STABILITY AND UNION IN SUBCAPITAL FRACTURES OF THE FEMUR

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Many surgeons are now convinced that the "unsolved" fracture should be renamed the "unsolvable" fracture, and the defeatist attitude of Sir Astley Cooper (1822) still lingers in present-day practice. This is reflected by the increasing tendency to abandon treatment by reduction and fixation, and to replace the femoral head with a prosthesis. This policy, which amounts to a confession of failure, would be fully justified if every subcapital fracture failed to unite. But non-union does not always occur, and many such fractures heal with modern methods of treatment. There must be a scientific explanation for the fact that union occurs in some, but not in all, subcapital fractures, and it would seem more logical to search for this explanation than to accept the widespread belief that there is something unfathomable about these injuries.

Over a hundred years ago Gurlt (1862), who believed that old age does not retard the progress of union, said: "There is no specific tendency to non-union in any form of fracture. If the ends of the broken bones can be kept in accurate apposition, union by bone will take place." Senn in 1883 stated "... we are not only justified, but warranted, in asserting that the only cause for the non-union in the case of intracapsular fracture is to be found in our inability to maintain perfect coaptation and immobilisation of the fragments during the time required for bony union to take place.” These nineteenth-century opinions have been amply confirmed by the successful results of treatment in countless fractures of the femoral neck where full reduction and efficient immobilisation have been achieved.
It is now clear that full reduction also implies full stability, and practical experience shows that when such stability is obtained union is almost certain to occur. Other things being equal, it therefore follows that if stable reduction could be achieved and maintained in every subcapital fracture the difficulties of union would be overcome. This, at first sight, may appear to oversimplify a problem which has been distorted and magnified in many ways. Nevertheless, the solution of this problem is more likely to emerge from its simplification than from the confusion of thought by which it is now surrounded.

![Diagram](image)

Fig. 2

Analyses of the mechanical forces acting upon different types of subcapital fracture (after Pauwels 1935). Differentiation is based on the degree of obliquity of the fracture line in the radiographic shadow, and it is assumed that displacement is produced by vertical loading. But the obliquity of the fracture line may be seen to increase in the same fracture as lateral rotation deformity increases, and the fracture is first subjected to forces which are not vertically disposed. These two-dimensional analyses are more applicable, therefore, to the cardboard models which are portrayed in the above diagrams than to the subcapital fractures which they are intended to represent.

Much of this confusion has followed the elaborate mechanical calculations that have been made from inaccurate, and often imaginative, diagrams, models or artificially produced fractures in laboratory preparations bearing little resemblance to the actual subcapital injury (Fig. 1). Deductions based on these false representations are themselves likely to be false, and if a serious attempt is to be made to understand this fracture all such conclusions must first be discarded. This will involve the rejection of many unchallenged assumptions, which, by repeated usage in the literature, have come to be accepted as scientific truths.

Many analyses of the mechanical forces acting upon the subcapital fracture have been made on the presumption that these forces are vertically disposed in the line of weight bearing (Figs. 2 and 3). But such forces are inoperative until the patient begins to walk, and the fracture fragments are first subjected to the combined effects of muscle spasm and gravity which lead to lateral rotation of the distal fragment (Fig. 4). Muscle spasm may be abolished by splintage of the fracture, but the force of gravity is unrelenting even in the anaesthetised or sleeping patient. When the fracture has been reduced by medial rotation of the affected limb, therefore, the immediate task of any form of fixation is to resist the natural tendency for lateral rotation to recur. When it fails to do so reduction is lost long before weight bearing is undertaken.
Confusion has also followed the unconfirmed belief that ischaemia of the head of the femur is primarily responsible for non-union. We know that avascular changes may follow union—but not that they prevent it. Stevens and Ray (1962) found that avascular bone remaining within the body of the rat retained its physical strength and composition: and a metallic fixation appliance must at first be tolerated better by a dead than by a living femoral head. Until it has been proved that early breakdown of reduction results from capital ischaemia, therefore, this assumption should be regarded merely as a convenient excuse for failure.

If a subcapital fracture of the femur resembled the cleanly broken injury it is so often shown to be in diagram form, it should, theoretically, be the easiest of all fractures to reduce. Simple medial rotation of the distal fragment, by opposing it to the mobile capital fragment, should result in automatic rotation of the femoral head into its normal relation with the neck (Fig. 5). Although the capital fragment may be represented more accurately as the terminal segment of a spiral tube, the same mechanical principle governs its reduction, and, when the femoral neck is cleanly fractured, stable reduction is, in fact, easily achieved by gentle medial rotation of the distal fragment. Internal fixation with any of the appliances now in common use is then likely to result in union. Conversely, when the fracture fragments are comminuted and reduction is unstable, non-union is equally likely to occur.

It is important, therefore, to distinguish between those fractures which lend themselves to stable reduction and those in which stability is difficult to obtain. In an attempt to achieve this distinction a method of classification based upon the degree of displacement of the fragments has been suggested (Garden 1961b). This classification recognises four stages in the development of this fracture (Figs. 6 to 9), and, in a series of 250 subcapital fractures treated by low angle fixation and early weight bearing, unstable reduction with subsequent non-union has been entirely confined to the Stage III and Stage IV injuries. Of these, the partially displaced and easily reduced Stage III subcapital fracture has united with greater frequency than the fully displaced Stage IV injury in which stable reduction is difficult—and sometimes impossible—to obtain. In the search for the solution of the "unsolved" fracture, therefore, two questions must first be answered: how does the unstable differ from the stable subcapital fracture, and how may its stability be restored?
Classification of subcapital fractures. Figure 6—Stage I—Incomplete fracture. The medial group of trabeculae in the femoral neck shows a "greenstick" fracture in a valgus position. Figure 7—Stage II—Complete fracture without displacement. The line of the medial trabecular group is undisturbed.

Classification of subcapital fractures. Figure 8—Stage III—Complete fracture with partial displacement. The capital fragment is tilted into a varus position, and its medial trabeculae are out of line with their fellows in the pelvis. Figure 9—Stage IV—Complete fracture with full displacement. The capital fragment has returned to its normal position in the acetabulum, and its medial trabeculae are in line with their pelvic projections.
THE NATURE OF DISPLACED SUBCAPITAL FRACTURES

The proximal end of the human femur is spirally disposed (Garden 1961a) and the femoral head is not set squarely on the neck as the usual diagrams suggest (Fig. 10). There is a well-defined postero-inferior overhang of the head, and the neck itself is convex anteriorly (Figs. 11 and 12). In the elderly patient the cortical shell of the neck is often paper-thin at its flared junction with the postero-inferior aspect of the head where it resembles the pouring lip of a jug (Figs. 13 and 14). When lateral rotation of the distal fragment follows subcapital fracture, extreme pressure is brought upon this fragile lip and comminution readily occurs. This comminution follows a regular pattern, and the fractured cortical lip is seen as a triangular fragment in every post-reduction lateral radiograph of acceptable quality (Fig. 15).

![Figures 10 and 11]

When the buttressing effect of this cortical lip has been destroyed by comminution, reduction by medial rotation perches the femoral head upon a base deficient postero-inferiorly (Fig. 16), and the mechanical advantage provided by the mobility of the head in the cleanly broken subcapital fracture then becomes a barrier to reduction in the comminuted injury. When the fragments of this fracture are apposed by medial rotation, pressure is first applied anterior to the central axis of the head, which is therefore forced to rotate in a posterior direction. The shattered postero-inferior cervical cortex can offer no resistance to this rotation, and a postero-medial tilt of the proximal fragment persists (Fig. 17). This rotational deformity is generally described as a simple anterior angulation, which is suggested by its radiographic shadow in the lateral view (Fig. 18). But the difficulties of reduction are more easily understood if it is recognised that pure movement in any one direction can occur only to a limited extent at the normal hip joint or at the site of subcapital fracture, and displacement is usually accompanied by some degree of rotation.

Carefully controlled traction in the long axis of the limb may open up the defect in the postero-inferior cortex, but this “artificial” reduction will be lost as soon as the traction is released (Figs. 19 and 20). Full anatomical replacement of the crushed and splintered bone fragments in this fracture is impracticable by any method of reduction, and even the post-mortem specimen held in the hands and under full visual control will defy accurate reposition of the fragments. The outstanding difference between the stable and unstable subcapital fracture thus appears to be that, in the former, the postero-inferior cortical lip is unbroken and, in the latter, it is fragmented and collapsed.

RESTORATION OF STABILITY

Any attempt to restore the equilibrium of the unstable subcapital fracture must compensate in some way for the defect in the postero-inferior cervical cortex. Reduction with the femoral head in the so-called valgus position closes this defect and improves stability. But the extreme
Fig. 12
Oblique view of the proximal end of the femur to show the postero-inferior overhang of the head.

Fig. 13
Figure 13—Radiograph to show the paper-thin cortex at the postero-inferior junction of the femoral head with the neck.

Fig. 14
Figure 14—The postero-inferior cortical buttress of the femoral neck showing its resemblance to the pouring lip of a jug.
Figure 15—Post-reduction lateral radiograph to show the appearance of the fractured postero-inferior cortical lip in a comminuted subcapital fracture. Figure 16—Post-mortem specimen of a Stage IV subcapital fracture to show the unstable support for the femoral head after comminution of the postero-inferior cortical lip.

Figure 17—Diagram to indicate the persistence of deformity—after reduction by medial rotation of the distal fragment—in a subcapital fracture comminuted postero-inferiorly. Figure 18—Lateral radiograph of a subcapital fracture to show rotational deformity. This deformity is generally believed to represent a simple anterior angulation. Figure 19—Lateral radiograph of a subcapital fracture "artificially" reduced by traction in the long axis of the limb. This unstable reduction will persist only so long as the traction is maintained. Figure 20—Lateral radiograph of the same fracture as in Figure 19, showing the collapse of reduction after releasing the traction.

valgus position (Fig. 21), in common with every severe rotatory displacement, twists and obliterates the blood vessels in the ligamentum teres (Smith 1959), and is associated with capital necrosis after union has occurred. When valgus displacement is of moderate degree, however, and the medial group of lamellae in the capital fragment lies at an angle of less than
180 degrees with the medial femoral cortex in the antero-posterior radiograph, the advantage of stability is seldom offset by subsequent avascular change.

Stability may also be obtained by various forms of osteotomy (Pauwels 1935, McMurray 1936, Voss 1937, Reich 1941, Leadbetter 1944, DePalma 1950, McNeur 1953); and Scheck (1959) suggested removal of part of the anterior cortex to compensate for the comminution of the posterior cortical shell. Partial excision of the antero-superior cortex may be more appropriate, but it should be noted that some of these procedures result in distortion of the neck with disturbance of the critical relationship between the aspherical femoral head and the screw-like acetabular runway. Incongruity of the opposing articular surfaces will then lead to degenerative arthritic change.

![Figure 21](image1.png)  ![Figure 22](image2.png)

**Figure 21**—The extreme valgus position in a subcapital fracture. The trabeculae on the medial side of the femoral head lie at an angle greater than 180 degrees with the medial femoral cortex. **Figure 22**—Antero-posterior radiograph of a subcapital fracture ten days after Smith-Petersen nailing. Breakdown of the reduction with lateral rotation of the distal fragment has occurred. Extrusion of the nail and apparent foreshortening of the neck create the illusion of absorption at the fracture site. The illusion is also created that the nail has ploughed through the femoral head in a forward direction, but, in these circumstances, the nail is avulsed from the capital fragment.

Ideally, therefore, any procedure designed to restore stability should preserve the normal configuration of the femoral neck. With this in mind, a wedge-shaped bone graft taken from the anterior superior iliac spine has been used to fill the defect at the postero-inferior aspect of the fracture, but this is technically difficult and involves wide exposure of the fracture site. Further research may discover a more simple means of restoring stability, but, for the time being, reliance must continue to be placed upon internal fixation to maintain reduction.

**Internal fixation**—Internal fixation is first required to resist the gravitational and muscular forces leading to lateral rotation of the distal upon the proximal fragment and redisplacement of the fracture. When the fracture is stable this resistance can be provided by any type of fixation appliance crossing the fracture site and securing a firm hold in both fragments.
End-results of low angle screw fixation in fractures of the femoral neck. Figure 23—Basal-cervical fracture. Figure 24—Mid-cervical fracture. Figure 25—Stage I subcapital fracture. Figure 26—Stage II subcapital fracture.
When the fracture is unstable the fixation device is required not only to resist the deforming forces of muscle spasm and gravity, but also to preserve whatever degree of “artificial” reduction may have been obtained by traction. This suggests that the fixation appliance should be placed postero-inferiorly, should be firmly fixed in both fragments, and should resist extrusion. This is contrary to the belief that overall compression is desirable in all subcapital fractures, and, indeed, many fixation devices have been specifically designed to allow and, on occasion, to encourage extrusion of the nail or screw to compensate for absorption or settling at the fracture site.

The uncomminuted subcapital fracture unites with no more absorption of the fragments than does any other fracture, and there is little or no extrusion of the fixation appliance after this injury. Absorption is most often described in the comminuted fracture, but here it is largely a radiological illusion. Although true absorption of the neck occurs in the ununited fracture of long standing, the appearance of absorption in the radiographic shadow of the recent fracture treated by reduction and fixation is created by the recurrence of deformity with lateral rotation of the distal fragment. This breakdown of reduction results in extrusion, or intrusion, of the fixation device and apparent foreshortening of the neck in the antero-posterior radiograph (Fig. 22). Early extrusion of the fixation appliance of more than a few millimetres must therefore be regarded as an indication of its failure to maintain reduction rather than as a measure of capital ischaemia or of bone absorption at the fracture site.

However this may be, sliding or compression devices are of undeniable advantage in the treatment of uncomminuted fractures of the femoral neck where the fragments can be safely encouraged to impact to a position of stability.

Basal-cervical, mid-cervical, Stage I and Stage II subcapital fractures can be expected to unite after internal fixation by most appliances now recommended for the treatment of these injuries. This is certainly true of low angle fixation, which may be used with the utmost confidence when immediate weight bearing is desired. Full radiological union invariably occurred in eighty-five such fractures treated by the low angle nail or screw during the past ten years, and kept under observation for twelve months or more (Figs. 23 to 26). This positive finding, which is easily verifiable by other workers, suggests that these stable injuries may be dismissed from the category of the “unsolved” fracture—at least as far as union is concerned. The real difficulties are found in the more common displaced subcapital fractures, and, despite the extravagant assertions that are made from time to time, no single fixation device has yet proved to be consistently successful in the treatment of these troublesome injuries.

Although the less exacting forms of classification allow a high overall percentage of union to be claimed by combining the universally good results of treatment in stable subcapital fractures with those of the unstable injuries, only a temporary advantage is gained in this way. Judgement of the true worth of any method of fixation should therefore be reserved until the results of its use in fully displaced subcapital fractures have been separately declared.

**Low angle fixation**—Internal fixation with the low angle Küntscher nail is followed by union in little more than 50 per cent of Stage IV subcapital fractures, and the author’s low angle screw is even less successful in the treatment of these particular injuries. This is readily explained by the different shape of the two appliances. The clover-leaf Küntscher nail is better designed to resist rotation than the rounded screw, and the steeply aligned Smith-Petersen nail must be more effective than either in this respect.

The low angle screw lies in the direction of loading in the femoral neck and thereby avoids the direct strains of weight bearing. It also lies in the mechanical axis of rotation, and is thus more likely to invite than to resist lateral rotation deformity. Its near-vertical position therefore explains its strength—and also its weakness. The same may be said of the near-horizontal position of the conventional fixation appliance which lies athwart the axis of rotation. In this position it offers greatest resistance to lateral rotation, but, at the same time, is directly exposed to the strains and stresses of weight bearing.
The leverage action of the low angle screw exerts a forward and upward pressure through the long arm of its lever where it pierces the lateral femoral cortex, a backward and downward thrust upon the calcar femorale which forms its fulcrum and a forward and upward pressure through the short arm of its lever where it lies in the femoral head. When the fragments are uncomminuted, the pressure of the screw in the femoral head is neutralised as soon as lateral rotation of the distal fragment begins to occur. Compression is then applied at the postero-inferior aspect of the fracture which forces the capital fragment to rotate antero-medially until an equal and opposite impacting force is exerted upon the antero-superior fracture surfaces (Fig. 27). It is this state of equilibrium between opposing forces which constitutes stability. When the supporting platform of the postero-inferior cortical lip has been lost by comminution no such equilibrium is possible. The unresisted forward and upward thrust of the screw in the capital fragment allows lateral rotation to recur, and the screw is avulsed from the cancellous bone of the femoral head. Additional measures must then be taken to ensure stability.

Two or more nails or screws offer a greater resistance to rotary movement than a single device can do. This was recognised as long ago as 1934 when Moore described his method of treatment by multiple pins, and Deyerle (1959) has again stressed the value of combined triple-screw and plate fixation. Geckeler (1937) and Von Bahr (1946) suggested the use of two parallel screws (Fig. 28), but simple experiment shows that the greatest torque resistance of two screws lying in a heterogeneous substance such as bone is reached only when they cross and make contact with each other. The screws then form a rigid double lever system with a common fulcrum at their point of crossing.

**Cross screw fixation**—The single low angle screw exerts a forward and upward pressure within the capital fragment, but, when combined with a horizontally disposed screw crossing it anteriorly, the direction of its pressure in the femoral head is reversed. This pressure, now exerted in a backward and downward direction, is immediately balanced by the upward and forward thrust now imparted to the capital fragment by the horizontal screw. The state of equilibrium between the forces acting upon the capital fragment is thus restored (Fig. 29).

The steeply positioned posterior screw obtains a rigid fixation in the distal fragment where it traverses the lateral femoral cortex and where it shares a common fulcrum with the horizontally disposed anterior screw. The latter also meets resistance where it pierces the

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**Fig. 27**

Diagram to illustrate sequence of movements which neutralise the forces leading to redisplacement of the reduced uncomminuted subcapital fracture. Lateral rotation of the distal fragment (1) forces the postero-inferior fracture surfaces into apposition (2). This in turn rotates the capital fragment antero-medially (3). This rotation is arrested as soon as impaction of the antero-superior fragment surfaces occurs (4). The capital fragment is then subjected to an equal and opposite counterthrust in a postero-medial direction (5) and the equilibrium which constitutes stability is complete.
cortex of the greater trochanter, and where it lies against the posterior screw. Overall postero-medial displacement of this double lever system is resisted by the buried cortical cortex known as the calcar femorale. Both screws therefore obtain an unyielding purchase upon the distal fragment through the medium of cortical bone, and the security of their fixation would thus be unimpaired if the distal fragment consisted only of an empty cortical shell. In the aged this fragment may often be found to merit this description closely.

In contrast with the fragile medulla of the trochanteric area and neck, the femoral head retains its dense cancellous structure even in the elderly patient (Fig. 30). If it were otherwise, internal fixation would be well-nigh impossible, but the fixation appliance should penetrate the capital fragment deeply if the greatest grip upon the cancellous bone is to be obtained.

**Fig. 28**

Von Bahr's (1946) method of fixation by two parallel screws.

**Bone graft fixation**—King (1939), Wardle (1945) and Patrick (1949) showed that fixation by a combined bone graft and Smith-Petersen nail is followed by a greater percentage of union in subcapital fractures than by the use of the nail alone. Godoy Moreira and Camargo (1957) have also improved their results by combining a bone graft and screw, and Judet (1962) has described a posteriorly positioned pedicle graft with screw fixation which has been followed by union in all of forty patients treated in this way (Fig. 31). But it has never been proved that a bone graft is essential to union in these fractures, and it is easier to assume that the primary function of the graft is to assist mechanically in the maintenance of reduction rather than to provide a local source of new bone.

In a mechanical sense the Judet graft appears to be an effective means of restoring the cortical defect at the postero-inferior aspect of the displaced subcapital fracture. The fibular bone graft inserted posteriorly must also compensate for this defect, and, in combination with the fixation device, will offer the increased resistance to lateral rotation deformity which follows the use of two parallel nails or screws.

The mere presence of a cortical bone graft within the narrow confines of the femoral neck ensures that the nail or screw cannot be inserted in the once popular and least effective central position where it lies precariously supported in the fragile marrow of the distal fragment. Instead, the graft displaces the fixation appliance downwards to a position of greater security...
against the inferior cortical buttress of the neck. When the fibular graft lies in a more vertical position than the fixation appliance and crosses it posteriorly, its mechanical effect will be greatly enhanced. The bone graft may therefore contribute to stability in several ways.

PRACTICAL CONSIDERATIONS

The principle of internal fixation by a double lever system is concerned with the position of the levers rather than with their design. The stabilising effect of this method of treatment may therefore be expected to follow the use of any combination of wires, pins, nails, screws or bone grafts of sufficient strength to counter lateral rotation deformity, and of large enough calibre to resist cutting through the cancellous bone of the femoral head. The anti-rotatory effect of the two levers will increase as they approach the orthogonal position, but it is difficult to locate a double lever arrangement in the proximal end of the femur with its members crossing at the ideal angle of 90 degrees.

The above considerations are at first theoretical, and their true significance can be determined only by practical application. Fixation by two crossed screws has therefore been chosen for clinical trial, and 100 consecutive Stage III and Stage IV subcapital fractures have been treated in this way. Shorter lengths of the self-tapping cannulated screws now in routine use for low angle fixation of stable femoral neck fractures have been employed.
Preliminary findings—None of the technical difficulties commonly found in the management of the displaced subcapital fracture has been avoided by cross screw fixation. Difficulty in reduction, misplacement of the fixation appliance as the result of guess-work following unsatisfactory radiography and occasional fracture of the screws themselves have all been encountered.

Early breakdown of reduction occurred in seven patients after cross screw fixation, and this was clearly the result of faulty technique. In six of these patients the anterior screw failed to engage the capital fragment fully, and, in another, the posterior screw was too vertically disposed with its tip lying at the summit of the femoral head instead of at the centre of its articular margin. In the former position the posterior screw lies in the axis of rotation and the brunt of the rotation forces then falls upon the anterior screw which, alone, is unable to maintain reduction.

Satisfactory reduction and correct location of the screws has been associated with radiological union in fifty patients followed up for the arbitrary period of twelve months or more (Figs. 32 and 33). Reduction was maintained, and union was sometimes complete, in eight of eleven patients who died within twelve months of the injury (Figs. 29 and 34). Reduction continues to be held in those patients still under observation for less than a year, but union is expected to fail in some as the result of precarious reduction or imperfect positioning of the screws.

The first fifty patients were not allowed to walk until three months after the injury in the belief that it was best to investigate one factor at a time, and to postpone the rigorous test of early weight bearing until it had first been established that cross screw fixation could maintain reduction, and thus provide the opportunity for union to occur. An attempt is now being made to assess the effects of weight bearing at an earlier stage, and some patients are...
walking without support within a few weeks of their injury. The final test will depend upon
the incidence of capital necrosis, and this will not be completed until many patients have
been observed for several years.

Whatever deductions may now be made from this limited experience of cross screw
fixation, it has at least been shown that imperfect technique has no place in this method of
treatment. Just as union can be confidently predicted when reduction is stable and fixation is
secure, so also may non-union be considered inevitable when the fracture is unstable and the
screws have been inserted in a faulty position. The most significant fact which emerges,
therefore, is that there is a known reason for mechanical failure—a relation of cause to effect
as in any other scientific problem.

**Quality of reduction**—Internal fixation is intended to maintain reduction, and when this has
not been obtained the fixation appliance can, at best, do no more than maintain deformity.

Experience with the low angle Kuntscher nail has shown that it is never worth while to
depend upon this method of treatment when the angle formed between the medial group
of lamellae in the capital fragment and the medial femoral cortex in the antero-posterior
view (varus deformity), or the angle between the central axis of the femoral head and the
central axis of the neck in the lateral view (anterior angulation), is less than 155 degrees.
There is no evidence to suggest that a greater degree of deformity can be safely exceeded
when cross screw fixation is used, and this “alignment index” of 155–155 is still con-
sidered to indicate the extreme limits of acceptable reduction.

Although this “alignment index” does not pretend to measure the precise degree of
anatomical reposition of the fragments, it provides a useful guide to the degree of
stability and thus to the prognosis. More accurate assessment of reduction must await
the development of new techniques to augment the limited information which the
present methods of radiography provide.

**Operative technique of cross screw fixation**—

It may be considered premature to describe the operative details of a method of fixation
which is still in the experimental stage. As in all experiments, however, it is essential that
every effort should be made to destroy the underlying theory, and the following short account
of the surgical technique may enable others to further these efforts by testing the results of
cross screw fixation for themselves.

A six-inch incision extends distally from the tip of the greater trochanter. The deep fascia
is incised, and the posterior edge of the vastus lateralis is identified. A bone lever is inserted
to displace this muscle forwards to expose the lateral femoral cortex (Silk 1959). This exposure
may be increased by nicking the tendinous posterior edge of the vastus lateralis near the
greater trochanter. Division of the transverse branch of the lateral circumflex artery is avoided
in this way, and the operation may often be conducted without the need for arterial ligature.

A guide wire inserted through the anterior half of the greater trochanter is directed
towards the inferior part of the femoral head in the antero-posterior view. In the equally
important lateral view the guide wire should lie about the middle of the femoral head. When a satisfactory position is obtained the horizontally disposed anterior screw is inserted in the usual way.

The obliquely disposed posterior screw should skirt the calcar femorale, and its tip should approach the mid-point of the articular margin of the femoral head. Its point of entry is chosen accordingly, and a hole a quarter of an inch in diameter is drilled through the lateral femoral cortex at the indicated level. This hole is enlarged and converted to an oblique channel by a cannulated drill-reamer. A simple locating device inserted into the Allen key socket of the anterior screw directs a second guide wire, introduced through the oblique entry channel, just posterior to this screw, and ensures that the two screws will lie firmly in contact (Fig. 35). When the position of this guide wire is satisfactory in both views the posterior screw is driven home. The correct lengths of the screws are indicated by the guide wires, but a three-inch anterior, and a four and a half inch posterior, screw are usually required.

It will generally be found that the position of the anterior screw corresponds with the direction of the lateral group of trabeculae in the internal structure of the proximal end of the femur, and the posterior screw coincides with the line of the medial trabecular group. The screws will therefore be more vertically disposed in the valgoid than in the varus neck, but it is in no way suggested that the mechanics of cross screw fixation are related to the tensile and compressive properties ascribed to these trabecular arrangements in the street-lamp bracket or crane theories of Ward (1838), Culmann (1866) and Von Meyer (1867).

The operative technique described above has been developed in conjunction with the use of an x-ray image intensifier, but the exacting requirements of cross screw fixation cannot be met by image intensification alone. The definition provided by this method of radiography, particularly in the lateral view, is of poor quality, and has always been supplemented by ordinary radiographic films. In the assessment of reduction the trabecular pattern in the femoral head and neck must be clearly seen, and for this purpose the image intensifier is wholly unreliable. It must also be recorded that the operator using this apparatus is exposed to a greater radiation hazard than is generally supposed, and the use of a television monitor is essential.

**SUMMARY AND CONCLUSIONS**

1. Practical experience has shown that subcapital fractures of the femur unite freely if reduction is stable and fixation is secure.
2. Stable reduction is obtained when the muscular and gravitational forces tending to redisplace the fracture are opposed by equal and opposite counterforces, and inherent stability is believed to depend upon the integrity of the flared cortical buttress at the postero-inferior junction of the femoral neck and head.

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3. In the stable subcapital fracture a state of equilibrium is reached when the forward and upward thrust of the fixation appliance in the femoral head is opposed by the counterthrust of the closely applied and cleanly broken fragments at the postero-inferior aspect of the fracture. When the postero-inferior cortical buttress is comminuted, inherent stability is lost, lateral rotation deformity recurs and the fixation device is avulsed from the cancellous bone of the head.

4. Stability may be restored by reduction in the "valgus" position, by various forms of osteotomy, by refashioning the fracture fragments or by a postero-inferiorly positioned bone graft. Theoretically, stability may also be obtained by a double lever system of fixation in which an obliquely placed fixation device or bone graft is combined with a horizontally disposed wire, pin, nail or screw crossing it anteriorly. Multilever fixation by three or more threaded wires or pins inserted at different angles and lying in contact at their point of crossing may likewise provide stability.

5. Fixation by two crossed screws has been chosen for clinical trial in 100 displaced subcapital fractures. Imperfect positioning of the screws in seven patients has been followed by early breakdown of reduction and non-union, but satisfactory positioning has been associated with radiological union in fifty patients who have been observed for twelve months or more.

6. Ultimate breakdown in some of these fractures is certain to follow avascular necrosis, and this complication has already been seen in a few patients treated by cross screw fixation more than two years ago. It is also expected that non-union will occur in some of those patients still under observation for less than a year. Even so, these preliminary findings indicate a percentage of union far greater than that obtained by previous methods of treatment, and, although statistically inadequate, they are presented in support of the belief that it should no longer be considered impossible to achieve the same percentage of union in subcapital fractures of the femur as we are accustomed to expect in the treatment of fractures elsewhere.

It is not implied, however, that this ideal will be reached merely by the adoption of some form of double or multilever fixation, and much will continue to depend upon the quality of the radiographic services, the precision of reduction and the perfection of operative technique.

7. Every advance in our understanding of what is meant by "perfection of operative technique" lends increasing support to the ultimate truth of Watson-Jones's (1941) dictum: "A perfect result may be expected from a technically perfect operation; an imperfect result is due to imperfect technique." But the simple and foolproof method of fixation which will end the search for technical perfection in the treatment of the displaced subcapital fracture has yet to be evolved, and many questions remain to be answered about this injury. Nevertheless, it is clear that the surgeon should now be prepared to attribute early mechanical failure in the treatment of femoral neck fractures to his own shortcomings, and the temptation to blame capital ischaemia for every disaster should be resisted.

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