QUADRICEPSPLASTY

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The disability from joint stiffness varies from one joint to another. In the wrist, ankle and subtalar joints, for example, loss of movement is compatible with good function and even the effects of an arthrodesis may be masked almost beyond recognition. In other joints, of which the knee is perhaps the most striking example, stiffness imposes a severe handicap and a degree of disability that compels a complete change in the patient's way of life. His work and leisure pursuits are both drastically affected, and this is all the more calamitous when it occurs in consequence of injury in an otherwise fit and vigorous young person. Since it is precisely such individuals who sustain the type of injury liable to cause a stiff knee, it is all the more important that it should not lightly be accepted either by surgeon or patient. One gets the impression, however, that many young and otherwise fit patients are being denied the benefits of quadricepsplasty simply because the possibilities of this procedure are not sufficiently appreciated. Since Thompson's (1944) classic paper the subject has received scant attention in the literature, though such reports as have appeared have been most encouraging (Judet 1959, van Nes 1962).

TABLE I
CAUSES OF KNEE STIFFNESS (THIRTY PATIENTS)

Cause	Number of patients
Fracture of femoral shaft	
Normal union	5
Delayed union	7
Non-union requiring grafting	7
Fracture of femoral condyles	2
Fracture-dislocation of knee	2
Fracture of tibial plateau	2
Synovectomy	2
Hip conditions	3
Total	30

MATERIAL

The object of the present paper is to present an analysis of thirty patients operated on during the past fifteen years, whose results have been very encouraging. Of these, ten were referred from other centres, and the remaining twenty were received from the accident services of two hospitals covering a population of 400,000 people in an area of heavy industry with a high accident rate. It is therefore a comparatively rare operation, as it should be in any properly organised accident service. Indeed, the surgeon who could claim a large series derived entirely from endogenous sources would hardly be inclined to publicise the fact.

Causes of knee stiffness—By far the commonest cause was a fracture of the femoral shaft (Table I). Of nineteen such fractures seven showed non-union and required bone grafting, and in seven union was delayed for over twenty weeks. No instance of stiffness of the knee

followed treatment by intramedullary nailing and early institution of knee movement. Clearly, knee stiffness is a particular hazard of delayed and non-union in which traumatised soft tissues about the knee joint have been immobilised for a long time.

Indications for operation—It is sometimes difficult to decide when to intervene. In general, a patient who achieves a total range of more than 70 degrees will be satisfied, but each case must be judged on its merits. In the present series fourteen patients had less than 30 degrees total range, and only three had more than 60 degrees. Two of these were exceptional in that they had ranges of 90 and 120 degrees, which in normal circumstances would have been considered good enough. But both required a greater range of flexion in order to get back to full work. The patient with a range of 120 degrees was a young miner who needed to be able to squat on his heels in order to work at the coal face, which to him meant a 50 per cent increase in earning power.

In all cases sufficient time had elapsed for it to be certain that no further improvement would occur without operation. All had received months of treatment in a well organised rehabilitation unit and a test manipulation under anaesthesia had demonstrated a rigid block to flexion. The after-care of quadricepsplasty is of crucial importance, and the value of intensive preliminary treatment—apart from avoiding unnecessary surgery—is that a patient who is thoroughly indoctrinated beforehand is much more likely to cooperate fully afterwards.

Morbid anatomy of knee stiffness—There are four ways in which flexion may be blocked, all of which act by preventing the normal distal excursion of the patella during flexion. It is not always realised just how great this is. The radiograph of a healthy knee (Fig. 1) shows that

FIG. 1

Radiographs of a normal knee in full extension and in full flexion. The patella has travelled $3\frac{1}{2}$ inches (9 centimetres).

between full extension and full flexion the patella travels a distance of $3\frac{1}{2}$ inches (9 centimetres) and this is also the excursion of the rectus femoris tendon. There are four causes of blocking: 1) Fibrosis of vastus intermedius tying down the deep surface of the rectus femoris tendon to the front of the femur in the suprapatellar pouch and above (Figs. 2 and 3). 2) Adhesions from the deep surface of the patella to the femoral condyles (Figs. 2 and 3). 3) Fibrosis and shortening of the lateral expansions of the vasti and their adherence to the lateral aspects of the femoral condyles, where normally there should be a smooth gliding mechanism in the "paracondylar gutters." If these gliding surfaces get stuck down they anchor the patella just as if it had been tethered to the sides of the femoral condyles by a couple of check reins. Indeed, in such circumstances the adherent vasti have exactly the same effect as the pillar

reins used to restrain a horse in its stall (Figs. 4 and 5). 4) Actual shortening of the rectus femoris itself.

Any or all of these causes may be present in the same case, but the first three are the common ones, and if they are effectively dealt with it is rare to find that true shortening of the rectus femoris still prevents flexion. This occurred only four times in the present series of thirty cases. When it does occur, however—and it only becomes apparent because flexion is still blocked after dealing with the other causes—then the tendon must be lengthened in order to gain flexion. This was the basis of the original Bennett (1922) procedure but it should be avoided if possible because it always leads to loss of active extension. If mobilisation can be achieved without interfering with the rectus femoris tendon, active extension is nearly always regained, though it may take many months or even a year.

It is usually impossible to predict in advance where the block is. It might be expected, for example, that in a comminuted fracture of the middle of the femoral shaft with no direct involvement of the knee joint the adhesions would be at the site of the fracture. But almost constantly in such cases they are found to be beneath the patella and lateral to the femoral condyles. The operation must therefore be planned to gain access to all four sites.

FIG. 2

FIG. 3

Diagram showing the effect of fibrosis of vastus intermedius and of femoro-patellar adhesions. Figure 2—Knee extended: adhesions relaxed. Figure 3—Knee flexed: adhesions tight.

FIG. 4

FIG. 5

Diagrams showing the mechanism of stiffness from fibrosis of the lateral expansions of the vasti. Figure 4—The patella held by the check reins formed by the contracted expansions. Figure 5—The role of the pillar rein. The horse's head is the patella. The pillar reins are the expansions of the vasti. The sides of the stall are the femoral condyles. If the pillar reins are fixed to the sides of the stall the horse can only move forwards a very short distance, but if somebody cuts the reins it is free to bolt.

TECHNIQUE OF OPERATION

A vertical midline 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

TABLE II
DETAILS OF THIRTY CASES OF QUADRICEPSPLASTY

Case number	Age (years)	Sex	Clinical details	Period of immobilisation (months)
1	37	M	Fracture tibial plateau	2
2	31	M	Fracture femoral shaft. Delayed union	5
3	31	M	Fracture femoral shaft. Non-union. Graft	10
4	47	M	Fracture femoral shaft	4
5	30	M	Synovectomy	None
6	22	M	Fracture-dislocation knee	2
7	22	F	Fracture femoral shaft. Non-union. Graft	8
8	35	M	Fracture femoral shaft. Non-union. Graft	9
9	25	M	Fracture femoral shaft. Non-union. Graft	10
10	24	M	Fracture femoral condyle	2
11	27	M	Fracture femoral shaft. Non-union. Graft	7
12	32	M	Fracture femoral shaft. Delayed union	7
13	55	F	Supracondylar fracture femur	3
14	18	M	Fracture femoral shaft	3
15	19	F	Fracture femoral shaft. Delayed union	9
16	28	F	Supracondylar fracture femur. Non-union. Graft	9
17	19	M	Fracture femoral shaft. Delayed union	6
18	37	M	Synovectomy	None
19	41	M	Fracture femur and upper third tibia	3
20	29	M	Fracture femoral shaft. Delayed union	6
21	30	M	Fracture femoral shaft. Non-union. Graft	12
22	30	M	Fracture-dislocation knee	2
23	17	M	Fracture femoral condyle and patella	2
24	56	M	Comminuted fracture tibial plateau	1½
25	40	F	Infective arthritis of hip	12
26	18	M	Fracture neck of femur with femoral vein injury. Open reduction at ten weeks; spica six months	10
27	35	M	Fracture femoral shaft. Delayed union	8
28	37	M	Fracture neck of femur and tibia and fibula same side. Infection hip leading to prolonged immobilisation: stiff hip and knee	12
29	51	M	Fracture femur and upper third tibia	3
30	23	M	Fracture femoral shaft. Delayed union	8

TABLE II—*continued*
 DETAILS OF THIRTY CASES OF QUADRICEPSPLASTY

Interval between injury and quadricepsplasty (months)	Pre-operative range (degrees)	Final range (degrees)	Flexion gain (degrees)	Extension lag (degrees)	Post-operative manipulations
7	180 120 = 60	180 55 = 125	65	None	2
11	180 135 = 45	180 60 = 120	75	None	2
13	180 150 = 30	180 50 = 130	100	None	1
7	180 160 = 20	Technical failure caused by skin necrosis			
12	180 125 = 55	180 40 = 140	85	None	None
9	180 130 = 50	180 60 = 120	70	None	2
18	180 170 = 10	180 70 = 110	100	45	None
15	180 145 = 35	Technical failure caused by fracture during post-operative manipulation			
30	180 165 = 15	180 80 = 100	85	None	1
6	180 125 = 55	180 45 = 135	80	None	2
9	180 150 = 30	175 50 = 125	100	5	None
24	180 125 = 55	180 40 = 140	85	None	1
7	*160 135 = 25	170 70 = 100	75	None	None
30	180 60 = 120	180 30 = 150	30	None	1
15	180 125 = 55	180 60 = 120	65	None	None
16	180 150 = 30	180 60 = 120	90	None	None
24	None. Fixed at 175	175 95 = 80	80	40	None
4	180 155 = 25	180 80 = 100	75	None	2
9	175 135 = 40	180 75 = 105	60	None	2
10	180 125 = 55	180 65 = 115	60	None	2
36	180 175 = 5	180 90 = 90	85	None	None
6	180 130 = 50	180 60 = 120	70	None	1
16	180 90 = 90	180 60 = 120	30	None	None
12	None. Fixed at 175	175 100 = 75	75	5	3
15 years	180 150 = 30	180 120 = 60	30	None	2
16	180 150 = 30	175 105 = 70	45	5	1
15	180 140 = 40	180 70 = 110	70	20	None
24	180 170 = 10	180 85 = 95	85	35	None
8	180 110 = 70	180 55 = 125	55	None	1
13	180 145 = 35	180 50 = 130	95	None	1

* This patient had 20 degrees flexion contracture at the time of operation, which improved to 10 degrees afterwards.

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 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

FIG. 6

Method of using extension of the normal knee to assist flexion of the stiff knee.

level of the tibia. 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 the first three sites has been dealt with and it is still not possible to flex the knee, then there must be an actual contracture of the rectus femoris, and the surgeon must decide whether to lengthen it in order to gain the desired amount of flexion. This will almost certainly result in some loss of active extension, but most patients, women particularly, will consider this a small price to pay for a considerable gain in flexion. Provided there is full passive extension, such patients walk with a nearly normal gait and can disguise the disability almost completely.

FIG. 7

FIG. 8

Case 21—Man aged thirty. Figure 7—Radiograph showing final state after femoral fracture requiring grafting. Only 5 degrees of movement three years after injury. Figures 8 and 9—After quadricepsplasty: 90 degrees of movement and full, strong active extension.

FIG. 9

After-care—In the earlier cases in this series the knee was immobilised in extension for the first few days after operation, after which active exercises were commenced. In more recent cases, however, the knee has been immobilised for the first three days at about 30 degrees short of the greatest flexion gained at operation. Thereafter, the knee is kept in full extension during the night and exercised during the day on counterbalanced slings.

Once the wound is soundly healed the surgeon should not hesitate to manipulate the knee under anaesthesia if flexion is being lost. This was done in just over half the cases in the present series, sometimes twice in the same patient. Pool therapy, free exercises, "self-assisted" flexion exercises (Fig. 6) and routine quadriceps drill form the basis of the later after-care.

FIG. 10

FIG. 11

FIG. 12

Case 22—Man aged thirty. Figure 10—Radiographs showing fracture-dislocation of knee before and after treatment. Six months after injury there was a range of movement of only 50 degrees. Figures 11 and 12—After quadricepsplasty: 120 degrees of movement and full, strong active extension.

which usually has to be continued for upwards of six months. This part of the treatment requires the utmost application and unremitting effort on the part of the patient and this should have been made clear from the start. Daily treatment in a well organised rehabilitation unit is of the greatest importance in these cases.

RESULTS

Extension lag—There is frequently an extension lag of 20 degrees or so in the early months after operation, but in all cases in which the rectus femoris was not interfered with the full pre-operative range of extension was eventually regained. This often took up to a year. There was only one exception (Case 17), in which the rectus femoris itself had been so damaged that it was hardly a functioning muscle to begin with and the knee had been completely fixed for two years before operation.

In four cases the rectus femoris tendon had to be divided (Cases 7, 26, 27 and 28) and in two of these the patella had also to be excised because of gross damage to its deep surface that would inevitably have resulted in further adhesions (Cases 26 and 28). In both these cases restoration of continuity was impossible. In one (Case 26) the divided rectus femoris tendon was sutured to the vastus medialis, the vastus lateralis expansion was split and the anterior half mobilised and sutured across into the vastus medialis. This patient eventually recovered active extension to within 5 degrees of full but gained only 40 degrees of further flexion. In the other (Case 28) the end of the divided rectus femoris tendon was split and sutured to the vasti on each side. There was 35 degrees extension loss with 75 degrees gain in flexion. In the two patients (Cases 7 and 27) in whom the patella was retained a simple tendon lengthening was done. The extension lag was 45 degrees and 20 degrees respectively, but with 100 degrees and 70 degrees gain in flexion. All these patients were convinced that the lost extension was more than compensated for by the gain in flexion.

The results are set out in detail in Table II. There were two failures from complications which prevented the normal after-care from being carried out. In the remaining twenty-eight cases the average gain in flexion was 68 degrees (Figs. 7 to 12). There was full extension in twenty-one cases with loss of only 5 degrees in a further three patients, two of whom had this amount of flexion contracture before operation.

SUMMARY

1. Thirty cases of stiff knee treated by the operation of quadricepsplasty are reviewed.
2. The causes and morbid anatomy are analysed. The operative technique is based on an appreciation of the latter.
3. The after-care must be meticulous and prolonged. Manipulation under anaesthesia was used after operation in over half the cases.
4. The results were most gratifying. There were two technical failures but in the remaining twenty-eight cases the average gain of flexion was 68 degrees. In twenty-one of these active extension was full and it was only 5 degrees short in another three. Permanent loss of active extension occurred when the rectus femoris tendon had to be divided or lengthened.

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