CHAPTER THREE

JOINT MOVEMENT IN CONSERVATIVE METHODS

PERFECT anatomical restoration and perfect freedom of joint movement can be obtained simultaneously only by internal fixation. It is possible to argue that most of the difficulties of closed fracture treatment can be traced to the prevention of joint stiffness. Closed methods can offer anatomical restoration only if the start of joint movement is delayed. It is the significance of delay in starting joint movement which is the crucial point in understanding closed methods.

The ultimate recovery of full joint function after a fracture depends on many factors and not only on early exercise. This is suggested by the fact that the end results of conservative treatment, after a slow start, can often be surprisingly good, while those of operative methods, after a very promising start, can sometimes be disappointing. It is therefore obvious that we must review the factors which govern the recovery of joint movement following a fracture, so far as we know them.

In studying the stiffness of a joint following a fracture of an associated bone the greatest danger to the furtherance of knowledge is the too facile acceptance of simple mechanistic explanations. It is probable that the processes concerned with the recovery of joint function are of great biological complexity. Too often there is a tendency to think of stiff joints in terms of stiff engine-bearings or of rusty door-hinges and, with this childlike concept, to devise apparatus to loosen the stiffness by repeated mechanical movements. This mechanistic interpretation of organic processes is inherent in many popular physiotherapeutic measures; the use of kneading massage 'to break up fibrositic nodules,' the softening of areas of induration by heat, the dispersal of œdema by stroking, the restoration of flexibility by inuncting oil, etc., are but few of the simple ways in which the tissues are imagined as lumps in pastry, or as wax to be softened by warmth, as wood to be made pliable with water, or as leather to be made flexible with oil.

In reviewing the facts concerning joint rehabilitation, it is surprising what little direct experimental evidence we have at our disposal and how scanty is our knowledge of the normal physiology of joint function. In the subsequent paragraphs evidence will be produced to support the writer's opinion that in closed treatment the prevention of joint stiffness by early joint movement may not be based on such sound biological fact as might at first sight be imagined.

It is hoped to show that **the late exercise of joints is part of the natural fracture healing process, and is compatible with normal healing processes.**

The Fixation of Joints in Plaster

We are now able to review in true perspective the massed experience of a decade (1930-40) during which the skin-tight plaster was extensively used in Britain according to the doctrine expounded by Böhler. In this teaching the joints above and below the fracture were immobilised in skin-tight plaster for just so long as it took the fracture to unite. If delayed union developed this fixation was continued over many months. It was Böhler's contention that no permanent joint stiffness would result from prolonged plaster fixation, provided that the joints were in the optimum position for function, and provided that the limb was actively employed in the performance of useful work while in its cast. This theory maintained that the static contraction of muscles would maintain the intercellular circulation and so prevent the stagnation and œdema which was regarded as favouring fibroplasia, which was regarded as the explanation of permanent loss of flexibility in joint capsules. Böhler went even so far as to declare that plaster fixation was imperative as an insurance against stiffness, and he believed that surgeons not understanding this were risking avoidable and permanent disability in their patients. *It is interesting and instructive to observe that this teaching put no emphasis on physiotherapy or special rehabilitation after removal of plaster*; it was believed that a patient should be able to walk out of his plaster with little or no disability if reablement while in plaster had been effectively carried out. To this end the patient was taught to perform exercises involving considerable physical exertion while still in plaster (*i.e.*, fractured spines in casts were taught to carry weights of 40 kg.). These enthusiastic claims for the conservative treatment of fractures by plaster are perhaps somewhat overdrawn, but in discarding those parts of his theories which in the light of further experience we now know to be false, we must not make the mistake of overlooking the great content of fundamental truth. The teaching of Böhler in part has failed, but it has not failed on the score of producing joint stiffness; **the teaching of Böhler failed only because it did not eliminate delayed union.** In challenging theories of plaster fixation we must remember that **the majority of joints treated in plaster do eventually recover their full range of movement** though there may often be some delay.

In considering the problems of joint stiffness resulting from plaster fixation we must isolate from discussion those cases in which sepsis or nerve injury has been present. **The commonest single cause of permanent joint stiffness is sepsis;** the stiffness caused by the dense scar tissue left by sepsis is irreparable.

It is probable also that we must use with caution the specific example of the stiff knee joint following a fractured femur; the study of stiffness in this joint after a fracture of the femur sheds much light on joint function, but the stiffness of this joint occurs more readily and is more resistant to treatment than is the stiffness of almost any other joint: its example must therefore not be allowed

to influence unduly the whole subject of plaster fixation. This tendency in surgical science, to allow a rather special example to be applied as a general principle, is one against which we must be continually on our guard (a similar instance of faulty deduction is in the example of the fractured carpal scaphoid which is allowed to influence adversely the treatment of many trivial fractures). In contrast to the knee joint, the speed with which the wrist joint almost invariably recovers its full range after many months of plaster fixation is always a most striking observation and, while taking longer to recover, the radius and ulna, and the tibia and fibula, also *eventually* recover practically full range in their associated joints after more than six months of continuous plaster fixation.

The experimental fixation of joints in plaster has been investigated by numerous workers and the literature is reviewed by Scaglietti and Casuccio (1935). These workers found that in dogs no serious and irreparable joint changes could be demonstrated after several months of continuous plaster fixation. Those parts of the articular surfaces which were in contact with each other always remained healthy, but those parts of the articular surfaces which were in contact with the joint capsule developed superficial ulcers. It appears that **the persistence of normal joint histology is probably the result of continuous minute movement which can never be abolished by plaster fixation.**

While it is probable that the fixation of joints in plaster does neither serious harm nor material good, there can be no doubt of its value in the treatment of fresh compound fractures. The recovery of function after prolonged plaster fixation in this type of injury is to be observed in the work of Trueta. The excellent joint function after the closed plaster treatment of compound injuries is the result of eliminating or minimising sepsis and so *eliminating one of the most sinister causes of permanent stiffness*. Our modern interest in chemotherapy must never allow us to forget that rest is and always will be a fundamental surgical principle.

STIFFNESS OF THE KNEE FOLLOWING FRACTURES OF THE FEMORAL SHAFT

The stiffness of the knee which is such a notorious complication of fractures of the femoral shaft is an exceptionally interesting subject for study. After a fracture of the shaft of the femur the knee stiffens more readily, and takes longer to recover its full movement, than probably any other joint in the body (with the exception, possibly, of the elbow); but even so it should not be imagined that the stiff knee after a fracture of the femoral shaft, troublesome though it is, has always a hopeless prognosis. It is a surprising thing about the knee joint that continuous recovery of movement often proceeds for as long as eighteen months after the start of full weight-bearing. This late recovery is quite unlike the behaviour of most other stiff joints which rarely increase by a significant range after the first six months of rehabilitation. The function of weight-bearing seems vital to the late recovery of knee range; but here, again, those cases where stiffness is due

to sepsis after compound fractures of the femur must be eliminated from the discussion, because in these the stiffness is caused by scar tissue too dense to absorb, and knee stiffness in these cases rarely improves after six months.

Intra-articular versus Extra-articular Causes of Knee Stiffness after a Fractured Femoral Shaft

Six lines of evidence can be adduced in favour of the theory that the limitation of knee movement which follows a fracture of the femur is mainly the result of extra-articular adhesions ; these are :

1. Comparison with Fractures of the Tibia and Fibula

Owing to the common occurrence of delayed union in fracture of the tibia treated by conservative methods it frequently happens that the knee has to be fixed in

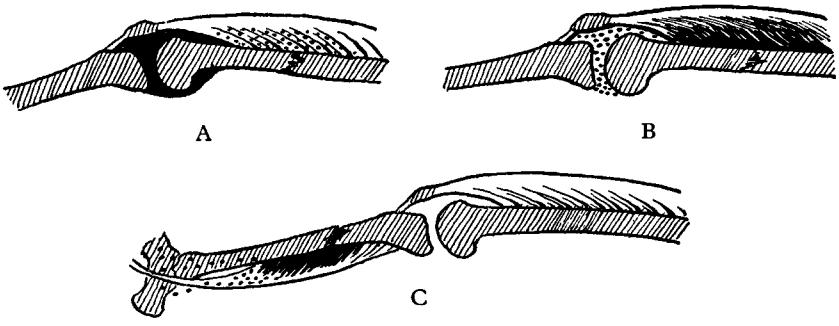


Fig. 55

A, Illustrates orthodox concept of knee stiffness after fracture of shaft of the femur as due to articular adhesions.
B, Indicates author's concept of stiffness due to 'master' adhesions in the quadriceps with only soft 'secondary' adhesions in the joint.
C, Illustrates tendency of the ankle to stiffen after fracture of the tibia, *but not of the knee*, even after prolonged fixation in plaster, when the fracture does not involve the quadriceps.

plaster for six months or more ; yet little or no difficulty is experienced in achieving 90 degrees of motion in a few weeks and often full knee range is secured by that time. The different behaviour of the knee joint after this duration of fixation in fractures of the femur is quite remarkable and would seem to indicate that the involvement of the quadriceps muscle in scar tissue might be the deciding factor (Fig. 55, A, B, C). In fractures of the tibia it is not uncommon to find stiffness of the ankle joint persisting for many weeks whereas this is not a common complication of fractures of the femoral shaft.

2. Injuries of the Knee Joint unaccompanied by Fracture of the Femur

When severe injuries to the ligaments of the knee are treated by immobilisation in plaster for three or four months the rapidity and completeness of recovery of

knee function are often astonishing. Sir Robert Jones has commented on the good knee function which is usually obtained after complete dislocation of the knee in the following terms :

> ' The interesting fact is that, in spite of the extensive rupture of ligaments, including the crucial ligaments, the functional results in recorded cases have been so good. The explanation of this is that the lesion is so formidable that prolonged fixation is absolutely necessary ; early use and movement is impossible without displacement occurring. Hence torn structures are usually given time to unite firmly, and with exercise and use considerable freedom of movement is recovered in time. . . . The great lesson seems to be that if the displacement is reduced and the limb fixed in a straight position, nature will do surprisingly well.'

Those who tend to decry conservative methods would do well to mark these words, remembering the vast clinical experience which promoted them.

3. Knee Recovery after Fracture at Different Levels of the Shaft

It is well known that fractures in the upper third of the shaft recover full knee movement without difficulty, whereas fractures in the distal shaft are prone to knee stiffness. This difference in recovery can be correlated with the different range of movement which takes place between bone and muscle at these two levels ; at the lower end of the femur the extensor apparatus has a linear movement of 2 or 3 inches during a full knee movement, whereas the most proximal fibres of the quadriceps cannot possess anything like this mobility ; adhesions in the upper part of the shaft will therefore have less effect on knee movement than they will at the lower level.

Against this explanation the fact is sometimes advanced that troublesome knee stiffness is encountered after arthrodesis of the hip where the quadriceps muscle is not involved. It must not be forgotten, however, that knee stiffness in these cases is only permanent in the elderly patient and this results, presumably, from the fixation of an abnormal joint.

4. Fractures of the Patella during Manipulation

Manipulation to secure more flexion in the knee after a fracture of the femoral shaft is often complicated by fracture of the decalcified patella. This fact would seem to indicate that the main resistance to flexion lies proximal to the patella, because flexion of the knee is secured with very little further effort after the patella has fractured. The intra-articular adhesions would, therefore, appear to be soft, whereas the adhesions in the extensor apparatus are dense. It is therefore reasonable to suggest that adhesions in the quadriceps are the ' master ' adhesions and that intra-articular adhesions are secondary to the enforced fixation of the knee (Fig. 56).

5. Results of Plastic Operations on the Quadriceps

Good results have been reported following excision of the adherent vastus intermedius at the level of the fracture as described by T. C. Thompson (1944). The operation offers a good chance of securing 90 degrees in knees which previously were very stiff. The procedure is often combined with incisions into the capsule of the knee joint in order to divide the lateral and medial expansions which usually

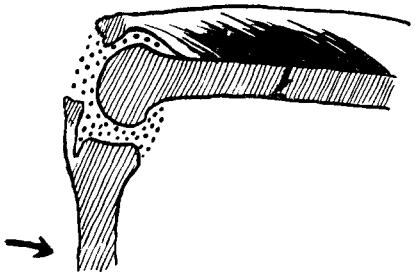


Fig. 56

Illustrating the significance of fracture of the patella, which may occur if violent flexion force is applied to a stiff knee after a fracture of the femur. The 'master' adhesions in the extensor apparatus must offer greater resistance to flexion than the intra-articular adhesions, which are readily overcome, once the extensor expansion has ruptured.

become thickened and indurated. After division of these extra-articular structures the knee can be flexed with the application of moderate force and without fracture of the patella which otherwise would occur. The best results from this operation are those where the fracture has been in the distal third of the shaft and in cases where the thigh muscles can be felt to tighten on passive flexion; old compound fractures in the lower third with adherent skin scars are particularly gratifying.

6. The Results of Plating Operations

Generally speaking the results of knee movement after plating the fractured femur are disappointing and this is particularly so when two plates are used for additional strength; immediately following the operation the promise of early return of knee function is usually encouraging, but at the end of one year considerable limitation of flexion is often still present. Most surgeons attribute this to adhesion of the muscle in the region of the plate; this is supported by the perfection of knee movement which results from treatment with the intramedullary nail of Kuntscher, especially when the postero-lateral approach to the shaft is used: by this method the quadriceps is scarcely touched. Experience has shown that the Henry approach, which goes through the important sliding portion of the vastus intermedius on the front of the femoral shaft, greatly retards the return of knee flexion and should be avoided at all costs.

RECOVERY OF KNEE MOTION AND THE SPEED OF UNION

Of all the factors which might affect the recovery of knee movement after a fracture of the femur *probably the most significant relates to the speed of union.* Clinical experience suggests that if bony union takes place promptly a full return of knee movement will result whether the knee was fixed throughout treatment or not; *per contra*, if delayed union occurs it is probable that some permanent restriction of knee movement will result even if strenuous attempts are made to prevent it by movement during the early stages of treatment.

The relation between early knee movement, early bone union, and final knee range is illustrated by the following personal anecdote. During the 1939-45 war five repatriated British prisoners were transferred to the author's care with gunshot fractures of the shaft of the femur caused by clean through-and-through bullet wounds. They all had been treated initially in enemy hands by a method entailing the minimum of supervision from their captors, yet the final results were so good that the lesson is worth recounting. We ourselves at this time were using a method involving a vast expenditure of energy and diligence directed to starting knee movement as soon as possible after eight weeks and at the same time striving to avoid the hazards of re-fracture. The method used on these five repatriated soldiers, on the other hand, had been: (1) four weeks of continuous skeletal traction applied through a supracondylar nail, (2) the application of a hip-spica with the traction *in situ*, (3) extraction of the supracondylar nail after hardening of the cast, and (4) no further attention until repatriated. When the plasters were removed by the writer at twelve weeks all fractures were soundly united; knee movement recovered slowly and continuously until practically a full range was eventually obtained. Within four weeks of removal of their plasters their knee range had caught up with that of their fellows who had been the subject of overwhelming diligence and earlier knee movement. From this and other observations I believe that this would be a common experience if controlled observations could be made and provided that sound bony union occurs from the start. It is perhaps significant that despite the fact that no knee movement was possible for three months, *the patients were all taught to contract their quadriceps muscles inside the plaster casts* and, having nothing else to do and feeling that it was the only way in which they might help themselves, they obeyed their instructions implicitly.

The diagram (Fig. 57) was obtained from a series of thirty-four fractures of the femur which were free from sepsis four weeks after injury (in those cases which were compound), which involved the middle and lower thirds only, and which were in patients between twenty and forty-five years of age. Knee movement was not started until clinical union was detected. Those patients who showed clinical union *at* or *before* eight weeks (average time 6·8 weeks) had an average range of motion in the knee of 114 degrees at six months after the injury, while those not showing clinical union till *after* eight weeks (average time fifteen weeks) had 74·5 degrees of knee motion (a difference of 39·5 degrees). One year

after fracture this difference in range had become less obvious and was respectively 129 degrees and 113·5 degrees (a difference of only 15·5 degrees).

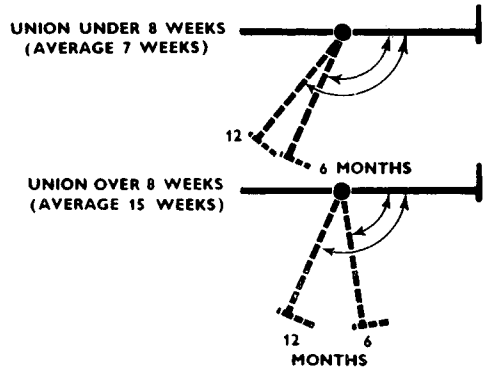


FIG. 57

Range of knee movement at six and at twelve months after fracture of the femur in relation to clinical union.

The recovery of the *last few degrees* of full knee flexion obviously cannot be dependent on simple mechanical factors *during early treatment*. The full recovery of knee motion depends on the complete recovery of elasticity in the

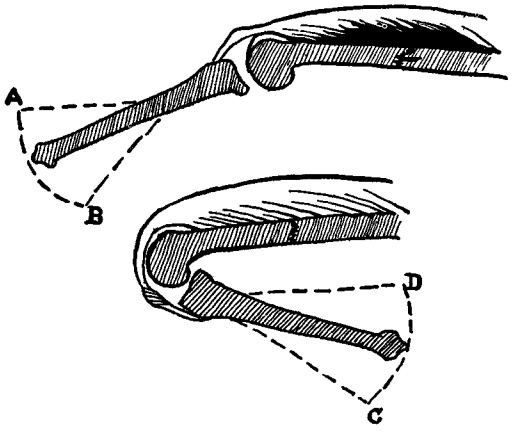


FIG. 58

Mechanical exercise over the arc BA at or before six weeks can have no direct influence on the final recovery of the range in the arc DC some six months later. Recovery of the range DC is dependent upon biological factors at the fracture site, which determine whether the provisional callus is absorbed completely or leaves permanent scar tissue in the muscle.

quadriceps muscle; this must depend on the complete resorption of all scar tissue near the site of the fracture. *It is difficult to see how exercise of the knee during the first few weeks, centred as it is on the semi-extended position* (Fig. 58), *can*

have much direct influence on the return of the last few degrees in the position of full flexion some nine months later. The production of scar tissue round a fracture is dependent on biological factors and is the response of these tissues when bony callus is defective.

A Hypothesis of Joint Movement

Sufficient evidence has been advanced in the preceding paragraphs concerning the special instance of stiffness in the knee joint after fracture of the shaft of the femur to warrant the making of a tentative hypothesis.

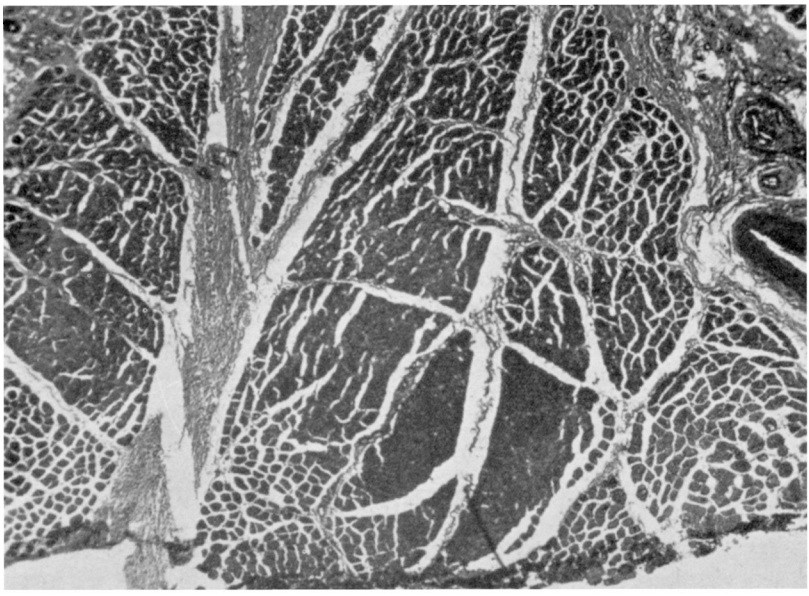
It would appear reasonable to suggest that the ultimate range of joint motion depends upon two factors : *a mechanical factor* related to mobilisation by physical processes, and a *biological factor* relating to the amount of scar tissue produced in an associated muscle group.

The nature of this *mechanical* factor is obvious ; it is the freeing of muscle from involvement in callus by simple mechanical movement. But some other factor must be present in addition to the simple mechanical factor, because early movement does not always result in a perfect joint and, on the other hand, late activity can often produce a mobile joint. The *biological* factor concerns the complete absorption and removal of the temporary tissues of repair. In some cases the temporary tissue of repair is converted into permanent fibrous scar tissue which causes tethering of the surrounding muscles. Scar tissue almost invariably follows when there has been sepsis, but the healing of a closed fracture should leave no permanent scar tissue. When delayed union is present the enormous production of fibrous tissue in the periosteum is well known ; normal healing of a fracture does not result in any permanent thickening of the periosteum. The involvement of muscle by scar tissue is shown in Fig. 59, A and B.

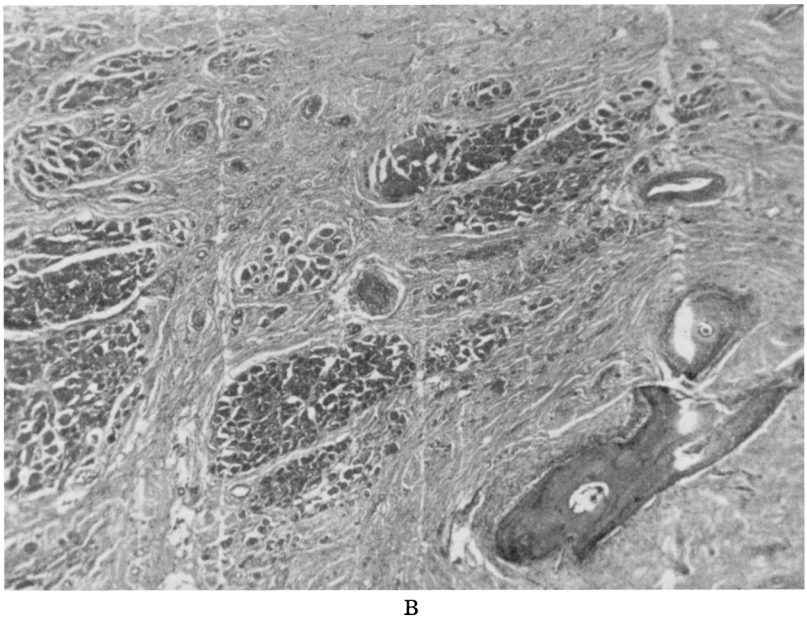
It has been the writer's frequent observation that when a fracture of the femur reveals a noticeable absence of bony callus in the roentgenogram at about six weeks, there will always be a threat of limited knee motion, and this will remain even if the femur is treated on an apparatus permitting knee exercise. This observation is interpreted as indicating that the provisional callus, failing to become bony callus, is attempting to effect a union of the femur by permanent scar tissue and, in so doing, involves the adjacent muscles in the adhesive process. The production of large amounts of permanent scar tissue around closed fractures will only be explained when the intimate nature of delayed union is understood.

By contrast, it has been the constant observation of the writer that fractures of the femur which show plentiful bony callus, appearing at three to four weeks, will unite early, and that eventually there will be perfect motion of the knee. Profuse bony callus appears to result in less adhesion of the quadriceps than the scar tissue which, though it is radiotranslucent, we know to be present if bony callus is deficient. The profuse callus of the fractured femurs in Fig. 9B, p. 8, and Fig. 20A, p. 19, did not impair the return of full knee movement.

When fibrous tissue is produced in the tissues surrounding a closed fracture it is possible that the liberation of muscle fibres by mechanical movement is



A



B

FIG. 59

A, Showing comparatively normal muscle in the vicinity of fibrous tissue round a fracture of the femoral shaft which is the site of delayed consolidation. Even here there is an excess of scar tissue in comparison with healthy muscle.

B, Showing scar tissue surrounding the site of delayed union in a fracture of the femoral shaft: note the bundles of muscle fibres included in it. This was not a compound fracture.

a futile hope. There is some collateral evidence to suggest that passive motion in these conditions may even be harmful, for when myositis ossificans develops near a fracture site it is well known that the best chance of securing a useful range of motion in the associated joint is by restriction of exercise. Passive movement in these cases can increase the area of the pathological process in the muscle fibres.

THE LAW OF CLOSED TREATMENT

I am tempted to suggest that these facts conceal a relation which might almost be elevated to the dignity of a natural law (the ' Law of Closed Treatment '), *i.e.*, that **after fracture of the shaft of a long bone, the associated joints will tolerate fixation for the duration of *normal* union without either permanent or significant loss of motion.**

JOINT STIFFNESS AFTER INJURIES INVOLVING JOINTS

Thus far I have considered only the causes of joint stiffness resulting from fractures at a distance from a joint. We must now examine what we know of the factors governing joint stiffness when the fracture directly involves the joint surfaces.

There is universal agreement, based on practical experience, that if a fracture involves a joint, mobilisation of the injured joint as early as possible is the only sure way of minimising permanent stiffness. While accepting this broad truth there are two important questions which demand discussion :

1. If the joint surfaces are distorted by a fracture, does the anatomical restoration of the joint by operation improve the final range of movement ?
2. Are there occasions when early mobilisation is harmful, and when a greater ultimate range will be obtained by an initial period of strict immobility ?

Is the operative restoration of joint contours essential ? It is frequently a simple matter to restore joint anatomy by arthrotomy and by fixing the fragments with one or two screws, at the same time preserving the theoretical advantage of early mobilisation. The functional results of this procedure vary considerably with different joints but, speaking generally, it is a surprising thing that the ultimate range of movement after the perfect restoration of intra-articular anatomy is frequently disappointing, whereas the rapid recovery of an effective range of movement in the presence of considerable distortion of the joint surfaces is often truly astonishing.

As a broad generalisation the attempt to reconstruct a distorted joint is less indicated in the non-weight-bearing upper extremity than it is in the weight-bearing lower extremity where later osteo-arthritic changes are more likely to develop.

The joints which most commonly suggest the need for arthrotomy when involved by fractures are the shoulder, elbow, knee, and ankle. The ankle usually

gives a good result, but of course the range of movement in the normal ankle is not great. The elbow almost invariably does badly after operative treatment; that is to say, after operation it rarely recovers a significantly greater range than is possible by early movement with the fragments accepted in their displaced position. Particularly disappointing as regards the final range of movement are extensive open operations with internal fixation for Y-shaped fractures of the humerus in the adult. Eastwood (1937) examined the results of treating fourteen Y-shaped fractures of the elbow in adults by early mobilisation without any attempt to reduce the fragments. All except two of these patients returned to their original employment, and whereas an adequate range of flexion was achieved in all cases, he reported the following loss of extension:

Three cases . . .	10 to 15 degrees.
Six cases . . .	30 to 35 degrees.
Three cases . . .	45 to 60 degrees.

My own experience of the operative treatment of these fractures would lead me to expect the same loss of extension, even after exact restoration of anatomy. This extraordinary behaviour of the elbow is emphasised when one remembers that a limitation of extension by 45 degrees is not uncommon after injuries with little or no anatomical disturbance as judged radiologically. Limited extension of the elbow after dislocation, or after crack fractures of the head of the radius without displacement, therefore, must be from causes resident in the soft parts and capsule or ligaments more than in the configuration of the joint surfaces. The case illustrated in Fig. 60, which was treated initially in a collar and cuff for one week and thereafter by early motion, achieved an effective range of motion through 50 degrees centred on the right-angled position. I doubt whether any better range could have been achieved either by open reduction with internal fixation or after four weeks in bed with skeletal traction on the olecranon.

Operative exposures of the elbow joint in order to restore the radiological anatomy must inevitably increase the trauma to the capsule, and operation may delay the start of active mobilisation some ten to fourteen days compared with the mobilisation of a joint treated conservatively. This delaying effect of operation arises because operation is frequently not undertaken until almost a week has elapsed, at which time active mobilisation might be starting in a conservative regime. This early period may be a critical one in the start of organisation in capsular structures.

The Knee.—In its ability to recover movement after operative treatment the knee occupies an intermediate position, and though the range of movement is rarely full it differs from the elbow in that the most useful range includes the extended position; and even if no more than half the normal range is recovered the limitation of flexion beyond 90 degrees is not a severe disability provided that full extension is possible.

The Shoulder.—The shoulder frequently invites consideration of operative treatment in cases of fracture-dislocation where the separated head has been ejected from the joint, partially or completely, because there is obviously no method of

getting a purchase on the proximal fragment by manipulation. The features against attempting a heroic open reduction are: (1) these fractures almost invariably occur in elderly patients, (2) even if reduced by open reduction, it is extremely difficult to fix the displaced head in the reduced position, and (3) in any

FIG. 60

T-shaped fracture treated by sling and early movement. Unlikely that accurate reduction with internal fixation would have secured a greater range than the 50 degrees which was obtained conservatively.

case the result will be almost a fibrous ankylosis of the shoulder. By early mobilisation in the displaced position sufficient movement can usually be obtained for ordinary duties below shoulder level and enough for a woman to dress her own hair (Fig. 61). Operative treatment is only indicated in these elderly patients when the humeral head is pressing on neurovascular structures in the axilla and then excision is probably the best procedure.

The Hip.—Posterior dislocations of the hip sometimes shear off a semilunar fragment of the posterior wall of the acetabulum, and though operative replacement with fixation by a screw is occasionally necessary the indications for it are rare. If a large fragment is displaced and a sciatic paralysis is present, exploration may

be necessary to eliminate the possibility of compression of the nerve by the displaced fragment. In the absence of sciatic paralysis the need for exploration can be assessed on the stability of the hip after reduction; the hip will always be stable in the fully extended position, but if when examining the supine patient under anæsthesia it falls into the dislocated position under its own weight before about 60 degrees of flexion is achieved (taking the fully extended position as zero), it would seem reasonable to advise operation.

Are there occasions when joint mobilisation can do harm? It has long been known that the elbow frequently shows a state of 'irritability' after injury which is not seen to the same extent in any other joint. In this condition the range of elbow movement fails to increase and it may even diminish. When the extremes of the range are tested passively there is marked muscle spasm even when this spasm does not evoke pain. Deterioration of function in this way can often be traced to the patient using passive stretching movements by such exercises as carrying buckets of water in his desire to increase the mobility. In a very small percentage some ectopic ossification will be discovered in the collateral ligaments or, if the original injury was a dislocation, in the brachialis muscle. If this is discovered it is necessary to rest the elbow, but there seems to be no advantage in applying a plaster cast as was often recommended in the past, and it seems sufficient merely to rest the elbow in a sling for two or three weeks before resuming active exercises again.

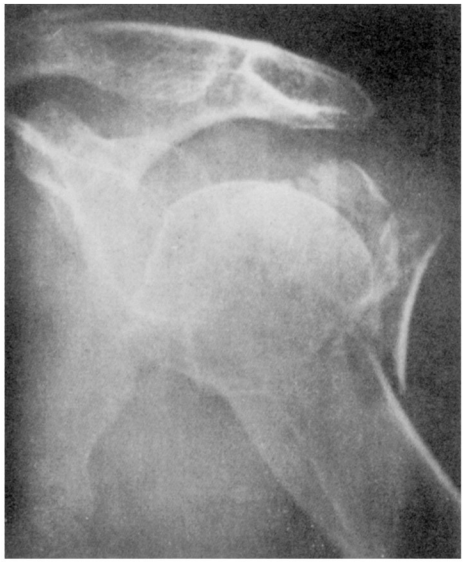


FIG. 61

Shattered fracture-subluxation of shoulder in senile patient, treated simply by early mobilisation. Patient eventually could raise hand to shoulder level without pain and with good power.

A puzzling thing about the persistent joint stiffness encountered in the elbow is that it is so frequently seen in children, whereas injuries involving other joints in children almost never cause lasting stiffness. If these stiff elbows are left strictly alone they will usually make a spontaneous recovery, though taking perhaps as long as two or three years before doing so. It is exceedingly unwise ever to manipulate a child's elbow to increase its range of movement. Whereas stiff elbows, occasionally, will respond dramatically to a single judicious *late* manipulation in the adult, nothing but harm can come from any attempt to increase the range of movement in a child's elbow by manipulation under anæsthesia either early or late.

An Interesting Clinical Observation.—Regarding the possible danger of excessive

joint exercise, Blockey (1954) has made some interesting observations on the behaviour of the dislocated elbow which throw some light on the well-known clinical fact that passive movements are to be avoided in this condition, but that active movements can do no harm. The observation can easily be repeated on any dislocated elbow two or three weeks after reduction. At this time it will probably be found that the active and passive range of flexion and extension will

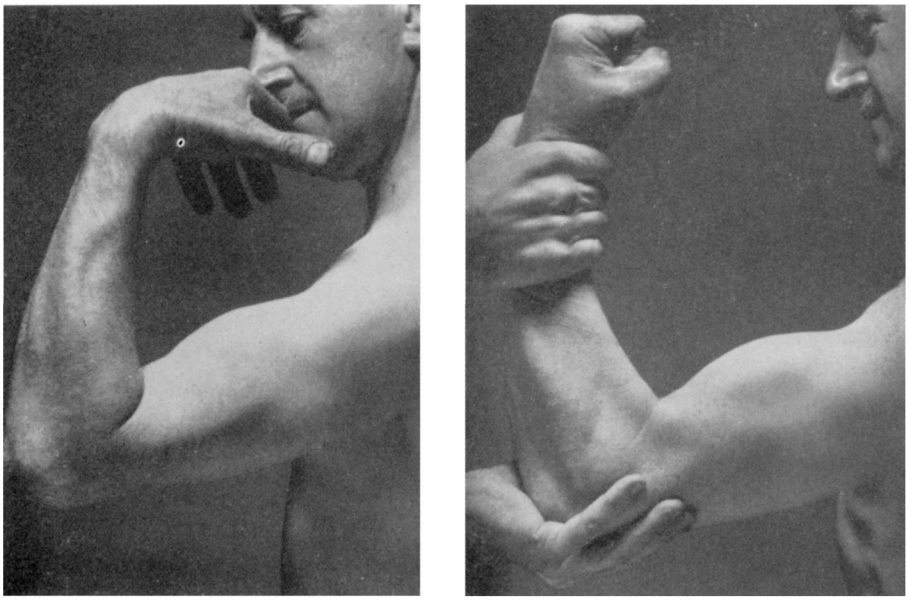


FIG. 62

Dislocated elbow fourteen days after reduction. *Left*, patient attempting maximal active flexion : note biceps brachii in only slight contraction. *Right*, patient pulling against external resistance in the mid-range of movement : note the greater tone in the biceps brachii. (*By courtesy of N. J. Blockey, F.R.C.S.*)

be through an arc of, let us say, 45 degrees centred on the 90 degrees position. If the patient is asked to pull actively against external resistance, it will be found that he can do this almost with normal power *provided that the elbow is held in the middle of the free range of movement* (*i.e.*, at 90 degrees). In this position the biceps and the brachialis muscles will be found on palpation to be in powerful contraction and the electromyograph will confirm active muscle potentials (Figs. 62, 63, 64). If, now, the external resistance is removed and the patient is asked to flex the elbow, and to hold it as strongly flexed as he possibly can, the biceps and brachialis muscles will be found to have ceased to contract, as can be proved by palpation and confirmed by the electromyograph becoming silent. It would seem reasonable to interpret this as indicating that the patient is unable to compress or stretch the organic block to flexion *because the muscles likely to do harm are inhibited as soon as the block is reached.* One presumes that the reflex mechanism permits the organic block a certain slight amount of compression or stretching

but that it inhibits the source of power if it becomes excessive. It was frequently observed that this inhibition occurred even without the patient feeling pain.

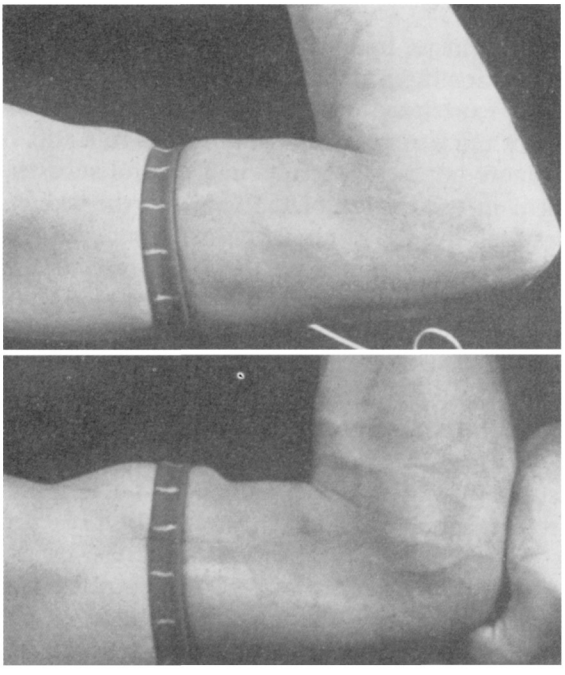


FIG. 63

Same experiment illustrated differently. Tone inhibited when contracting actively against pathological block to flexion at extreme range; tone not inhibited when contracting against external resistance in the middle range. (*By courtesy of N. J. Blockey, F.R.C.S.*)

This simple observation thus illustrates the clinical fact that repeated passive stretching, certainly in the elbow, is contrary to the natural process

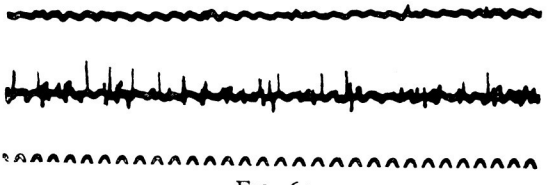


FIG. 64

Electromyograph tracings showing inhibition of action potentials in upper tracing (at extreme range of flexion), and presence of potentials in middle tracing (in middle range). (*By courtesy of N. J. Blockey, F.R.C.S.*)

of recovery of joint movement but that active mobilisation probably cannot do harm.

EXAMPLES OF FRACTURES INVOLVING JOINTS

Fractures of the Os Calcis

The treatment of this major injury is based on principles relating to (1) fractures involving joints and (2) fractures of cancellous bone.

It has been my experience that any attempt to restore the anatomical configuration of the os calcis almost invariably results in a stiff subastragaloid joint and, which is even more important, results in a painful subastragaloid joint. The striking improvement in the quality of the foot and the reduction of the time of total disablement which results from early mobilisation of the fracture in its impacted position has to be experienced to be believed and is one of the most instructive object lessons in fracture surgery.

The ill-effects on function resulting from attempts to restore the normal anatomy of the os calcis are, I believe, probably attributable to an unrecognised fibrous consolidation produced when cancellous fragments are disturbed from their natural state of intimate contact in the impacted position, and put into uncertain contact at a few precarious points in the 'reduced' position where cavities are created between the fragments filled with organising blood clot.

Powerful skeletal traction, using nails through the tibia and os calcis, as was recommended by Böhler, has been abandoned because of the universally poor results. This indicates that the advantage of restoring the normal length of the heel, which theoretically restores the normal leverage to the calf muscles, is neutralised by the disastrous effect on joint function which accompanies delayed consolidation of the os calcis in the distracted position.

Since adopting early mobilisation of the foot, without attempting to restore the anatomy of the heel, I have been impressed with the fact that most patients are able to walk with relative comfort in eight weeks, and if there is no compensation neurosis present they are capable of returning to a useful occupation nine to twelve months after the injury. In a patient who is reasonably co-operative, treated by early mobilisation, the function of the foot six months after the injury is only in the exceptional case bad enough to make one consider subastragaloid fusion.

It would appear that the gloomy prognosis which it has been customary to give the patient with a severe fracture of the os calcis is the result of 'over-treatment' of this fracture. In this connection we must not forget also the serious and far-reaching psychological ill-effects of a gloomy attitude adopted by the surgeon, and unconsciously conveyed to the patient, as a result of the sinister past reputation of this injury. A cheerful and optimistic attitude combined with early mobilisation and short hospitalisation can work miracles in this particular fracture. Even in the days when the os calcis was maltreated by distraction, and when a perpetual air of despondency surrounded the case, the very late end results (five years or more) were frequently much better than one might expect. When all compensation is settled many of these patients eventually get back to their original work.

Technical Details.—It is important to apply a firm elastic pressure dressing to the fractured os calcis and maintain this for about two weeks. Neglect to apply

pressure will permit the formation of fracture blisters which may become infected. Early movements are permitted within a few days and weight-bearing encouraged after four weeks. In a few cases where there is very severe eversion of the heel an attempt may be made to manipulate and mould the heel into better shape and apply a light plaster cast, but this should not be retained for more than two or three weeks before starting mobilisation.

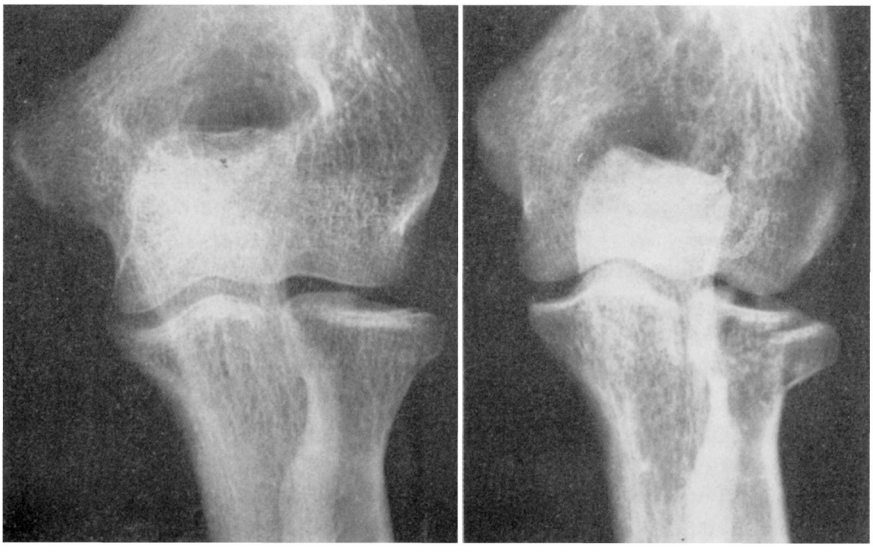
Fractures of the Head of the Radius

There is a wide divergence of opinion in the literature on the treatment of fractures of the head of the radius. Some surgeons advocate complete excision of the radial head whenever there is any doubt concerning the amount of displacement or comminution. I cannot help feeling that those who advocate excision of the radial head *when in doubt* do so from illogical reasoning. It is generally accepted that a fracture of the radial head is only a small part of what is a much more extensive injury to the soft tissues of the elbow joint, and that it may be the only manifestation of what has been a momentary subluxation of the elbow, sometimes accompanied by tearing of the medial collateral ligament. This is supported by the clinical fact that full extension of the elbow is always slow to return, although anatomically this movement is not related to the radial head, whereas it is common knowledge that pronation and supination almost always recover quickly and completely, yet this is the range most intimately connected with the anatomy of the radial head.

In association with a fracture of the radial head there may be a superficial contusion of the articular cartilage of the capitellum, not visible in an X-ray, and this is sometimes offered as a reason for the loss of full extension which so often follows quite a trivial crack fracture of the radial head without displacement. But superficial contusion of the cartilage covering the *capitellum* is surely no logical reason for advising excision of the *radial* head. Superficial contusion of articular cartilage is a condition ideally suitable for treatment by early joint mobilisation. Superficial contusion of the articular surface of the capitellum is unlikely to be responsible for permanent limitation of extension of the elbow, the cause of which is most probably sited in the ligaments and capsule, and excision of the radial head when in doubt will do no good to the damaged ligaments and capsule. Final proof lies in the results of excision of the radial head, and in my experience these do not show any quicker recovery of extension than in cases not operated upon. Excision of the radial head always delays early mobilisation of the injured elbow, often by as much as three weeks because, not being a true emergency, excision is often postponed one week, at which time active mobilisation would be starting in the conservative regime.

The two cases shown in Fig. 65 illustrate the above points; the patient with the almost undisplaced marginal fracture (A) had not recovered the last 30 degrees of extension five months after the injury, yet the patient with considerable comminution (B) had recovered full extension within three months. These two examples illustrate my attitude to resection of the radial head, because some

surgeons would have resected the displaced and comminuted radial head in case B. As it happened, this patient had already recovered 75 per cent. of pronation and supination fourteen days after the injury, though only about 25 per cent. of the flexion-extension range had returned. With such a recovery of rotation there seemed no point in recommending excision because I did not believe that this would help the recovery of flexion and finally extension. The decision was justified by the result and she recovered full pronation and supination despite the comminution.



A B

FIG. 65

Showing lack of correlation between functional result and radiological displacement in fractures of head of radius. Both cases achieved full range of pronation and supination; case A never completely recovered full extension but case B did.

This example illustrates the importance of assessing the actual range of pronation and supination *by clinical testing* rather than by supposition from the radiological appearance.

It is sometimes suggested that if the radial head is to be excised it should be done early (*i.e.*, within the first ten days) or not at all. It is impossible to assess the necessity for excision of a radial head (which is only to restore pronation and supination) until at least two weeks have elapsed and when pain and spasm have more or less subsided. If after two weeks a comminuted fracture has not recovered an acceptable range of pronation and supination (which starts to return early if it is going to return at all) then excision can seriously be considered. I have not seen ectopic ossification follow this slightly delayed intervention.

Treatment

Patients with fractures of the radial head, even with considerable comminution, should be encouraged to practise active extension of the elbow within two or

three days of the injury. They should never be allowed to retain a sling for longer than the initial week and, if possible, it should be discarded two or three days after the injury. All movements should be active and, of course, repeated passive stretching should be prohibited.

Manipulation of the Elbow after Fractures of the Radial Head

If there remains limited extension of the elbow after three months of conservative treatment of a fracture of the radial head, especially if there has been relatively little displacement, a gratifying improvement in the range of extension of the elbow can sometimes be obtained by a manipulation under anæsthesia. This is occasionally a most valuable procedure and no harm will be done if the manipulation is confined to one single occasion and is not repeated if no benefit immediately ensues.

The elbow is a joint which usually responds badly to any manipulation undertaken with the idea of improving its range of motion, and clinical teachers in the past have wisely laid great stress on condemning the practice. It must be clearly realised that I am advocating a single late manipulation in the special instance of fractures of the radial head and not for all and sundry causes of elbow stiffness after trauma and certainly never in children.

Summary of Treatment of Fractures of the Radial Head

As a working rule I would recommend the following axioms :

1. Mobilise the elbow actively as early as possible (active extension exercise after two to three days).
2. When in doubt do not excise the radial head.
3. The radial head is to be excised only if its deformity appears likely to limit pronation and supination. Practical experience shows that only very gross deformity is likely to restrict rotation.
4. Failure to recover a reasonable range of rotation by clinical testing at the end of the second week after injury, in the presence of comminution, is probably the best indication for excision of the radial head.
5. If it is decided to operate on the radial head, it should be excised *in toto*. The removal of loose fragments alone gives poor results.

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