17 of these (65%) were complicated by delayed union or non-union. It would be wrong to infer from these figures, however, that stiffness of the knee is a frequent complication of femoral shaft fractures. Half the patients in the present series were referred from other centres, leaving only 13 cases in 16 years of entirely endogenous origin. These came from two hospitals serving a population of 400,000 people in an area of heavy industry with a high accident rate. It is therefore a comparatively rare complication, as of course it should be in any properly organised accident service. Indeed, the surgeon who could produce a large series entirely of his own making would probably feel somewhat reticent about publishing his experiences.

All the 26 cases following fracture of the femoral shaft resulted from conservative treatment. There was no instance of stiff knee

following intramedullary nailing, although this procedure had been adopted in nearly a third of all femoral shaft fractures treated during the 16-year period under review. Moreover, these operations were all done from the anterior approach, so the current fashion of condemning this approach on the grounds that it causes stiff knees is not supported by the facts. Stiffness is caused not by a clean surgical incision through muscle, but by the prolonged immobilisation of damaged soft tissues spanning both sides of a joint.

Mechanism of Stiffness

The mechanism of knee stiffness following trauma can be explained in terms of the pathological anatomy. Blocking may occur in any or all of four different places:—

1. Lower third of thigh and suprapatellar pouch, due to fibrosis of vastus intermedius.
2. Retropatellar, due to adhesions from patella to femur.

3. Paracondylar, due to adhesions of the aponeurotic expansions of the vasti to the sides of the femoral condyles.
4. Inside the knee joint, due to adhesions between the femoral and tibial articular surfaces, or to contracture of the posterior cruciate ligament.

Adhesions in the first three places act by limiting the distal excursions of the patella during flexion and it is not always realised just how much this is. The superimposed radiographs in Fig. 1 show that in fact it travels a distance of $3\frac{1}{2}$ inches (9 centimetres) throughout its full range and more than half of this occurs in the first 60° . This also represents the excursion of the quadriceps tendon and anything that anchors this tendon will limit flexion. If, for example, there are adhesions which reach full stretch after the patella has travelled 2 inches, movement will be limited to about 60 degrees. The quadriceps tendon is a complex mechanism, consisting of two central components (rectus femoris and vastus intermedius) which fuse to form a single tendon above their insertion into the patella, and two lateral expansions (vastus medialis and lateralis) which pass round the sides of the patella, to which they are attached before continuing distally to be inserted into the ligamentum patellae and the tibia. In the normal knee, these aponeurotic expansions glide freely over the femoral condyles, from which they are separated by a sulcus lined by synovial membrane. If this sulcus is obliterated by adhesions, the aponeurotic expansions get stuck down, and by virtue of their attachment to the patella can limit flexion just as effectively as when the patella itself is stuck. This is, in fact, one of the commonest mechanisms of stiffness in all hinge joints and it can occur from prolonged immobilisation alone, even when the joint itself has not been involved in the fracture.

The component of the quadriceps most frequently damaged is the vastus intermedius, which is wrapped round the bone and therefore most liable to be torn or contused in the type of comminuted fracture by direct violence so frequently seen in the present day high velocity injury. The muscle becomes fibrotic and inextensible and through its deep attachment to the rectus femoris tendon it anchors the patella like a check rein (Fig 2). This tethering action is clearly seen in idiopathic contracture of the vastus intermedius, a rare

Fig. 2 (a)

Fig. 2 (b)

FIG. 2.—Diagrammatic representation of effect of fibrosis of vastus intermedius and of adhesions inside the knee joint.

- (a) Knee extended : adhesions relaxed.
- (b) Knee flexed : adhesions tight.

condition occurring in young children. Flexion can be restored quite easily in these patients by dividing the fibrotic intermedius tendon and disconnecting it from the rest of the quadriceps apparatus.

The patella is frequently bound down to the front of the femur by adhesions (Fig. 2) and in several cases in the present series it was stuck so firmly that it had to be dissected off with a scalpel.

Finally, there are often adhesions in the knee joint itself (Fig. 2). These may extend from the femoral to the tibial condyles or there may be a contracture of the posterior cruciate ligament. This ligament is normally slack in extension and taut in flexion. If it contracts, as it may do if it is immobilised for a long time in its shortened position, it will limit flexion.

There is one other way in which flexion can be blocked after all the above causes have been dealt with, and that is by contracture of the rectus femoris itself. In this condition the muscle becomes so fibrous that it completely loses its extensibility. To use an analogy, the patella is then, as it were, attached to the pelvis by a piece of string instead of a piece of elastic. Fortunately this is rare—it only happened four times in 38 cases in the present series—but when it does occur it is comparable to contracture of the tendo Achillis causing fixed equinus of the ankle and must be dealt with along similar lines by lengthening the tendon. This was the basis of the original Bennett procedure, but interference with the tendon should be avoided if at all possible because it always leads to loss of active extension. This is related to the long excursion of the tendon, which may have to be lengthened as much as 3 inches to gain 130 degrees of flexion. When the knee is straightened again after such a lengthening procedure, the elongated tendon curls up in a series of folds and it is obvious that the fibrotic rectus muscle is quite incapable of taking up so much slack. In a normal knee this would not matter because full extension can be achieved by the vasti alone, as can easily be demonstrated in any case of patellectomy for arthritis in which no attempt has been made to restore continuity between the rectus tendon and the ligamentum patellæ. However, in the circumstances in which the rectus femoris has to be lengthened in quadricepsplasty the expansions of the vasti have already been disconnected from the patella and their extensor action seriously interfered with. However, if loss of voluntary extension has to be accepted in order to gain a reasonable amount of flexion, it is a penalty well worth incurring, provided there is no loss of *passive* extension.

The disability in these cases of “extension lag” is surprisingly slight, and in explaining this to patients or their doctors there is nothing so convincing as visual demonstration. One ex-patient who is kind enough to appear from time to time in this role has a total range of 120 degrees with an extension lag of 20 degrees, having started with a total pre-operative range of 30 degrees and no lag. He drives heavy lorries, walks with a perfect gait, goes up and down stairs normally, cycles, skips, climbs and dances. He cannot run fast and he would not

be selected to take a penalty in a Cup Final, but otherwise it is difficult to demonstrate his “disability”.

The Operation

The operation is based on an appreciation of the morbid anatomy and must be planned to give access to all the sites at which adhesions may be encountered. It is impossible to tell in advance where these will be, although the nature of the causative injury may give a clue. In injuries around the knee, for example, they are most likely to involve the lateral expansions and the inside of the joint, but these sites are also commonly affected following fractures in the middle third of the femur. It is rare to find only one or two sites affected and common to find all four. Sometimes, having divided all visible adhesions at all sites, the knee still refuses to flex until manipulated. It then yields with an obvious giving way of something in the back of the joint, either adhesions out of sight or a contracted posterior cruciate ligament.

A vertical mid-line incision is used, extending from three inches above the patella to the level of the knee joint. This may have to be extended upwards if there is extensive scarring of the vastus intermedius, but usually the rectus femoris is free in its upper half. The flaps are dissected laterally and the junctions of vastus medialis and vastus lateralis with rectus femoris are identified and divided. These incisions are carried down through the expansions of the vasti on each side of the patella and about half an inch from it, opening up the knee joint freely. Any fibrotic vastus intermedius muscle binding down the deep surface of the rectus femoris tendon can now be seen and removed; adhesions from the deep surface of the patella to the femur are divided and the lateral expansions of the vasti are mobilised down to the level of the tibia. Finally, adhesions inside the joint itself are divided. The knee is manipulated at each stage of the dissection until flexion of about 120 degrees is obtained, at which stage it is not necessary to go any further. In most cases it is impossible to suture the vasti back into place and no attempt to do so should be made unless it can be achieved with the knee in 90 degrees of flexion. The skin must be sutured carefully, however, because sound healing is essential to allow early exercise.

If everything at all the usual sites has been dealt with and there is still insufficient flexion with a very tight rectus femoris at the limit of movement, then there must be an actual contracture of the rectus femoris. In these circumstances the surgeon must be prepared to lengthen the tendon, but it is undesirable to exceed $2\frac{1}{2}$ inches. The same technique is used as in lengthening the Achilles tendon, by splitting it in the coronal plane.

The secret of success in this operation is that once having started, the surgeon must be prepared to go on until he has achieved his objective of 120 degrees of flexion. As the dissection proceeds, things begin to look more and more alarming, and the inexperienced operator may well get the impression half way through that he is about to ruin the patient's knee for life. If he steels himself against the temptation to pull out in time, the knee looks such a shambles at the end of the operation that he may well panic and start sewing things up again. This is a fatal mistake, for he is merely recreating the conditions that he has been at such pains to disturb. Nothing but the skin should be sutured, but this must be done very carefully indeed to ensure primary healing and allow early movement.

In the present series the operation has been performed under tourniquet control and it rarely takes more than half-an-hour. No attempt has been made to secure bleeding points by removing the tourniquet before closing the skin. No vessels of any size are cut and hæmostasis is easily secured by a pressure bandage with the knee in flexion. If 120 degrees of movement has been achieved the knee is fixed in plaster at 90 degrees for the first three days. This flexed position has two advantages—it helps to secure hæmostasis by keeping everything in moderate tension, and it minimises the risk of adhesions reforming in extension during the early days when the knee is too painful to move. Before fixing the knee in this position, however, the surgeon must be completely satisfied that there is no undue tension on the skin wound that might interfere with primary healing.

After three days the plaster is removed and exercises on slings commenced. Between exercise periods the knee is kept in flexion on a plaster back slab, but at night it is supported in extension.

Selection and After-Care

The after-care is so important and so pro-

FIG. 3.—“Do-it-yourself” exercises. Extension of the normal knee is used to assist flexion of the stiff knee.

longed that no patient should be selected for this operation who is not manifestly capable of co-operating to the full and driving himself to the limit. Most patients will already have been assessed from this aspect because they will have attended for exercises and physiotherapy over a period of many months. The essential pre-requisites are a determined patient, a determined surgeon, and a first-class rehabilitation unit in that order. The patient should have been thoroughly indoctrinated during his preliminary treatment and should suffer from no illusions as to the relative merits of active exercises by himself and the laying on of hands by a physiotherapist, however charming. All the patients in the present series had failed to yield to manipulation under anæsthesia after they had been at a standstill for some months under treatment in a well organised rehabilitation unit.

After operation, treatment must be continued for upwards of six months. Pool therapy, active exercises and quadriceps drill, form the basis of the after-care and the “do-it-yourself” type of assisted flexion illustrated in Fig. 3 is particularly useful. It is a simple gadget that can easily be fixed up in the patient's home. One patient who came from Greece went home a few weeks after operation equipped only with this device and a good deal of initiative and determination. He did his pool therapy in the Aegean Sea, which he reached by exercising his quadriceps on a non-stationary bicycle. He achieved an excellent result.

If flexion is being lost, the surgeon should

not hesitate to manipulate the knee under anaesthesia during the post-operative months. This was done in about half the cases in the present series, but since adopting the flexed post-operative position, it has become less necessary.

TABLE 2
SUMMARISED RESULTS IN 38 CASES OF
QUADRICEPSPLASTY.

There were 2 failures due to avoidable technical faults and 2 exceptional cases with 90 and 120 degrees of movement before operation (see text), both of whom achieved full movement.

34 REMAINING CASES

	Mini- mum	Maxi- mum	Aver- age
Interval (months) between injury and quadricepsplasty (excluding 1 case of 15 years)	4	36	14
	Degrees		
Pre-operative range	nil	60	40
Final range	60	140	106
Flexion gain	30	100	70
Extension lag (4 cases)	15	40	32

Results

Quadricepsplasty is undoubtedly one of the most rewarding operations in orthopaedic surgery, and why it has failed to achieve the popularity it deserves is a complete mystery. The results in the present series are summarised in Table 2.

The average pre-operative range of movement was 40 degrees and all but two patients had 60 degrees or less. These two patients were exceptional in that they had ranges of 90 degrees and 120 degrees respectively, which is normally considered adequate. But both required full flexion to enable them to resume pre-accident work. The patient with 120 degrees was a young miner on light work who asked to have the operation because he needed 150 degrees in order to work at the coal face, which to him meant a 50% increase in earning power. This seemed a reasonable enough indication, and in fact the

crucial extra movement was obtained very easily.

There were two failures, due to technical faults which prevented the normal after-care from being carried out. The average gain of movement in the remainder was 70 degrees, and only 4 patients failed to reach 90 degrees of flexion or more. There was an extension lag in 4 cases. This varied from 15 to 40 degrees, but in none of these was there any loss of passive extension, so function was excellent and all four patients were completely convinced that the operation had been worthwhile.

Summary

1. Thirty-eight cases of stiff knee treated by the operation of quadricepsplasty are reviewed.
2. The causes and pathological anatomy are analysed. The operative technique is described and this is based on an appreciation of the pathological anatomy.
3. Selection and after-care are of great importance and the latter must be persistent and prolonged. Manipulation under anaesthesia during the after-care period was used in about half the cases, but the need for this has diminished since adopting fixation in the flexed knee position for the first three post-operative days.
4. The results were most rewarding. There were two technical failures—both avoidable—but in the remaining 36 cases the average gain of flexion was 70 degrees. Lengthening of the rectus femoris tendon had to be carried out in 4 cases only. This should be avoided if possible since it leads to loss of active extension. This did not occur in the other cases, except as a temporary phenomenon lasting six to twelve months. Even if active extension has to be sacrificed it is a penalty well worth incurring, provided there is no loss of passive extension.

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