CHAPTER THIRTEEN

FRACTURES OF THE SHAFT OF THE FEMUR

THE treatment of fractures of the shaft of the femur is of particular interest, demonstrating as it does certain fundamental fracture mechanics previously described in more general terms. It seems probable that new operative methods of treating the fractured femur—such as the medullary nail of Kuntscher—will in the future take precedence over closed methods for transverse fractures of the shaft (which are always difficult to handle by conservative means) and for most other fractures in the middle and upper thirds. For fractures of the femur **in the distal third** which have been successfully reduced I believe that Thomas' method is unrivalled.

One of the many lessons we can learn from this fracture is the danger of becoming too much engrossed in minutiæ, if by so doing we lose the broad view of a problem. This is an error into which the tempo of modern life makes it easy to fall. We must never lose sight of two facts: firstly, that a fracture of the shaft of a femur can often be the easiest of fractures to treat conservatively; and secondly, that *full recovery* after a fracture of the femur takes about one year (which is the time necessary for full reconstruction of the ivory shaft of this bone). These are facts which we tend to forget when assessing new methods which apparently offer quick dividends and short hospitalisation. *Procedures adopted in the early phases of treatment can sometimes have disappointing and unexpected repercussions at a later date.* Thus in the case of early knee movement during the treatment of a fracture of the femur a considerable range of knee movement at three months is easily obtained in many traction-suspension methods, but if bony union is present only as a precarious bridge, or if fibrous union results, the need for a plaster hip-spica or a caliper splint may completely negate the early prospects of full knee range. **In some cases early knee movement may be responsible for fibrous union of the fracture, and hence a stiffer knee may result than if no joint exercise had been permitted in the early phases.** In the same way concentration on early knee movement may invite the appearance of a late varus deformity because this is difficult to prevent in any apparatus allowing knee movement. To end with the visible deformity of bow leg is but poor compensation for a good range of knee movement; this is all the more unfortunate when it is realised that a straight leg could in all probability have been secured by a slower method and still with a serviceable range of knee movement.

It is not out of place here to comment on a strange fact; while a patient will blame his surgeon for late deformity, he will usually tend to blame himself for

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knee stiffness. A patient regards deformity as something completely within the surgeon's scope, but often thinks that knee stiffness arises from defective material with which the surgeon has had to contend. If there exists deformity as well as knee stiffness, the patient invariably connects the two and explains the knee stiffness quite simply—' because the surgeon never " set " the leg properly ! '

Remote repercussions of early treatment on late results must also be considered in the operative treatment of fractures of the femur just as much as in the non-operative methods. If we see a case demonstrating the merits of internal fixation, we must first ascertain whether this result could also have followed the simplest form of conservative treatment (as is often the case in oblique or spiral fractures). If the operation of plating is favoured on the theory that it will facilitate early knee movement, it must not be forgotten that callus production is thereby commonly inhibited ; and if callus is tardy in its appearance the plate may angulate and the slow consolidation may result in a permanent restriction of knee movement through the need for late fixation in hip-spica or bone grafting ; thus the end result is the very opposite of what was intended.

Nor must the dangers of sepsis be lightly dismissed in the internal fixation of fractures of the shaft of the femur. *A solitary instance of sepsis in any series should be regarded as considerably reducing the merit of the series as a whole.* Sepsis after the plating of a femur is possible, because the operation often demands considerable muscular exertion from the surgeon, may consume much time, and may necessitate a very extensive exposure of the shaft. The operation is usually required in athletic young adults where the retraction of bulky investing muscles offers considerable difficulty. **Sepsis is the commonest single cause of permanent joint stiffness, and it must not be forgotten that an infection which resolves on chemotherapy may still scar the muscle of the quadriceps with serious consequences for knee movement.** One cannot help suspecting that some cases which run temperatures after operation, but which never discharge pus, may fall into this category.

Viewed in its broadest aspects, the problem of the fractured femur has no simple solution by conservative means, nor can any simple dictum be enunciated to guide the inexperienced. It is an over-simplification to say that the problem of the fractured femur is the problem of the stiff knee ; quite as great a problem is the late deformity (varus bowing), which is the ugly penalty of concentrating too much on early knee movement. **A good conservative result is a successful compromise between minimum deformity and minimum restriction of joint movement.** A good conservative method is one which yields a constant satisfactory result rather than a series of perfect cases interspersed with an odd catastrophe.

The healing of the fractured femur must be regarded as a process extending over a twelve-month period ; this is the time taken for the complete reconstruction of the cortex of the femoral shaft. First and foremost this fracture is a fracture of a weight-bearing bone ; it is also a fracture of a bone which possesses long levers, thereby exposing the callus to abnormally high stresses. The soundest plan of treatment is that which is directed primarily to securing sound bony union in the shortest possible time; this can only be done by planning to eliminate all factors which are known to delay consolidation. My own experience leads me to believe that **if sound bony union can be secured in three months, there will be an excellent recovery of knee movement by the end of one year even if no movement of the joint is permitted in the early months of treatment.**

It is the purpose of the following pages to attempt to expound the opinion

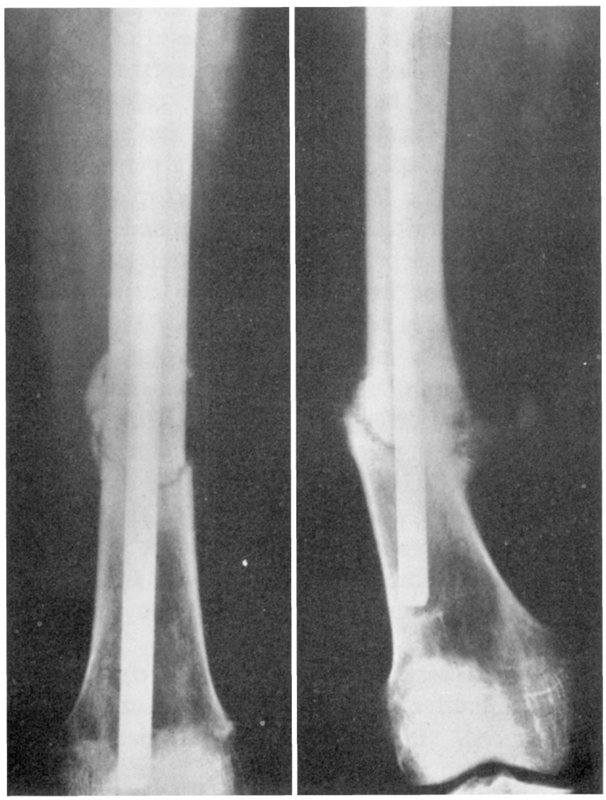

FIG. 130

Showing how intramedullary nail cannot control angulation in lower third of femoral shaft unless nail is passed so far distally as almost to penetrate knee joint.

that, *for fracture in the lower third of the shaft of the femur*, the conservative treatment using the Thomas splint is superior to all other methods, either operative or non-operative. From being, as it is in some circles, relegated to the status of a crude first-aid device, it is hoped to show that the Thomas splint possesses mechanical features which are superior to any other closed method, and that it is superior to any of the operative methods which use plates, because the latter may impede the mobility of muscles which have such a large excursion in relation to the lower third of the shaft. In the *lower third* of the femur the intramedullary nail by itself is not satisfactory because the expanding lumen of the distal fragment offers but a poor hold for the nail (Fig. 130). In fractures of the *middle third* the method of Thomas is unsuitable as a method of choice because the control of the proximal fragment is uncertain. The intramedullary nail would appear to be almost an ideal solution at the *midshaft*, as in the *upper third*.

Deformity

Classical fractures have classical deformities. Deformities are of two kinds: initial and late. Initial deformities result from the balance of muscle groups acting on the fragments; late deformities often depend on the method used for the treatment of the fracture. Late deformities are not necessarily the same as initial deformities; thus in the lower third of the femur the initial deformity is a backward angulation of the lower fragment, but the commonest late deformity is a varus (bow leg) angulation.

FIG. 131

Untreated femur in a native illustrating the fact that backward angulation is not a very noticeable deformity when the quadriceps fills up the anterior concavity and the knee joint compensates by flexing. Varus or valgus deformities, on the other hand, cannot be concealed, and both produce ugly appearances.

In the treatment of a fractured femur popular opinion always seems to stress the prime importance of correcting backward angulation, while the correction of varus deformity seems to be regarded as a simple matter to be dealt with *secundum artem*. In practice some residual backward angulation (though it need never occur with the Thomas method) is the least important deformity, because backward angulation can be compensated by flexion of the knee and the convex bulge of the quadriceps muscle conceals concavity in the femur. An extreme example of this is shown in the untreated femur of a native in Fig. 131, where the only disability was 2 inches of shortening and some limitation of terminal flexion (strangely enough there was no excessive hyperextension in the knee joint). By contrast a **slight varus deformity will result in an ugly bow leg if it is as much as 10 degrees, because deformity in the varus-valgus plane cannot be compensated at the knee joint and is always fully revealed when the knee is extended.** The concealment of varus deformity by the flexed position of the knee is a common reason for its presence in the end result when femurs are treated with the knee flexed to 45 degrees as they are on weight-traction; in this type of apparatus a varus bow is often noticed only on X-ray examination, whereas, had the limb been treated on the straight Thomas splint, even 5 degrees of varus bowing would have been detected at a glance.

A COMPARISON OF THE MECHANICS OF DIFFERENT CONSERVATIVE METHODS

The method of H. O. Thomas uses fixed traction with counter-traction by the ring of the splint and stands in sharp contrast to all other conservative methods which use weight-traction with counter-traction from body weight. The methods using weight-traction, conveniently grouped under the term traction-suspension methods, are numerous but *essentially the splint takes second place to the action of the traction force*, and indeed in some cases no splint is used at all. The principal modes of using weight-traction are represented by the following selection (Fig. 132):

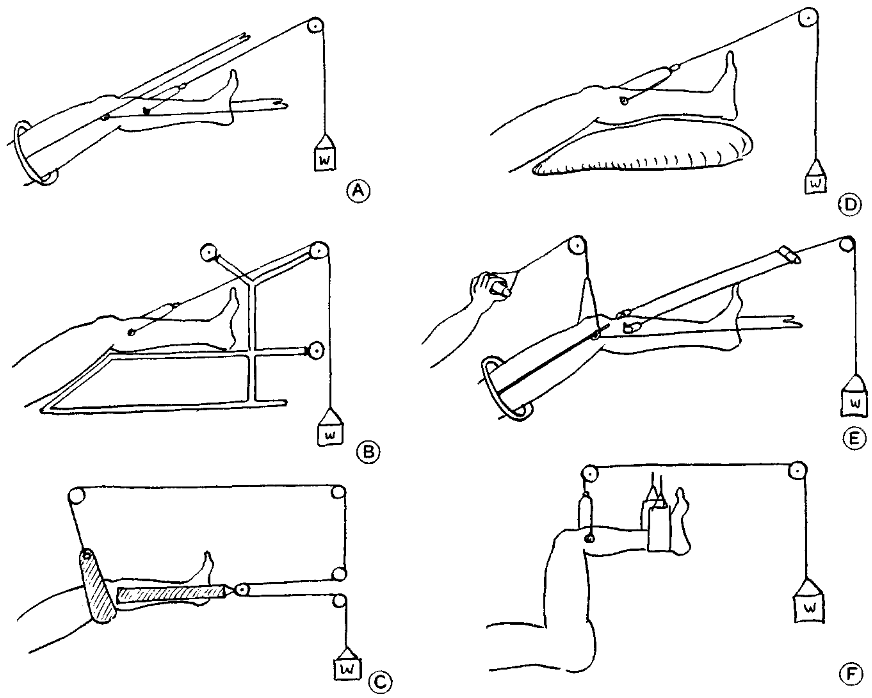

FIG. 132
Various modes of sliding traction.

(A) *Thomas Splint and Pearson Knee-flexion Piece.*—Here the Thomas splint acts merely as a cradle; it bears no fixed relation to the skeleton and can have no positive action in controlling deformity.

(B) *Braun Frame.*—This splint is again merely a cradle for the limb; an added disadvantage is that the position of the pulleys cannot be altered and the size of the splint often does not fit the limb as exactly as might be wished. Lateral bowing is common because the splint and the distal fragment are fixed to the

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frame while the patient and proximal fragment can move sideways leaving the frame behind.

(C) *Russell Traction.*—Posterior angulation of the distal fragment is controlled by a sling; the lifting force of this sling is related to the main traction force through the medium of pulleys. No rigid splintage is used in this method.

(D) *Perkins.*—Here no splintage at all is used; the posterior angulation of the thigh is controlled by a pillow; alignment and fixation depend entirely on the action of continuous traction.

(E) *Fisk.*—Here an ingenious hinged version of the Thomas splint is arranged to allow 90 degrees of knee movement; it is particularly attractive in that it allows of active extension of the knee joint. Fixation and alignment depend entirely on the weight-traction and the splint merely applies the motive power for assisted knee movements.

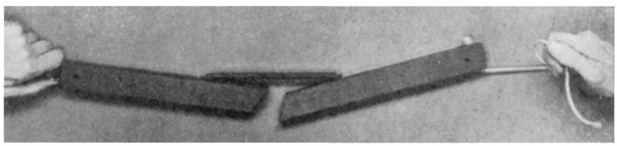

FIG. 133
Showing how traction in the axis of the femoral shaft cannot correct backward angulation but merely results in distraction with deformity persisting.

(F) '90—90—0.'—Here the thigh is suspended in the vertical plane by weight-traction pulling vertically upwards; the ill-effect of gravity as the cause of backward angulation of the fragments is thus eliminated.

Nearly all methods which depend on heavy traction are open to the following criticisms:

1. The action of continuous traction is frequently made to subserve a threefold function: to maintain length, preserve alignment, and fix the fragments. **It is impossible to diminish the traction force alone without jeopardising the stability of the reduction.**

2. **Gravity is not used to help in correcting the deformity of backward angulation.** The thigh, being suspended at its distal end, shows a natural tendency to sag at the fracture site under the action of gravity; this has to be combated by slings or pads which continually require adjustment.

3. There is always a tendency for the line of traction to pull into the axis of the femur. It should be an axiom that **backward angulation of the distal fragment can never be corrected by traction in the axis of the femur;** traction in the axis merely results in elongation without correction of angulation (Fig. 133). To correct backward angulation it is necessary for the traction force to act against a rigid fulcrum placed below the distal fragment; to do this *the direction of the traction must be deflected away from the axis of the femur* so as to exert a turning movement on the lower fragment round the fulcrum (Fig. 134).

THE THOMAS METHOD

If any one maxim can ensure success by the Thomas method perhaps it is that **the fracture must always be amenable to manipulative reduction**

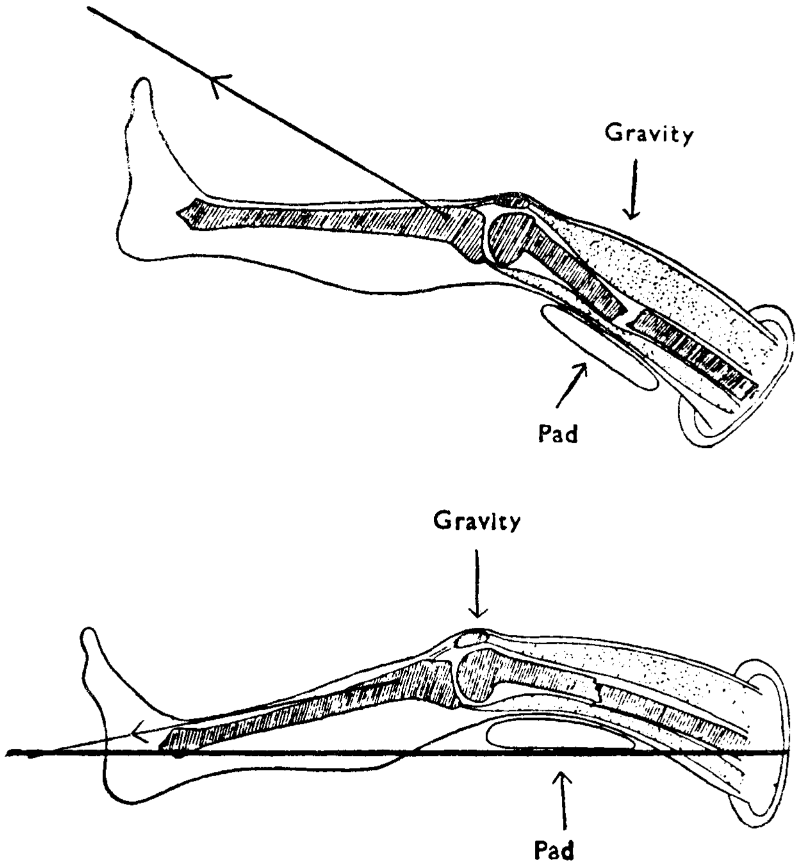

FIG. 134

Showing how gravity tends to encourage sagging at the fracture site in traction-suspension methods, but encourages anterior bowing in the Thomas method and is assisted in this by traction directed away from the axis of the femur (*i.e.*, in the axis of the tibia).

before the splint is applied. The Thomas splint with fixed traction is only capable of *maintaining* a reduction previously secured by manipulation. A common source of failure with this method arises from continuous attempts to secure additional length by repeatedly tightening the traction cords after an unsuccessful attempt at manipulative reduction.

When a fracture has been successfully reduced and has been fixed in a Thomas splint the tension in the apparatus, on recovery from the anæsthetic, should be merely that generated by the tone of the resting muscles. This method therefore differs fundamentally from traction-suspension methods where the tension in the apparatus is always that of the imposed weight and may have no relation to the physiological requirements of the muscles. Under weight-traction the 'stretch-reflex' calls out further contraction from the muscles, and until the muscles lose their tone from fatigue or adaptation the initial weight is in excess of that demanded by the resting muscles. **With fixed traction it is the length which remains constant,** while there is a continuous diminution of traction force as the tone of the muscles diminishes, as no further stimuli are thrown in to evoke a stretch reflex. **With weight-traction it is the tension which remains constant** and the length depends on the amount of tearing of the inter-muscular septa and fibrous tissues of the thigh. *With fixed traction the fracture can be 'set' at a predetermined length irrespective of the tone of the muscles or the laxity of soft parts.*

In the Thomas method it is undesirable to be continually re-tightening the traction cords if the length of the limb is adequate. The evidence of the tape measure is not to be despised—it is almost as helpful as the X-ray and more easily carried out.

If the fracture is oblique, adequate length can always be held with quite gentle traction. If the fracture is transverse this method possesses the desirable feature, not present in any other, that it allows the traction force to be deliberately decreased, once the bone ends have been 'hitched' by manipulation, without invoking angulation; because **alignment is controlled by the splint and not by the traction force.** If the fracture is transverse and manipulation has not secured a reduction, then the fracture is unsuited to this method; in this case one may resort to open reduction.

The case illustrated in Fig. 135 is a good example of the management of a case by the Thomas method using the principle of 'controlled collapse.' *The features of special interest are:*

1. The patient was seventy-one years of age.
2. Gentle traction held the length with a predetermined amount of shortening ($\frac{1}{2}$ inch).
3. The side bars of the Thomas splint controlled the angulation in the presence of only a token traction force (not more than 2 to 3 lb.).
4. Union was facilitated by the 'controlled collapse.'
5. The first signs of clinical union were detected six weeks after the injury because fixation was incomplete; thus active movements were possible inside the confines of the splint and the limb could easily be released to test for union.
6. Clinical union being detected, all splintage was abandoned and the limb laid over a pillow for another two weeks. If the fracture had been transverse this would not have been permissible because late angulation would be threatened, but it was safe in an oblique fracture.
7. Eight weeks after the fracture the patient had nearly 90 degrees range of movement in the knee and was permitted to take weight on the leg with assistance.

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8. At four months the patient had recovered with a full range of knee movement.

Contrast this with what might easily have happened on 'balanced' weight-traction if used by a surgeon unaware of the potential dangers of the method:

1. In order to maintain alignment, adequate tension would have to be maintained in the fascial structures of the thigh, which would necessitate 10 to 15 lb. of longitudinal traction.

2. This amount of traction would have pulled the fracture out to full length (and might even have distracted it).

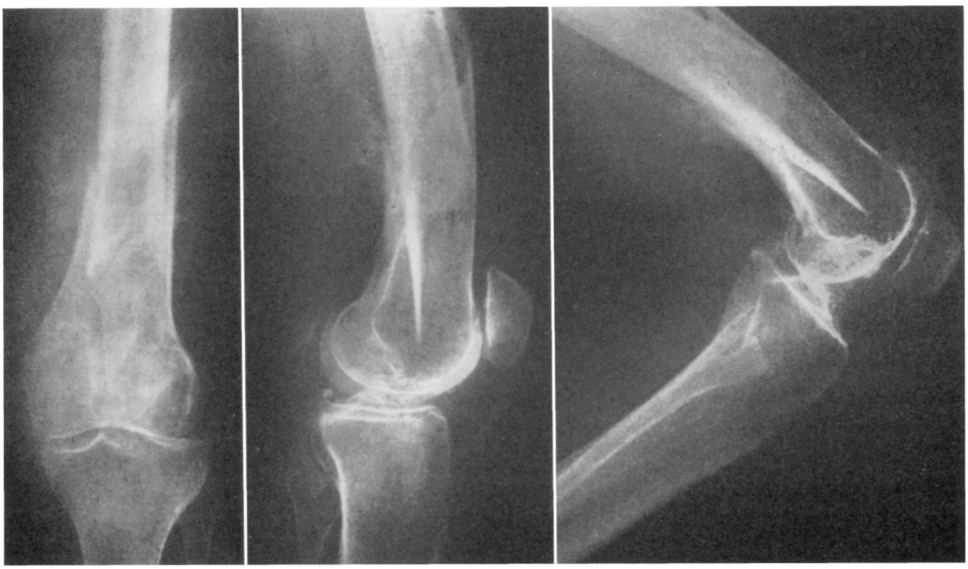

FIG. 135

Lower-third fracture of femoral shaft in patient seventy-one years of age, treated with Thomas splint, skin-extension, controlled collapse, and mobilisation as soon as clinical tests suggested union. Note flexion range (100 degrees) three months after injury. Excessive traction might have delayed consolidation.

3. Failure to promote collapse would have impaired rapid consolidation of the fracture and rendered it unsuitable for weight-bearing.

4. By using balanced traction 30 degrees of active knee movement might have been achieved at three weeks, but if consolidation had been imperfect the later progress of knee range would have been slow.

5. Attempts to diminish the amount of weight-traction would have encouraged angular deformity by allowing the fascial structures in the thigh to become slack.

If treated in a plaster cylinder or hip-spica the disadvantages would be:

1. Shortening might become excessive.

2. Fixation would be more rigid than is necessary.

3. It would be impossible to detect the first signs of the return of active movement as an indication of early union. Plaster thus would have to be retained

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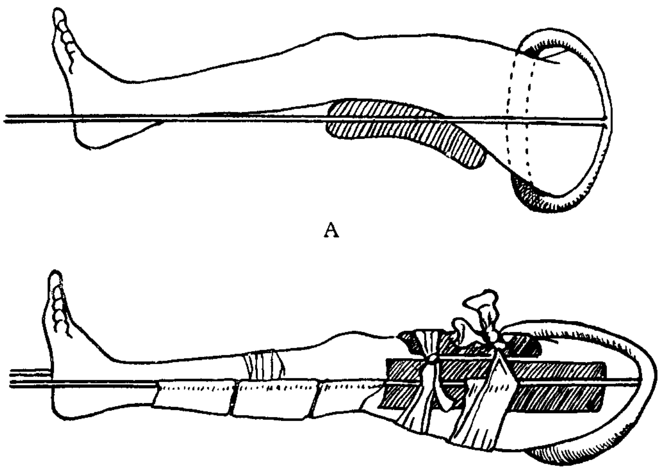
for an empirical period, *i.e.*, eight to twelve weeks, and thereafter rehabilitation would have to start from zero.

The Correction of Posterior Angulation

In the correction of backward angulation in fractures of the distal third of the femur the method of Thomas presents some particularly attractive features. It must be mentioned that the method to be advocated here is not exactly that described by Thomas himself; it differs from his original description in that the knee is elevated in front of the side bars of the splint by means of a large pad under the lower fragment and popliteal fossa, which causes the knee to be flexed by about 20 degrees (Fig. 136, A). In the classical description the knee was flexed by not more than 5 degrees, and it lay between the bars of the splint with two-thirds



A

B

FIG. 136

A, Modified Thomas method as advocated by the writer; the whole thigh lies in front of the side bars, not two-thirds in front and one-third behind as in the original method.

B, Classical arrangement of Thomas splint as used by H. O. Thomas—reproduced from his *Contributions*.

of the knee in front and one-third behind (Fig. 136, B). With the knee straight the traction force acts only in the length of the femoral shaft and, as was posed as a maxim in a preceding paragraph, traction in the axis of the femoral shaft cannot help in the correction of backward angulation. It is probable that as used by Thomas some slight posterior angulation might often have persisted by this method, for it must be remembered that the work of Thomas preceded the X-ray. This serves to emphasise how a slight posterior angulation need cause no noticeable external deformity.

In the modified method here to be described the large pad behind the lower fragment acts as a fulcrum over which the backward angulation is corrected by the traction force. The direction of the traction force lies in the axis of the *tibia*, *i.e.*, 20 degrees away from the axis of the femur; the higher the pad, and therefore **the more flexed the knee, the more effective becomes the correction of backward angulation by traction in the axis of the tibia.**

It will be observed in this method how economically the force of gravity is

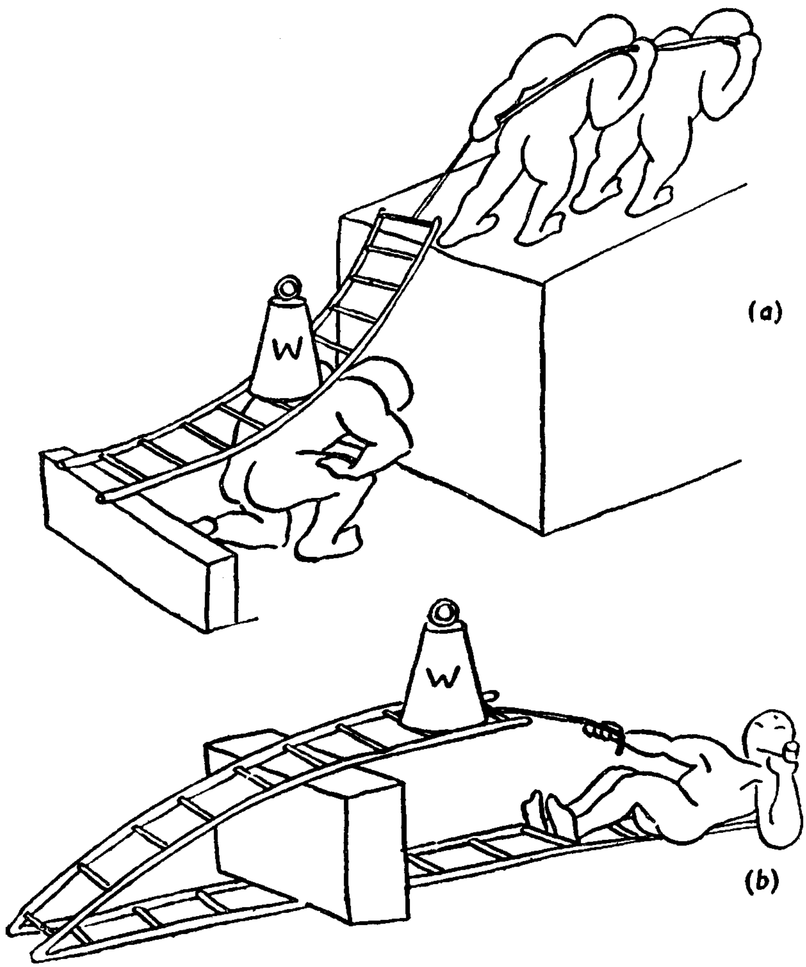


FIG. 137
Cartoon illustrating the essential difference between traction-suspension methods and the Thomas method. In the former there is a wasteful use of force to combat the ill-effects of gravity, in the latter gravity is harnessed and results in great economy of traction force and less danger of over-distraction.

coerced into restoring anterior convexity to the shaft of the femur. Instead of the fractured shaft sagging under the action of gravity by being suspended from its distal end, as it is in traction-suspension methods, the shaft is moulded over the convex surface of the pad by the weight of the thigh assisted by the pull in the length of the shaft of the tibia. This arrangement is illustrated in the cartoon in Fig. 137.

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Counterpoising the Thomas Splint

The principal disadvantage in using the Thomas splint with fixed traction is that it can be very uncomfortable. The compact ' triangulated ' arrangement of the forces, with the splint and pressure pad in a fixed location in regard to the limb, depends on firm contact between the padded ring of the splint and the root of the limb. If the nursing staff is not diligent in caring for the skin under the ring, this is likely to blister if fixed traction of more than a few pounds is being exerted through it. To ease the pressure of the ring against the perineum the Thomas splint, with its fixed traction *in situ*, can be counterpoised from a Balkan beam and light weight-traction can be applied to the end of the splint to keep the ring pressure comfortable (Fig. 142, p. 182). It is rarely necessary to apply a traction weight of more than 5 lb. because the fracture has already been reduced by manipulation. After the first two weeks it is often unnecessary to have any weight-traction acting in a longitudinal direction and then the fracture is merely resting on a counterpoised splint held to an adequate length by the fixed traction inside the splint.

The Thomas Splint

In its original form the ring of the splint consisted of a simple geometrical ovoid, and this is still the best shape of ring. The numerous attempts to ' improve ' it, by innovations such as introducing a V-shaped dip with the idea of improving the ischial bearing, are valueless. The idea that the ring exerts its counter-extension against the tuber ischii is a fallacy which should be boldly exposed; in actual practice **the major part of the counter-extension is taken against the perineum and the fatty folds of the buttock.** To insist that the ring should exert its counter-extension only against the tuber ischii, *which it most palpably does not*, is one of the reasons why critical observers have viewed this method with distrust. H. O. Thomas in his own description of the method never uses the term tuber ischii, nor does he indicate by any other name that the ring bears against any bony point of the pelvis. Throughout his work he refers to the ring as the ' groin ring ' and busies himself with the accurate fitting of the ring to the circumference of the ' root of the limb.'

Particularly objectionable are those first-aid splints which possess only a half ring, completed in front by a strap; in this type of splint the half ring is sometimes hinged to the side bars, which is a most undesirable feature except in first-aid work.

There should be a complete stock of these splints with rings varying from 11 to 26 inches in 2 inch steps. The rings should all be newly covered with soft leather and should be dressed with saddle soap. The hard, dry, cracked rings which result from previous use on other patients are not to be tolerated. An arrangement should be made with the splint shop for recovering dirty, used, rings and keeping the stock series complete. A ring should be chosen which fits the thigh as closely as possible, but it will always be found that it becomes looser as the thigh shrinks; when this occurs a pad placed between the lateral part of the ring and the great trochanter will keep the medial part of the ring from

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the anus and nearer to the region of the tuber ischii. *After six weeks, when the fracture is first examined for the progress of union, the splint must be changed for one with a closer fitting ring.*

The Slings

Slings should be of strong calico or flannel and should be 6 inches in width. They should be applied as illustrated in Fig. 138 so that four thicknesses are under the limb. The most important sling is that which supports the pad under the distal fragment—**the 'master sling'**; this should never be held by paper clips but **must be rigidly fixed to the side bars because it is the key to the reduction.**

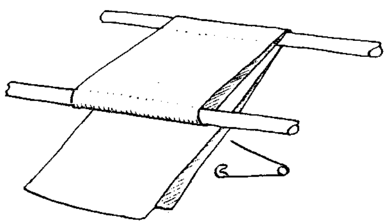

FIG. 138

Method of applying the master sling behind the lower fragment.

A source of mechanical failure with the Thomas splint is a tendency of the master sling to slide on the side bars of the Thomas splint and so to drift away from the position initially set by the surgeon. This is easily remedied by the simple expedient of binding the side bars with adhesive strapping for a short distance before applying the master sling.

The Pad

Lying on the master sling is the pad used to support the lower fragment and popliteal fossa. The pad is made by enclosing cotton wool in a length of 6 inches diameter stockinet and turning in the ends. When compressed between the hands the pad should measure approximately 2 inches in thickness, 6 inches in width, and about 9 inches in length. It is placed transversely across the splint under the distal fragment and popliteal fossa.

Fixed Skeletal Traction

In the classical method of applying fixed traction on the Thomas splint skin traction was always used. Skin traction is uncomfortable and some patients find that itching of the skin can be greater torment than the discomfort of the fracture. Unless a nursing staff is available skilled in supervising this type of treatment, there is a great danger of pressure sores near the tendo Achillis. Paralysis of the external popliteal nerve is a not infrequent complication of skin traction on a Thomas splint, due I think to the tendency of the leg to roll into external rotation, which is difficult to check by skin traction. In the externally rotated position the external popliteal nerve moves from its normal posterolateral position in the upper part of the calf to lie directly posterior on the splint under the full weight of the leg, trapped between the slings below and the neck of the fibula above.

I do not advise the use of skin traction as primary treatment for a fresh fracture of the shaft of the femur in a strong young adult, because time may be wasted while the fracture is capable of reduction by the more positive force of skeletal traction. Experience with skin traction is of great value, however, in teaching the surgeon how easily some fractures of the femur can be kept at full length, and even distracted, by very small forces ; experience such as this fosters respect for skeletal traction.

The method of using fixed skeletal traction which I recommend combines a Steinmann nail in the tibial tuberosity with a light below-knee plaster cast. This combination of nail and plaster is what I have called a traction unit (Fig. 126, p. 162) and it offers the following features :

1. The foot is supported at right angles to the tibia.
2. The external popliteal nerve and calf muscles are protected from pressure against the slings of the splint. The tibia is suspended from the Steinmann nail inside the plaster so that an air space develops under the tibia as the calf muscles lose their bulk.
3. External rotation of the foot and distal fragment of the femur is controlled.
4. The tendo Achillis is protected from pressure sores.
5. Comfort : the patient is unaware of the traction when applied through the medium of a nail.

The traction unit is applied before starting the reduction and after threading the Thomas splint over the limb. This has to be done after the anæsthetic has been started and it takes about ten minutes to complete because the plaster must harden before it is possible to proceed with the manipulative reduction.

A Steinmann nail is passed through the tibial tuberosity and a stirrup attached. The leg is held by assistants holding the stirrup and the foot and, after applying plenty of padding around the malleoli and heel, a light below-knee plaster is applied. The plaster must incorporate the nail ; this is an important detail because unless this is done, the top edge of the plaster will cut into the calf as it lies on the Thomas splint.

A small refinement is added at this point, and though it may seem a little fussy, it will later prove of great value ; a piece of wood is applied transversely across the sole of the foot about its mid point and is incorporated in the plaster. This piece of wood should be about 6 inches in length and it rests on the side bars of the splint, so that it prevents rotation of the foot ; if desired it is possible to make the foot rest in about 10 degrees of external rotation by a suitable inclination of the cross-piece to the long axis of the foot (Fig. 139).

When the plaster of the traction unit has set, the fracture is reduced, using the Steinmann stirrup to exert powerful manual traction. During the manipulation the splint will carry only the master sling and its pressure pad to give a fulcrum for the manipulation. When the surgeon is satisfied that ‘ hitching ’ of the bone ends has been obtained, and that telescoping no longer occurs, the reduction is held by tying traction cords *to each end of the Steinmann nail* and passing them down the length of the splint, where they are tied to the end of the splint. The stirrup is not used for attaching the traction cords.

The thigh at this stage is supported by the pressure pad on the master sling, and the foot is supported by the transverse wooden bar attached to the sole of the plaster

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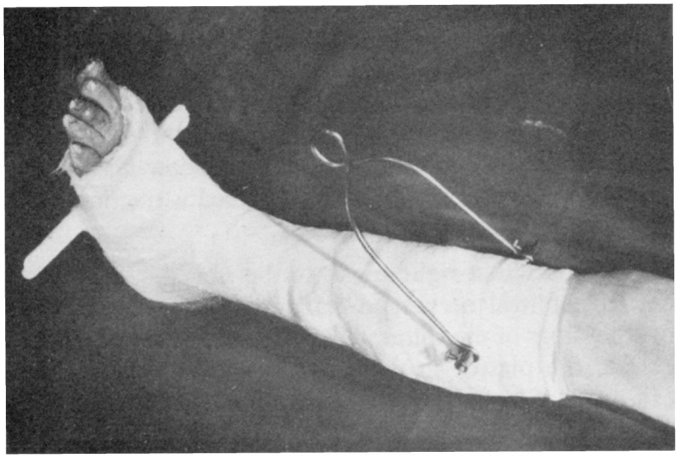

FIG. 139
Showing pin-and-plaster traction unit as an alternative to traction by adhesive plaster arranged for the treatment of a fracture of the shaft of the femur on the Thomas splint.

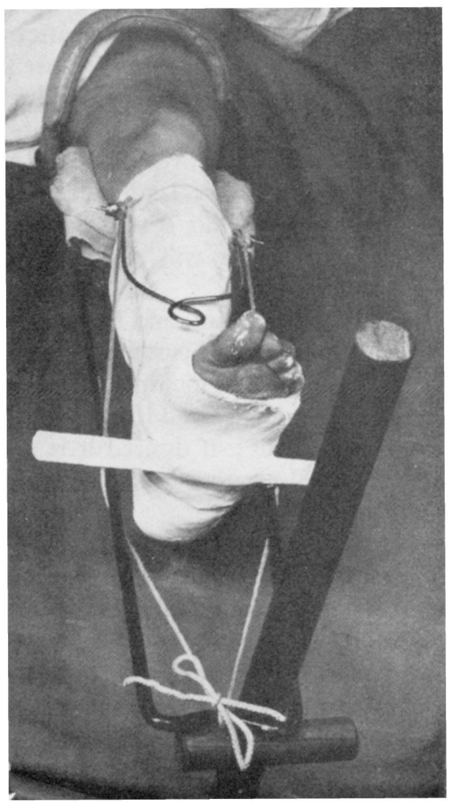

FIG. 140
Showing the function of the cross-bar fixed to the sole of the plaster traction unit. Any degree of rotation of the foot can be maintained by the position of the cross-bar.

traction unit (Fig. 140). This arrangement exposes the lower fragment to the maximum ' turning movement ' to correct backward angulation, but at the same time it exposes the soft parts behind the thigh to maximum compression against the pressure pad. This compression is the sum of the weight of the limb, plus the weight of the plaster, plus a downward component of the fixed traction force. This compression can be controlled by passing a sling under the upper end of the plaster of the traction unit and tightening it until it is judged that excessive pressure has been relieved from the back of the thigh. The importance of this detail is often overlooked and in order to emphasise it this sling might be called the ' moderator sling ' because it moderates the pressure of the master sling. It will be realised

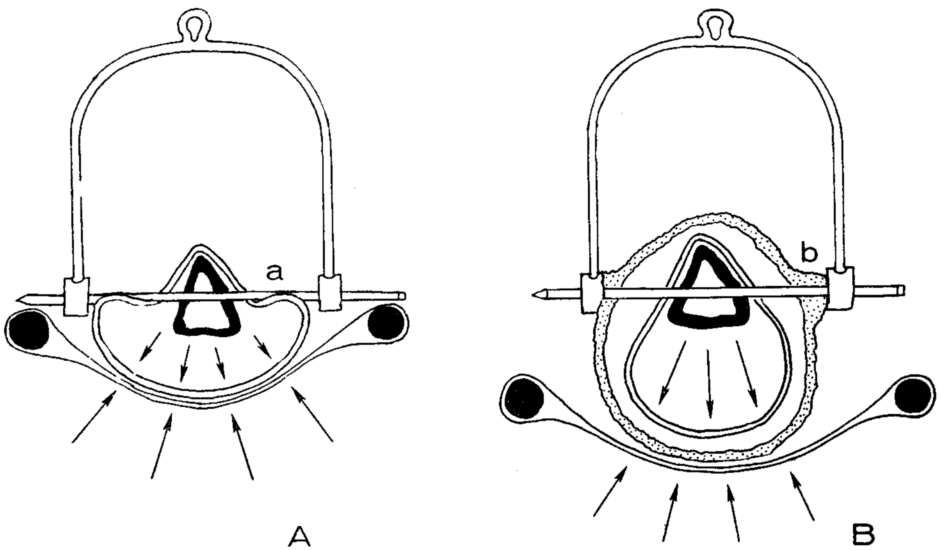

FIG. 141

Illustrating the danger of resting the leg on the slings of a Thomas splint, (A), when skeletal traction is used. When the pin-and-plaster unit is employed, (B), the calf of the leg is not compressed against the underlying slings by the weight of the limb.

that the moderator sling does not compress the soft parts behind the calf because these are suspended, free from pressure, by the Steinmann nail incorporated into the plaster (Fig. 141).

This detailed description of the traction unit may seem rather elaborate and even suggest that it is merely a gadget or a personal fad ; I have used it, however, for several years and whenever I have abandoned it to try other methods I have usually regretted it and I have returned to the traction unit with the renewed conviction that it is a valuable appliance. Once the traction unit has been applied it can be left untouched for twelve weeks, making the maintenance of the case an easy nursing problem. During the 1939-45 war I found it possible to supervise thirty-five fractured femurs at one time with this traction unit, which would have been quite impossible using adhesive traction.

Suspension of the Splint

Using an overhead beam, the Thomas splint can now be suspended and counterpoised so that it moves easily when the patient moves in bed. If pressure of the ring against the groin is likely to be excessive, due to the amount of traction required, weight-traction can be applied to the foot of the splint which is added to the fixed traction already present (Fig. 142). Slight elevation of the foot of the bed will be necessary to counterbalance this sliding traction.

It will be noted that in this arrangement the addition of weight-traction does

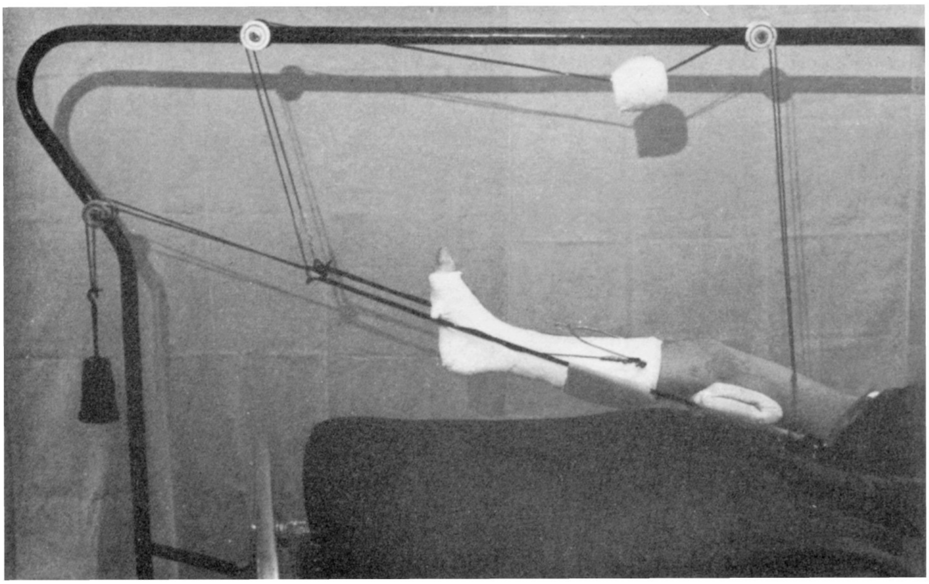

FIG. 142

Illustrating suspension of the Thomas splint, with pin-and-plaster traction unit, with the addition of a small amount of long-axis weight-traction to relieve pressure of the ring of the splint against the groin without seriously disturbing the attractive features of fixed skeletal traction. This makes the arrangement very comfortable for the patient.

not disturb the relationships between the site of the fracture, the splint, and the pressure pad, because the pressure pad is fixed to the splint and the fixed traction fixes the limb to the splint. In this way it is superior to many other methods where an increase in traction may cause the whole limb to move in relation to the splint and disturb the relationship between the pressure pad and the fracture. As long as the weight-traction is less than the fixed traction the full pressure of the ring against the patient will be alleviated and the mechanism of fixed traction will remain unaltered.

Comparison with the Braun Splint

Very few surgeons appreciate that there is any significant difference in the mechanics of this arrangement of the Thomas splint from the Braun splint which is so widely used on the Continent. While there is not much difference for a few minutes after the Braun frame has been adjusted the system of forces rapidly becomes ineffective, because the limb is able to move in relation to the splint. If the limb moves longitudinally in relation to the splint the site of the pressure pad will change in relation to the fracture. If the pelvis moves medially in relation to the splint, a varus deformity is produced because the knee is held by the splint. If the Braun splint had a ring to grip the top of the limb these defects would be eliminated; but in that case it would be a Thomas splint!

Details of the Reduction

The reduction of an oblique, or comminuted, fracture is simple and can be carried out by the operator single-handed. The surgeon applies long-axis traction standing at the foot of the splint with one hand gripping the stirrup and applying

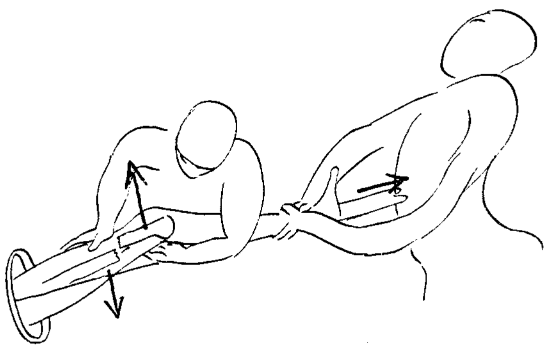

FIG. 143
Assistant and surgeon reducing a fracture of the lower third of the femur.

counter-extension with the foot of the splint against his body to force the ring of the splint against the patient's perineum. The thigh is then laid on the pressure pad and the traction cords are tied to hold the position obtained by the initial powerful traction force.

If the fracture is transverse it will be necessary to have an assistant to exert powerful traction force while the operator concentrates on attempting to manipulate the fragments into apposition. With the assistant standing at the foot of the splint, exerting counter-pressure against it with his body and applying traction to the stirrup with both hands, the operator stands at one side of the splint and attempts to coax the fragments into alignment, testing for 'hitching' of the bone ends by the ability of the fracture to resist telescoping when the traction is temporarily relaxed.

The commonest displacement is backward angulation of the lower fragment and the operator should therefore attempt to lift the lower fragment with his hand below the thigh, and press backwards the upper fragment with his hand in front of the thigh (Fig. 143). If resistance to telescoping is achieved the thigh is

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lowered on to the pressure pad, and the hand extracted from between the under surface of the thigh and the pad when the traction cords have been tied.

Radiographic control at this stage is of great value.

This manipulation is best carried out in the bed so that the final supervision of the splint can be performed without unnecessary disturbance.

A point of great importance concerns the displacement of the proximal fragment. It is inadvisable to apply a sling under the posterior surface of the thigh proximal

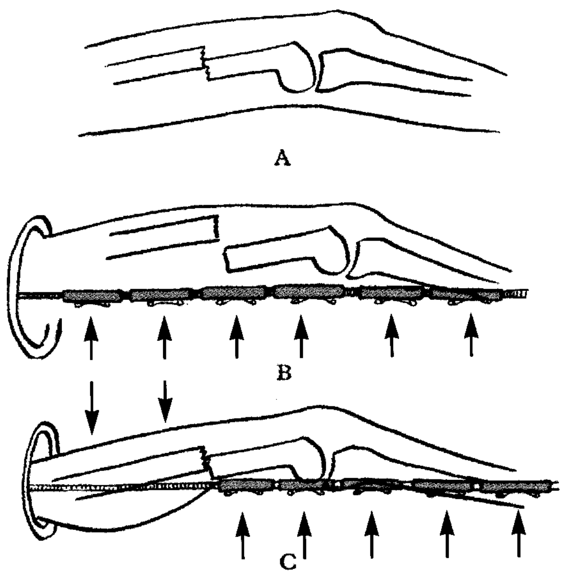

FIG. 144

Illustrating the danger of tightening the slings which underlie the proximal fragment. It is important to get a differential action by only supporting the leg, popliteal space, and the distal third of the femur, while the proximal fragment is allowed to fall backwards under its own weight.

A, Reduced position.

B, Displacement caused by tightening proximal slings.

C, Differential forces applied and reduction restored.

to the master sling. If this is done the proximal fragment is likely to be pushed forward and, although the fragments are still in parallel alignment, they will lose apposition (Fig. 144). In order to prevent this it is important to preserve a differential action of forces above and below the level of the fracture. Sometimes a reversed sling is useful at this point, *i.e.*, one passed between the side bars but in front of the proximal fragment to press it backwards.

Failure to Reduce a Transverse Fracture

Inability to secure the last $\frac{1}{16}$ inch of full length in a transverse fracture may mean all the difference between reduction and complete failure. Speaking generally,

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I do not think transverse fractures of the shaft of the femur are suitable for conservative treatment; for these I advise the use of an intramedullary nail. If for special reasons it is necessary to treat a transverse fracture of the middle of the shaft of the femur conservatively and if simple long-axis traction fails to get full length, the method of increasing initial angulation may sometimes succeed. To do this the surgeon lifts the knee off the splint until the distal fragment is vertical and at right angles to the proximal fragment; he then pushes downward against

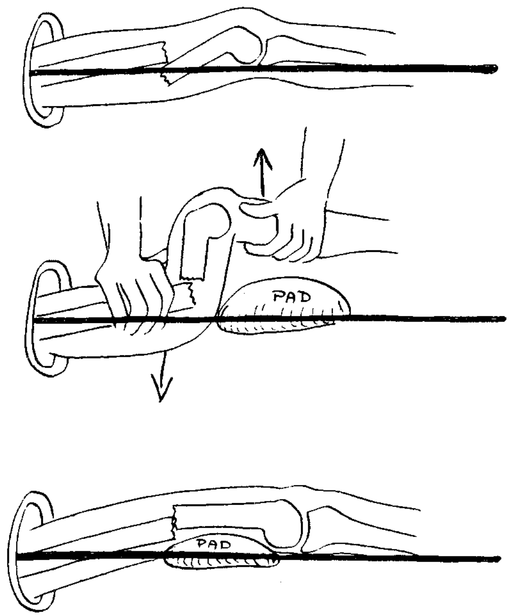

FIG. 145

Technique of reducing a transverse fracture in the lower third if longitudinal traction fails. Note that the master sling with its superimposed pad is applied to the splint *before* this manœuvre is executed because it is an important fulcrum in the actual manipulation.

the front surface of the proximal fragment while with the opposite hand maintain an upward pull on the distal fragment (Fig. 145). When the limb is straightened it can be deduced that the ends of the fragments are in contact if it is stable against a telescoping force.

When traction applied to a nail in the tibial tubercle fails to reduce an overriding transverse fracture, I have on occasions succeeded by changing to a supracondylar nail (Fig. 146). In the supracondylar region skeletal traction is more effective in its action on the distal fragment than equal force applied through the medium of the ligaments and capsule of the knee-joint when the tibial site is chosen for the nail. If supracondylar traction is used it should not be retained for more than two or three weeks, and the nail should thereafter be transferred to the tibial site. The ill-effects of supracondylar traction are the result of slight infection in the muscle planes which form the extensor mechanism of the knee-joint. Infection is inevitable if a supracondylar nail is left too long *in situ* and if quadriceps exercises are attempted.

If a reduction is still not obtainable it will generally be found that the thigh is

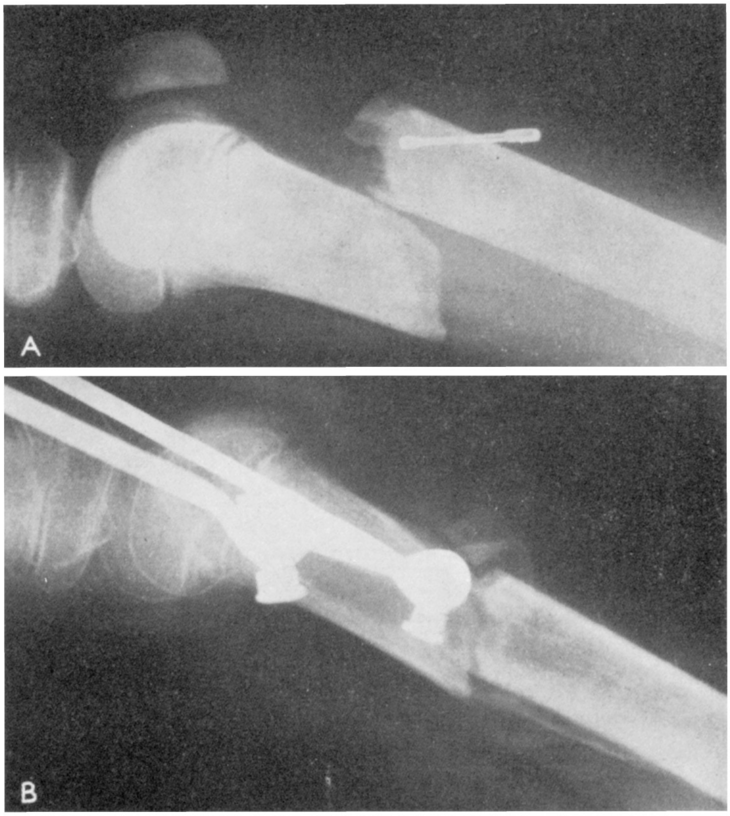

FIG. 146
Case of a transverse fracture of the shaft of the femur which resisted manipulative reduction using a tibial nail, but which was reduced by supracondylar traction.

grossly swollen and the barrier to obtaining full length is turgor from the effusion of blood into the closed fascial compartments of the thigh, which tend to assume a spherical shape, gaining in width at the expense of length. In this case, open reduction may be indicated after a delay of one or two weeks.

Abduction of the Splint

There is a constant tendency to the development of varus angulation in the conservative treatment of a fracture of the shaft of the femur. This is due to the

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powerful pull of the adductor muscles, and if any varus deformity starts these muscles are in an advantageous mechanical position to increase the deformity by a ' bow-string ' action.

A varus deformity is an unsightly deformity because it cannot be concealed in the standing position with the knees straight.

By maintaining the splint in considerable abduction throughout the post-operative course it is possible to counteract the action of the adductors and prevent a varus deformity (Fig. 147).

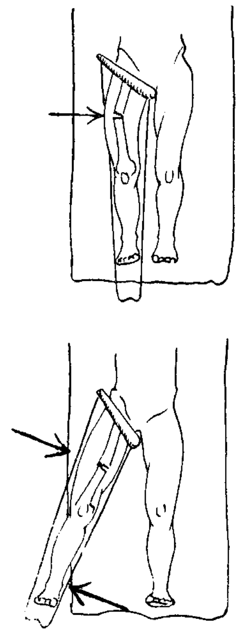

FIG. 147

Showing how the adducted position of the Thomas splint invokes lateral bowing and how the abducted position of the splint, which invokes medial bowing, anticipates this natural result of strong adductor tone. Note that in this illustration the fracture is in the midshaft of the femur; this is not a suitable site for treatment by this method, unlike fractures in the lower third, and a Kuntscher nail is preferred by the author at this level.

Watching the Ring of the Splint

In the post-operative course it is important to inspect the ring of the splint and the condition of the skin of the perineum in contact with it. By using 5 to 10 lb. of weight-traction the pressure of fixed traction against the skin can be mitigated, but it is important to make sure that the ring is not being pulled too far away from the perineum and lying in the region of the upper one-third of the thigh. This can only happen if the weight-traction severely exceeds the fixed traction inside the splint. If it is the result of slipping or stretching of the traction cords the ring can be approximated to the groin by shortening the fixed traction cords.

It is only by maintaining the ring close to the perineum that any control of the proximal fragment can be maintained. If the ring is allowed to take up a position in the middle of the thigh the method is no better than simple weight-traction applied to the distal fragment without any splint being used.

Post-operative Exercises

It is of fundamental importance to encourage the patient to try static quadriceps contractions as soon as he can after the apparatus has been set up. The patient does this by attempting to press the popliteal surface of his thigh against the pressure pad, at the same time endeavouring to lift his foot encased in plaster. Quadriceps contractions are encouraged by moving the knee as straight as possible, but control of the deformity of posterior angulation is best served by about 20 degrees of flexion of the knee.

In my experience the ability to perform quadriceps contractions early is invariably attended with rapid union and good callus formation in the radiograph at six weeks. It is impossible to say whether this is cause or effect; phlegmatic individuals seem to develop good callus, good quadriceps tone and early recovery of full knee motion, while the apprehensive patient is the reverse. Anything which causes pain when an attempt is made to contract the quadriceps must be searched out and counteracted so that there is no reflex inhibition of muscle action.

After six weeks, clinical union may be developing so satisfactorily that it may be possible to change the system for simple skin traction. Skin traction at this stage is used merely to hold the Thomas splint in position so as to protect the fracture from angulation. When the skeletal traction is removed the Thomas splint should be changed to one with a smaller ring to adapt to the size of the thigh which by now will have lost considerable volume. At this stage the limb is splinted with the knee as straight as possible; instead of the large pad producing 20 degrees of flexion which is necessary in the early stages, a small pad is used so that the knee is not flexed more than 5 degrees. This is important as it greatly facilitates quadriceps contractions. In this position it is possible for the patient now to acquire a longitudinal excursion of the patella of about $\frac{3}{4}$ inch in relation to the lower end of the femur. An excursion of $\frac{3}{4}$ inch of the patella is equivalent to about 40 degrees of movement in the knee joint, so that even if no movement of the joint is allowed the extensor apparatus can still be kept mobile in readiness for the time when the knee is set free.

Discarding the Splint

It is impossible to lay down any hard and fast rule for when splintage can be abolished with safety; perhaps the following remarks will indicate the line of reasoning which I use as a guide. The danger at this stage is late angulation or even re-fracture. This is particularly the case in transverse fractures which have been reduced accurately end-to-end, because in these very little periosteal callus may be present and the mechanical strain on the callus is very great in a transverse fracture (see page 58). If knee stiffness is to be avoided some slight risk has to be taken, but if the following matters are appreciated, and if the surgeon supervises the matter himself, disaster should be avoided.

If the fracture is clinically firm by the first six to eight weeks the knee can be exercised, for short daily sessions, by the physiotherapist temporarily untying the traction cords and assisting the patient with straight-leg raising exercises and knee-bends. Often at this stage the patient is strong enough not only to elevate the leg but to elevate the splint and the leg in one piece. It is important, at this stage, that the cords are carefully retied at the end of each exercise with the splint ring well up in the groin. If the cords are carelessly tied and the groin ring is allowed to drift down the thigh, the ring will act as a fulcrum and instead of preventing will cause angulation.

The ultimate decision to abandon splintage entirely is often a little difficult. If the surgeon plays too much for safety there is a danger of prolonging the duration of knee stiffness more than necessary, while on the other hand he cannot toy lightly with the risk of re-fracture. It is dangerous to abandon the splint completely at three months if: (1) there is definite tenderness in the callus, (2) the amount of radiological callus is scanty or present only at one side of the fracture with none on the other, (3) there has been a constant tendency to late angulation which suggests defective consolidation.

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Even if all these points appear adequate a re-fracture may still occur unless the surgeon is aware of *the significance of the range of knee movement in forecasting a threat of late angulation.* To make sure of this a record of gain in knee range

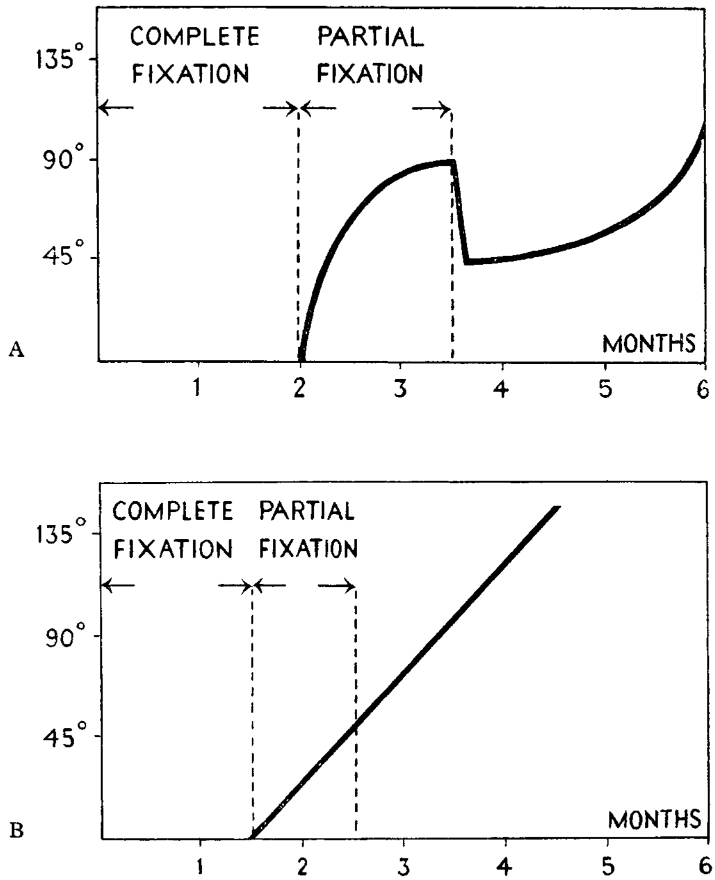

FIG. 148

A, Illustrating a sudden deterioration of knee movement after the thirteenth week, when all external support had been discarded. It is postulated that recovery was in abeyance until true consolidation of the fracture had been assured.

B, Illustrating a case in which strong bony union took place without incident and without any threat of re-fracture or late angulation. Knee movement returned spontaneously and progressively.

should be kept by the physiotherapist while intermittent knee exercise is being encouraged. When the decision is taken to try the patient out of the splint the patient should be allowed to sleep without the splint for one night, and the following day the range of movement in the knee joint should be measured. It will be found that the earliest sign of late angulation is a diminution of knee movement (Fig. 148). If the patient can get over a week without the splint and without losing the knee movement he had when the splint was abandoned he will have escaped the danger of spontaneous re-fracture or late angulation. This test depends on the fact that unsound callus is malleable and spontaneous fracture does not occur under the effects of gravity without a slow yield taking place before the final rupture. If the callus is unsound and is yielding the muscles are inhibiting and the range of knee motion is lost. This test is only a guard against the *spontaneous* yielding of *unsound callus* under gravity and muscular power ; it cannot anticipate the fracture of a thin bridge of true bone as a result of injudicious weight-bearing or of external strain.

Even using this test of union *the splint should rarely be abandoned completely before a minimum period of three months has elapsed*, and for this reason the patient must stay in bed during this period.

The Recovery of Knee Movement

For those who dislike the Thomas method, the absence of early knee movement appears to be the final abomination. Nevertheless, in the end result the recovery of knee movement is more often good than bad. It is surprising how knee movement will return spontaneously and continuously for as long as eighteen months following a fracture of the femur treated conservatively and this is particularly noticeable under middle age. The tendency to be pessimistic about any further recovery of the knee range after six months is often based on the bad prognosis of compound fractures which have had bone sepsis, and also because most other joints, especially the elbow, rarely gain more motion after six months. The stiff knee after a septic fracture is more intractable than after slow prolonged fixation in the absence of infection.

The recovery of knee movement is probably more closely related to biological matters in the process of bony union than to simple mechanical movement of the knee during treatment. A femur which is showing sound bony union by three months is certain to have rapid and continuous recovery of knee movement. Where knee movement is slow to recover the fracture almost invariably shows defective callus.

The Caliper Splint

In the original Thomas method the use of a caliper splint was a routine in the treatment of a fractured femur. The ‘ bed-splint ’ was converted into a ‘ walking-splint ’ at three months by cutting off the end of the splint and bending the ends to fit into holes drilled in the heel of a boot.

In the uncomplicated case a caliper is unnecessary. If clinical union has been present at eight weeks, it is quite certain that no caliper will be needed. If the fracture is a long oblique fracture there is certainly no need for a caliper (page 58). If the fracture is transverse greater caution is required, but even here, if clinical union has been present at eight weeks, if there is good callus at three months, and if the range of knee motion is improving progressively in the absence of splintage, there is no danger of re-fracture. If, however, callus is scanty, or restricted to

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one side only of the transverse fracture, and if the recovery of knee movement is slow or is stationary, the hazard of re-fracture must always be borne in mind, but even here a caliper splint is not always reliable in preventing re-fracture and in the modern world a prophylactic bone graft using the Phemister technique (see page 248) is advisable.

EXAMPLES:

In Fig. 149 are shown some of the results which are to be expected from this method. It is important to observe the standard of reduction which is to be regarded as praiseworthy; *half-diameters apposition in good alignment is to be regarded as perfect.*

Results

The only figures available for the results of treatment by the classical Thomas method (*i.e.*, three months in the bed-splint and three months in the caliper without knee movement) are those of Diggle (1944), and even these are only an impression of the results of 200 unselected cases; an average range of about 90 degrees was obtained after nine months with a maximum of $\frac{3}{4}$ inch of shortening. These results included the aged as well as the young.

In my own series of thirty-four cases (Charnley, 1947) only patients between the ages of twenty and forty-five years were studied, and only fractures in the middle and lower thirds of the shaft:

Average age	26 years.
Start of knee movement	$10\frac{1}{4}$ weeks.
Average time of follow-up	12 months.
Average final knee range	128 degrees.

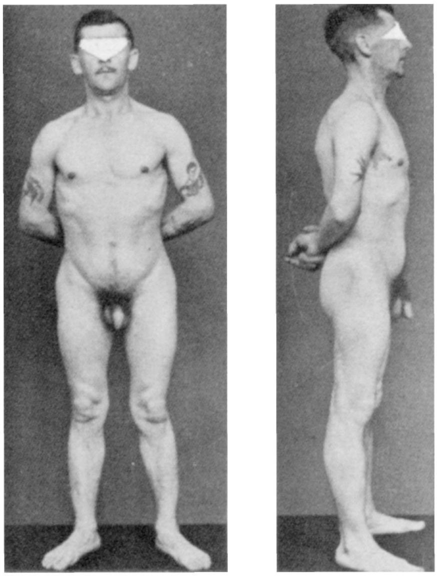
There were records of the knee range at six months in only twenty-seven of these cases; twenty-four of these had 90 degrees at six months = 88 per cent.

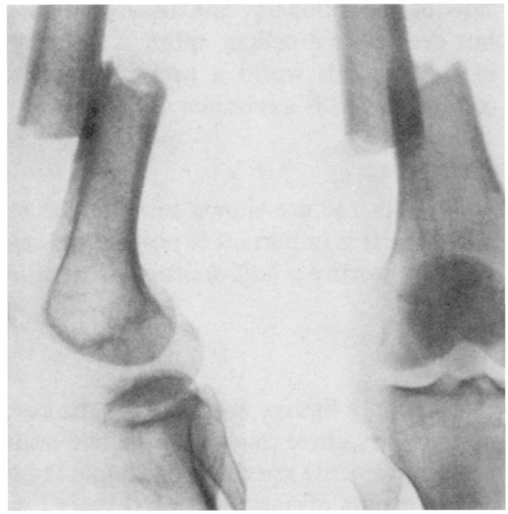
A comparable series which I selected from the published figures of the Massachusetts General Hospital (1930) (*i.e.*, twenty to forty-five years of age, closed fractures and middle and lower thirds) showed in eighteen cases:

Average age	37 years.
Start of knee movement	10 weeks.
Average time of follow-up	15 months.
Average final knee range	125 degrees.

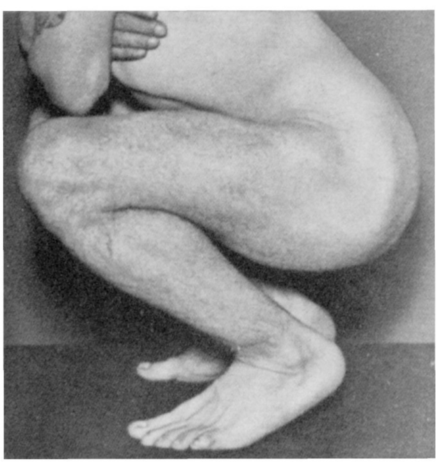
In this series it is recorded that ten out of the eighteen had 'full' knee movement.

For the results of *early* knee movement in the treatment of this fracture Pearson (1918) used supracondylar ice-tongs and moved the knee at one month or as early as other factors allowed, and in sixty-eight cases there were fifty-five with 90 degrees at six months = 80 per cent.; Burns and Young (1944) in thirty-five cases with early knee movement on traction-suspension had thirty-one with 90 degrees at six months = 88 per cent.

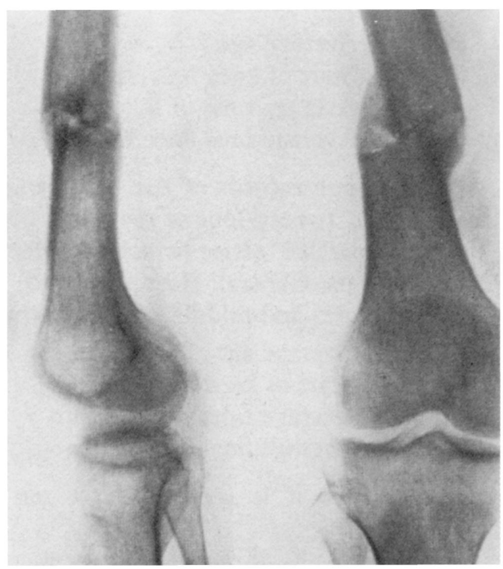




B
Right femur—before reduction.



A
Bilateral femoral fractures; to maintain perfect alignment in both limbs throughout the treatment of a bilateral case is a rigorous test of the mechanical soundness of any conservative method; very slight valgus present in left leg.



C
Right femur—united.

FIG. 149

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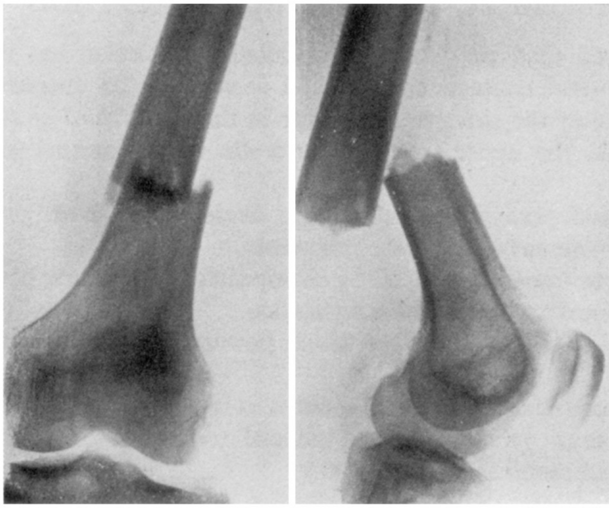
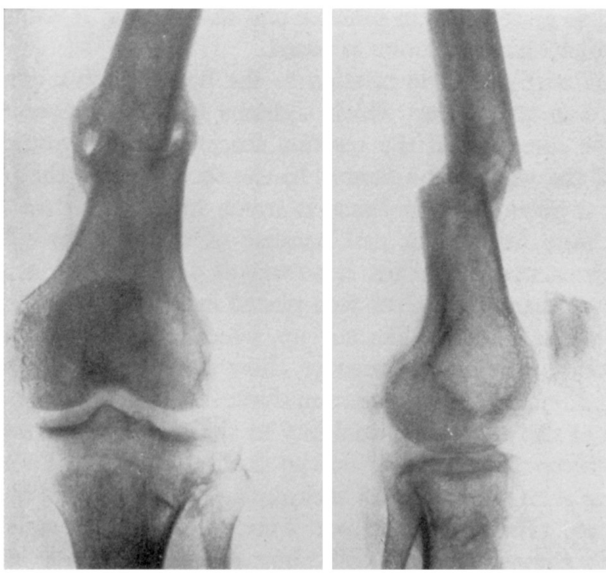


D
Left femur—before reduction.



E
Left femur—united.

FIG. 149

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SUMMARY OF THE THOMAS METHOD

1. It is claimed that, provided a manipulative reduction has been successful in getting end-to-end contact, this method is superior to operative methods of treating a fracture of the shaft of the femur in the *lower third of the femur*. The lower third, unlike the upper third, is not a site where internal fixation is easily applied.

2. This method permits traction to be decreased without prejudice to the stability of the alignment of the bone fragments.

3. The fracture must be reduced by manipulation. The method merely holds a reduction previously secured by manipulation.

4. Skeletal traction gives comfort which favours the start of active quadriceps contractions.

5. It is necessary to envisage three months in bed for the conservative treatment of a fractured femur: six weeks with skeletal traction and six weeks with skin traction and partial mobilisation.

Kirschner Wire versus Steinmann Nail

Many surgeons regard Kirschner wire and the Steinmann nail as alternative methods of applying skeletal traction; that these are of equal merit, and that the choice of one or the other is largely a personal whim. The superiority of the Steinmann nail is so great, both in practice and theory, that it is important to state the reasons on which this contention is based.

The Kirschner wire moves in relation to the bone which it pierces; the wire being solidly fixed to the stirrup which tightens it, every movement of the limb which changes the direction of the traction forces causes pivoting of the stirrup and movement of the wire in the bone. In the second place the pressure exerted on the bone, for a given traction force, is much higher with the Kirschner wire than with the 4 mm. Steinmann nail because of the difference in surface area. The Kirschner wire acts much in the same way as does the wire of a cheese cutter, but the 4 mm. Steinmann nail when well placed in thick cortical bone will remain firm for over six weeks. The Böhler stirrup, which is the best appliance by which to attach the traction cord, is designed to allow the stirrup to pivot freely on the nail even if the direction of the traction force changes through a considerable angle. By reason of the absolute immobility of the nail in the bone, sepsis is slow to start. Sepsis creeping inwards from the skin is abolished if the sealing of the punctures is done with an adequate technique. I have found that wool soaked in tinct. benz. co. (Friar's balsam) or Mastisol is highly satisfactory. Wool impregnated with these adhesives will cling as tenaciously to the steel of the nail as to the skin at the point of entry or emergence. This close adhesion to both skin and nail materially helps in checking movement between the skin and nail. Adhesives such as collodion on gauze do not 'bond' themselves to the metal of the nail, and thus movement can still take place between the nail and the skin and induce slight sepsis (Fig. 150).

In penetrating the skin with the Steinmann nail it is wise to incise the skin before inserting the nail or before allowing the point to emerge. This reduces the tension in the surrounding skin and minimises a slough. But more important than this is the careful inspection of the 'lie' of the skin around the points of

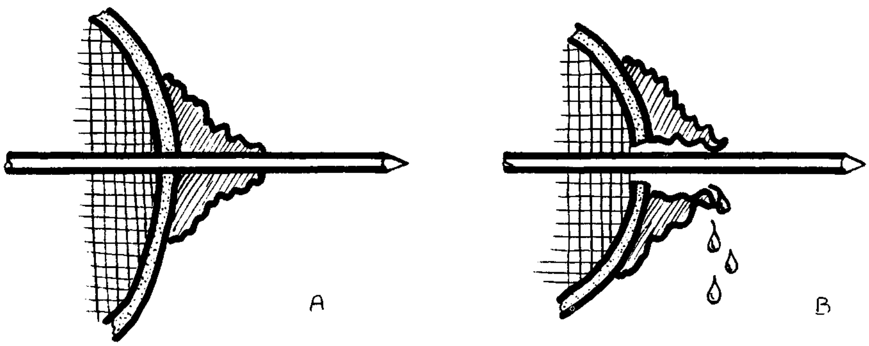

FIG. 150
Illustrating the importance of an adhesive.
A, Bonds to metal as tenaciously as to skin (*i.e.*, Mastisol or tinct. benz. co.).
B, Collodion will not bond to metal and movement is therefore possible between skin and nail, inviting ulceration and infection.

penetration to make sure that there is no pull in the skin to cause puckering of the skin on one side. This can be prevented by incising the skin on the puckered side (Fig. 151).

Sometimes a large ulcer can develop when a Steinmann nail is used without the plaster of the 'traction unit' (Fig. 141, p. 181). If the nail is inserted when the

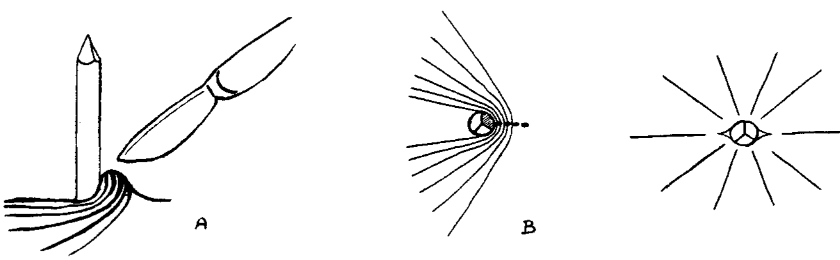

FIG. 151
The lie of the skin round the Steinmann nail; if the skin is puckered on one side a slough will result. This can be prevented by incising to equalise the tension.

calf muscles are dependent from the tibia, being unsupported from below, there is always a tendency for the skin to be pressed upwards against the nail when the leg is later made to lie on a splint. When the plaster of the traction unit is used, the soft parts of the calf are suspended inside the plaster and protected from pressure as the plaster lies on the splint.

These technical points in the use and upkeep of Steinmann nails are of great importance in their many applications to orthopædic surgery, and if they are observed there should be no difficulty in avoiding sepsis in nail tracks for as long as three months.

Fractures of the Femur complicated by Burns or Skin Loss

Os Calcis Traction

When there has been extensive skin loss or burns complicating a fracture of the lower third of the femoral shaft, the tibial tubercle may be unfit to receive a Steinmann nail, and the use of skin adhesive traction may similarly be out of the question; in these cases a Steinmann nail through the os calcis may save the situation.

Fractures of the Femur complicated by Fracture of the Tibia

It is not uncommon for a fracture of the femur to be complicated by a compound fracture of the tibia on the same side. The treatment of this combination is discussed on page 243.

Fractures of the Shaft of the Femur in Children

Up to about ten years of age the treatment of fractures of the femoral shaft should be dictated by principles of the utmost simplicity. It is almost unnecessary to use radiological control because the external appearance of the limb is the essential thing.

During the first three weeks after the injury the surgeon should concentrate on the length of the limb while maintaining alignment only very approximately. Any form of adhesive traction may be used (*i.e.*, fixed Thomas after five years of age, Bryant's suspension under five). During this initial three weeks a shortening of ½ inch should be considered ideal. Full length is not advisable as there is a danger of growth being stimulated by the fracture and of the final length of the leg being excessive.

After three weeks callus will be present and no recurrence of shortening will result if traction is removed. Traction can therefore be removed and a single-sided hip-spica should be applied, under anæsthesia, so that a careful moulding of the plastic callus can be obtained. The plastic callus can be bent like bending a lead pipe and we avoid the problem of controlling angulation in two planes simultaneously, as is necessary in a fresh fracture. Using radiological control at this stage an accurate correction of alignment can be obtained and easily held.

Using this technique of planned 'delayed moulding' (*cf.*, fractures of radius and ulna in children, page 124) the treatment of these fractures is not only very simple but it is also rendered very precise.

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