Notes on Military Orthopaedics.

IV. ON MALUNITED AND UNUNITED FRACTURES.

BY

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The conditions to which the terms "delayed union" and "non-union" are applied may be difficult to distinguish, because often we find that, even after months, osteogenetic changes leading to consolidation will take place in a fracture considered to be permanently united. If we are to avoid disagreeable experiences, we must recognize that for various reasons, some of which we know and some of which are still unknown, a certain proportion of fractures take longer to unite than others. Some years ago I was called to a distance to operate upon a fractured femur. The accident had occurred three months previously. The length and alignment were good, but the patient had some sugar in the urine, and we decided, instead of operating, to place the limb, free from circular constriction, in a Thomas's bed splint (Fig. 1). Certain other procedures which I advise were not carried out, but in four weeks very firm consolidation had occurred. This case affords an example of a clinical type. There may be several weeks of apparent inactivity in callus formation, and then consolidation occurs quite rapidly. If a practitioner takes care to maintain a good length and accurate alignment, he should look forward cheerfully to a happy issue even if union is delayed. As a rule, this is exactly what he does not do. At the end of the fifth week he begins to feel nervous, he disturbs the bone ends, modifies his methods, and by degree transforms into a permanent disability a condition which merely demanded patience.

Delayed union is most common in the middle of the femur, in the humerus at the junction of the middle and upper third, and in the tibia and fibula at their lower third.

CAUSES OF DELAYED UNION.

In many cases there is an obvious reason for the delayed union. Very often it is not due to malposition; it is, indeed, quite remarkable how often in delayed and ununited fractures the bones are almost automatically opposed. I will not waste time by doing more than mention some of the academic causes assigned—such as tabes, syphilis, and acute diseases. I would prefer to focus attention on the more real and practical conditions which have a direct relation to the method of treatment.

Circular Compression.

An obvious and frequent cause is inefficient reduction, and later on, in dealing with malunion, I will refer to this in greater detail. I will, however, deal first with another cause of delayed union—circular compression of the limb by splint and bandage.

A fundamental principle in the treatment of fractures is to secure and maintain good length and good alignment, and in attaining these ends care should be taken that the

circulation of the limb shall be in no way hampered. The splint used should be so constructed that after the bandage is applied the fingers can be readily introduced between it and the lateral aspects of the limb. In looking back upon the ununited fractures I have seen, I generally recall an attenuated limb and a thick plaster case. When the casing is removed the blanched limb becomes red, and the blanched bone begins to take its fill of blood. It is because plaster generally fails to secure length and adequate blood supply that it is a prolific source of delayed union and ununited fracture. I would not condemn the use of plaster altogether, much as I dislike it, but it should be used with discrimination. It should be fixed in such a way that the limb remains in extension and in good alignment, and that the circulation of the limb is in no way hampered.

Duration of Period of Consolidation.

Textbooks have led us astray in regard to the period required for the consolidation of bone. Fractured adult bones are never firm after four or five weeks, as the books would lead us to infer.

For practical purposes, ignorance of this fact may make no difference in the case of the upper limb, but in the case of the lower limb, where the effect of body weight has to be considered, to underestimate the period of consolidation is to invite disaster.

TREATMENT.

If a case of delayed union is first seen in the seventh or eighth week we need do no more than make quite sure of good alignment, length, and circulation. Nature will do the rest.

Percussion and Damming.

If a long time has elapsed the need for action is more pressing, and we must endeavour to transform the indolent callus into an osteogenetic factory, so that bone may be generated. I know of no better means than that suggested by H. O. Thomas, and named by him "percussion and damming."

Femur.

As an example, I will take non-union of the femur with shortening probably of two or three inches. Under an anaesthetic the soft fibrous callus is broken down and the fractured ends are turned towards the skin and beaten with a mallet; a pulley is then applied to the limb, and as much length as possible gained. A Thomas knee splint is then adjusted and the extension maintained. Two pieces of india-rubber tubing are tied around the limb, one three or four

inches above the fracture, and the other at an equal distance below. They are kept on, to begin with, for about twenty minutes each day until they can be borne for several hours at a time. They should be kept tied sufficiently tightly to produce considerable swelling and stasis. Usually in two or three weeks callus is thrown out, and the osteoblasts begin actively to produce bone. Local congestion between two india-rubber tubes is much more effective than congestion by one proximal tube. I can recall many cases in which bones that had remained ununited for several months became firmly consolidated after use of this simple device (invented by Thomas and ascribed twenty years later to Bier) for stimulating osteogenesis. The method of applying the india-rubber tubes to produce congestion is shown, applied to the humerus, in Fig. 2.

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Fig. 1.—Thomas's bed splint

Fig. 2.—"Damming" or congestive treatment of ununited fracture of the humerus by Thomas's method.

Fig. 3.—Pulley used in setting and operating upon fracture of tibia and fibula; counter-extension shown.

Tibia and Fibula.

In old ununited fractures of the tibia and fibula complete extension is not so easily attained, and it may be necessary to remove bone. If this be done, the operation should be performed under pulley extension (Fig. 3), or by turning the ends of the bone out of the wound and engaging the fragments in shoe-horn fashion after the method of Lane. If the case be suitable and the surgeon possess the mechanical skill subsequently to keep a good alignment, it is best to avoid the introduction of plates or screws. The bones should be kept in absolutely good apposition, and where it can be easily accomplished they should be wrapped in transplanted fascia which will act as a binding membrane in the same way as periosteum.

FIG. 4.—Bone grafting. A. Lateral bone graft for fracture. B. Lateral bone graft for a case in which bone has been removed.

In another type of case in which the bone is eburnated with feeble callus production, it is well after sawing the ends to crenate the edges with bone nibblers, and to transplant bone from some other part of the body. The sides of the fractured ends should be prepared to receive the transplanted portion, which can be affixed laterally (Fig. 4 A), or driven into each end of the medulla. The transplanted bones and the fractured ends are held in position with transplanted fascia wrapped around them.

Figures 5 A and 5 B illustrate a method of sliding a transplant to bridge over the fracture. Albee's twin saw is used to enable the operator to detach with mathematical correctness a strip of bone partly above and partly below the line of fracture. A chisel is used at either end to complete the detachment. The shorter detached piece (in the figure the lower) is removed and the larger piece is slid down (Fig. 5 B.)

Autogenous transplantation of bone is far more effective than transplantation from another patient or from an animal. A bone graft without periosteum is sometimes as effective as one taken with its periosteum. This fact is important, for if bone is removed from some other part of the body subperiosteally, the removed bone is very rapidly replaced by new bone. Where convenient, however, the periosteum should be retained.

Non-union is very apt to occur where a wide gap exists between the bones. In the case of fracture of the tibia of long standing, where the growth of the fibula has progressed, I have operated with success by removing a large lateral slice from the upper end of the fractured tibia, and using it as a bridge to span the gap (Fig. 4 B).

Compound Comminuted Fractures: Retention of Fragments.

This leads me to speak of compound comminuted fractures associated with loose pieces of bone. The removal of these pieces is very frequently the cause of non-union.

If loose pieces are felt, provided the wound is not suppurating, they should be scrupulously saved; the pieces, if quite loose, should be taken out of the wound and laid in alcohol, and then carefully replaced in position or round the site of fracture. In such cases I refrain from introducing any foreign bodies, such as nails, plates, or wires. If a drain be used at all, it should be for forty-eight hours only.

Weak Union: Exuberant Callus.

Malunion of the femur of six or seven weeks' duration can almost always be corrected by powerful manipulation. The same is true of all the long bones. At my clinic every week I am accustomed, by wrench or hand, to correct malunited fractures of several weeks' standing. The method is especially applicable to a Colles's or a Pott's fracture.

Weak union can be diagnosed almost with certainty even when ordinary manipulation fails to detect it. It is suggested by tenderness on pressure over the site of the old fracture, and confirmed by the additional sign of exuberant callus exudation. A malunited fracture of some months' duration, if accompanied by these two signs, can usually be corrected by forcible manipulation. This is a very important clinical fact to remember from the point of view of immediate or gradual correction.

Exuberant callus is sometimes so abundant as to be mistaken for malignant disease, and I have met with many instances in which the patient has narrowly escaped amputation. This error is more likely to occur in the femur than in any other of the long bones, especially when the force applied to produce it has been so slight as to suggest that the fracture was spontaneous.

MALUNION.

Malunion of a fracture can always be prevented, and should raise a strong presumption of inefficient treatment. Our duty, therefore, is to examine the cause of malunion, and to arm ourselves with a knowledge of the weak points in our method of treatment.

The causes of malunion may be found (1) in errors in the initial treatment or setting of the fracture, (2) in errors in the method of maintaining the fracture in position, or (3) in errors of after-treatment.

I. INEFFICIENT REDUCTION OF THE FRACTURE.

Malunion of a fractured bone is due to this cause more often than is commonly supposed. Sometimes it is due to want of knowledge, but more often to want of experience and confidence.

It is necessary, of course, to have a clear knowledge of the anatomical proportions of the limb and of the mechanics of its action; but it is still more important to know the

FIG. 5.—Bone grafting. A. Diagram showing incisions through tibia by twin saw and chisel, detaching a strip above and below the fracture. B. Second stage of operation. The lower fragment has been removed, and the upper has been pushed down so as to bridge the fracture (Albee).

FIG. 6.—End-to-end apposition of fractured femur. A. End-to-end apposition and perfect alignment; B. imperfect apposition but with good alignment; C. end-to-end apposition with faulty alignment.

nature of the impairment of function likely to occur after any particular fracture, so as to be ready to take means to anticipate and to prevent it.

Common causes of inefficient reduction are—

(a) Insufficient extension of the limb in fractures of long bones—such as the femur or humerus—so that the overriding of the fragments is not completely corrected.

(b) In Pott's fracture there is always an associated dislocation of the ankle outwards and backwards. If the backward dislocation is not fully corrected there is pain over the front of the ankle when the patient walks, and, in addition, inability to dorsiflex the ankle, which causes a serious impairment of function.

(c) In Colles's fracture the backward displacement of the lower fragment is very serious, and is not always corrected by the orthodox traditional "hand-shaking" method of reduction. The lower fragment carries with it the articular surface for the head of the ulna, and if this is out of line, the upper and lower articulations between the radius and ulna are thrown "out of truth" and the radius will not rotate properly. This leads to impairment of pronation and

FIG. 7.—Diagrams to illustrate effects of malunion of tibia. A, Malunited fracture of tibia, producing bow-leg and throwing body weight on to outer side of foot. B, Malunited fracture of tibia in such a position that the weight of the body is carried to the inner side of the foot, producing flat-foot.

supination, and consequent very serious interference with function.

These are merely instances of how a want of sufficient determination in reducing the initial deformity may play an important part in causing subsequent loss of function. I have referred to them because they occur in common fractures, with the treatment of which everybody ought to be familiar, yet I see a large number of cases of serious impairment of function really due to these causes.

II. FIXATION AFTER SETTING OF FRACTURE.

If the fixation of the limb after the fracture has been reduced is in-

FIG. 8.—Boot and iron for use after Pott's fracture. A, Showing the boot with crooked and elongated heel and the outside iron; B, the same applied.

efficient so that material amount of movement can take place between the fragments, then every such movement causes pain, and produces a reflex contraction of the muscles. This reflex spasm may very readily cause overriding of the fragments, and in the case of the shafts

of long bones lead to shortening. In fracture of the neck of the femur it modifies the angle between the neck and the shaft and so causes the flexion of the joint, with the result that body weight is not transmitted in

the normal line. In consequence of this, crippling changes of an osteo-arthritic character subsequently occur in the joint. Faulty alignment of the bones may arise from inefficient fixation, even in a case in which the fracture was originally fully reduced and the bones brought into correct alignment (Fig. 6). The result is that the true line of the shaft of the bone is not maintained, and the joint at one end of the bone is thrown out of its proper relation to the joint at the other; in consequence, muscles do not act in their correct line, and the usefulness of the limb is impaired. Further, in the lower limb the line of transmission of body weight is altered, and this throws an improper strain on joints and ligaments, resulting in changes in the joints, in flat-foot, and in other disabling deformities. For instance, in fracture of the tibia and fibula a little shortening of the limb does not seriously impair its strength if the alignment is good. A slight bow-leg even is not serious (Fig. 7 A), for slight bow-leg is a harmless type. Many muscular and powerful men are, indeed, slightly bow-legged, but in a valgoid deformity the weight of the body is carried too far to the inner side of the foot, and this throws too much weight on the arch, and the result is a flat and everted foot (Fig. 7 B).

Any valgus deformity at the knee, in the leg, or at the ankle is a weakening deformity, and greatly reduces the usefulness of the limb. It is a good fault, therefore, to err on the side of producing a slight bow-leg, with its varoid accompaniment, if there is to be any error at all. In cases of malunion, when the callus is still tender, it is generally not difficult to readjust the limb by manipulation without having to perform an open operation. In the case of the femur, this can usually be done two, or even three, months after the original fracture. As a rule, the worse the position of the bones the longer will the callus take to consolidate.

The next point to which I would draw attention is that callus may yield in such a way as to throw the bone out of proper alignment. A good example of this is frequently afforded by cases of Pott's fracture which have been correctly reduced, and six weeks later are in good position and united. A month after this, however, the patient may complain of some pain at the site of the fracture, and also of symptoms of flat-foot.

Here the counter pressure of the ground on the foot forces the astragalus against the external malleolus, and so produces a lever action, straining the callus. To avoid this, every case of Pott's fracture should be set to walk with the inner side of the heel raised to keep the foot inverted, and if the patient is a heavy subject an outside brace also should be worn (Fig. 8 A and 8 B). It is disconcerting and puzzling to see a perfectly good functional result replaced by a bad one; to avoid disappointment of this kind it is advisable, particularly in fractures of the lower limb, to apply some sort of guard to prevent straining of the callus.

FIG. 9.—Position for fractures about elbow in the adult. The elbow is even more flexed in children.

FIG. 10.—To show the complete supination and extension of the arm necessary in fractures of radius and ulna.

THE FUNCTIONAL IMPAIRMENT ASSOCIATED WITH VARIOUS FRACTURES.

Before discussing the treatment to be adopted in particular cases, it is well to recognize the forms of impairment of functions commonly associated with each fracture.

Humerus.

Fractures of the humerus near the shoulder-joint (that is, those of the surgical neck and above the insertion of the deltoid) are commonly associated with inability to abduct the limb fully. The reason is that the upper fragment is often tilted outwards, and end-to-end union does not take place. In order to avoid this, the surgeon's object when setting the fracture should be to bring the fragments end to end if possible. He should pull the arm at right angles to the trunk, or even straight upwards until all overriding is completely overcome, and should then endeavour to engage the end of the lower fragment on the broken end of the upper fragment. By pressing the two together he can at once tell if they are engaged or are sliding past each other. If they are engaged, the arm can be gently brought down to the side and secured to the trunk by bandages. Once the fragments are engaged they are not likely to become disengaged again.

FIG. 11.—Dorsiflexion of wrist for fracture of carpus.

Elbow-joint.

In fractures about the elbow-joint, with the single exception of fracture of the olecranon process, the usual disability is limitation of flexion.

The limb should therefore be extended to push away any fragment likely to obstruct extension afterwards. The forearm should be supinated to make sure of clearing a right of way in that direction, and then the elbow should be fully flexed and bandaged (Fig. 9), care being taken not to produce tight circular constriction of the limb in any part. In this way we may make sure that there shall be no callus exudate in the bend of the elbow, and at the same time the tendon of the triceps acts as a posterior splint.

When a stiff elbow, after an injury, has to be dealt with, the same manœuvres are gone through so as to force the recently formed callus out of the way until full flexion is secured. Usually this can be done on one occasion, but in some cases it may be necessary to flex the joint in two or three stages.

Radius and Ulna.

In fractures of the bones of the forearm the disability most to be feared is obstruction to supination; pronation is usually good. Therefore, in setting the fracture, or when breaking down callus and resetting the fracture, the surgeon should extend the forearm and supinate fully in order to make sure of a clear right of way for supination, and then set the fracture, taking great care that the ulna is perfectly straight, and that there is no lateral pressure anywhere on the shaft of the radius (Fig. 10). It must, however, be remembered that the radius is a curved bone

which rotates on the ulna like the handle of a bucket; if the arched shape of the radius is destroyed the joints at its ends will be out of their true line, and impairment of function will be the result.

Carpus.

Fractures of the carpus often result in a stiff wrist in a flexed position. Every schoolboy knows that the grasp of the hand is weakest when the wrist is flexed. Therefore, in every case of fracture or injury of the carpus, the wrist should be put up in a hyper-extended position (Fig. 11).

FIG. 12.—Malunited Pott's fracture, showing eversion of foot.

If the wrist has been allowed to get stiff in a flexed position, it should be dorsiflexed under an anaesthetic and fixed in that position. In rare instances a fragment of the scaphoid is displaced on to the dorsum and blocks extension; if this has occurred, it may be necessary to remove the fragment before the wrist can be hyper-extended.

Ankle-joint.

When we turn to fractures near the ankle-joint we find that many patients complain of both pain and stiffness

which lasts for months or years. A study of the causes brings to light two principal factors responsible for loss of function here. Eversion of the foot, for instance, is fairly well recognized as one of them (Fig. 12). If the patient is allowed to recover with the ankle in a valgus position, the body weight when he stands will fall too far to the inner side of the foot, and at once all the factors which make for the production of flat-foot are produced. It is, however, not sufficiently well recognized that these conditions may be at work in an ankle which has every appearance of being in good position when the patient is discharged from hospital. Straining of young callus by body weight is very common in fractures around the ankle-joint, owing to the patient being allowed to walk on the unprotected joint too early. I therefore always turn these patients out with a "crooked" heel and often with an outside brace as well, to ensure that the body weight shall fall on the outer side of the foot (Fig. 8 A, 8 B). The natural corollary of this is that if body weight will produce a valgus deformity by straining the callus, it will also correct it if we "crook" the foot well, and therefore when the callus is already strained in the valgus direction, and the patient comes with a stiff painful ankle and foot, all we need do in many of the milder cases is to crook the foot well on the inner side, and let the patient "walk out" his deformity. In older and more severe cases it is from the first necessary or advisable to wrench the foot into an inverted position under an anaesthetic, and then let him walk with his heel well crooked; this is made easier by the application of an outside brace (Fig. 8). If this after-treatment is not persisted in for some weeks the condition will most likely recur.

The second great disability, after injuries about the ankle-joint, is inability to dorsiflex the ankle. The patient, when walking, cannot get forward on to the toes and fore part of the toes without pain across the front of the ankle.

This is a very difficult condition to correct once the deformity has been allowed to become established. The proper thing is to prevent it when the injury is recent; to make sure of this the surgeon should dorsiflex the foot and so satisfy himself that he has commanded a complete and clear right of way for this movement in the future.

Both these disabilities are well illustrated by cases of Pott's fracture; this injury essentially consists of a fracture of the fibula about three or four inches above the external malleolus with a dislocation of the ankle outwards and backwards (Fig. 13). There may be minor complications, such as fracture of the tip of the internal malleolus or the less well recognized fracture of the edge of the articular surface of the tibia. These, however, do not alter the general nature of the disability.

The method of reduction I adopt is the following: The knee is flexed to relax the calf muscles. If these muscles give trouble, tenotomy of the Achilles tendon will put them out of action, but this is only necessary in exceptional cases, and strength returns but slowly after this apparently harmless operation. Grasping the foot by the heel in one hand and the dorsum in the other, the foot is pulled and everted to make sure of thoroughly disentangling the fractured ends. While still pulling, the foot is fully inverted and the ankle dorsiflexed. If the ankle cannot be dorsiflexed fully, it means that there is a definite posterior dislocation or that the anterior edge of the tibia is fractured. It is necessary then to push the tibia back and bring the foot well forward until the ankle can be well dorsiflexed. The foot is then fixed in splints in the fully inverted

FIG. 13.—Malunited Pott's fracture, showing dislocation backwards of the foot.

FIG. 14.—Operation for malunited Pott's fracture: wedge from tibia and osteotomy of fibula.

position and dorsiflexed a little beyond the right angle. If the surgeon maintains it in this position, he may wait with confidence for a good result. If he is content with a less thorough reposition, he is in great danger of getting a result with some stiffness, pain, or limitation of movement, which will seriously interfere with comfort in walking.

Since the days of Percival Pott many splints have been devised. The shape and style of the splint does not matter a jot. The important element is the surgeon. If he knows his work, he will fix the foot in the position described and will be rewarded by a good result.

As we have seen, malunion and consequent functional disability depend on two factors: (a) eversion, (b) diminished dorsiflexion.

(a) Eversion often calls for operation. In comparatively simple cases all that is needed is to pass a chisel through the internal malleolus, and also through the site of the old fibular fracture. The foot should then be forcibly inverted, and treatment continued to maintain the inversion. In the more severe type of case an open operation is advisable. A wedge of bone is removed from the

FIG. 15.—Diagram to illustrate position of leg and foot in posterior bowing of fractured tibia.

lower end and inner side of the tibia (Fig. 14). The wedge should only go a distance of four-fifths through the bone. An osteotomy of the fibula is next performed. The wounds are closed, and not dressed for twelve or fourteen days. The stitches are then removed, and, under gas, the limb is fractured by forcible inversion. This two stage operation eliminates the anxiety which must attend the treatment of a compound fracture, and this is an important matter when powerful manipulation is necessary. For many reasons, however, it may be advisable to complete the reduction at the time of operation.

(b) Dorsiflexion of the ankle may be blocked by callus exudate the result of fracture of the anterior articular edge of the tibia. Complete dorsiflexion of the ankle at the time of accident would save the patient from this deformity, for the fragment of bone would in this way be pushed to one side, but if this has not been done, and at a later date we find that dorsiflexion is prevented, an incision should be made and the offending prominence chiselled away. The space left by the removal of bone should be packed with fat removed from any convenient part. This prevents the new callus exudate from giving

FIG. 16.—Fracture of neck of femur. A, Fractured neck, showing position in adduction. B, Fractured neck of femur correctly reduced in abduction.

rise to trouble. In all operations where bone is removed and pseudarthrosis is desired I find the generous employment of fat most helpful, and in order to reduce the callus exudation the exposed cancellous bone should be lightly hammered.

Tibia.

In fracture of the tibia faulty alignment may be brought about by posterior bowing; the weight of the body may

be thrown so far back that it passes at some distance behind the ankle, as shown in Fig. 15.

Fractures of the Femur.

Fractures of the neck of the femur, and all fractures about the small trochanter, should be treated in the

FIG. 17.—Fracture of upper third of femur. A, Adduction deformity. B, Abduction faulty, as the upper fragment does not participate.

abducted position to prevent deformity of the coxa vara type (Fig. 16 A and B). Stiffness of the hip associated with limitation of abduction, often accompanied by "osteoarthritic" changes in the hip-joint, is the sequel of malunion in this region. To prevent this it is necessary to secure abduction and to maintain extension in the abducted position. If the fracture is of some weeks' standing and the area is still tender, the callus is certainly not consolidated; forcible abduction and extension in an abduction frame and rigid fixation in this position will then be followed by adaptation of the callus to the corrected position.

Fractures of the shaft of the femur, especially in the middle third, are frequently followed by gross forms of malunion, which will excellently serve to illustrate malunion in long bones.

The faults commonly found are:

1. *Shortening or overriding*, due to the fact that (a) reduction has been incomplete, the surgeon not having pulled until the fractured limb was at least as long as its fellow; (b) the method of fixation and extension used has been inefficient, and the muscles have caused overriding after the fracture was set; (c) the body weight has caused yielding of the callus after the patient has begun to walk.

2. *Angular deformity or erroneous alignment* is the result of inefficient methods of fixation, and more particularly of inefficient extension in the line of the limb. Erroneous alignment throws all the muscles of the part out of line, and, what is more important, puts the joints above and below out of their correct relations. A common fault in fractures at the junction of the lower and middle third is a posterior sagging (Fig. 18), which is best seen when the patient begins to walk. The body weight is thus thrown on the posterior part of the capsule. The deformity resembles a genu recurvatum.

3. *Rotation deformity* is far too common, and can only be the result of careless and inefficient treatment.

Diagnosis.

In a case of malunion of the shaft of the femur in which one or more of these elements are present the whole region

FIG. 18.—Diagram to illustrate posterior sagging in malunited fracture of femur in the middle third.

of the fracture is tender, and is also the seat of pain for weeks and months after consolidation ought to be complete. This means that consolidation is far from complete, and that the callus is the seat of active change. Nature, in fact, is struggling with the problem of buttressing up the malunited fragments so that they can meet the forces which are acting in them, hence the exuberant production of callus, which is attended by pain and tenderness.

Treatment.

In such cases it is not difficult to break down the callus by manipulation. Extension with block pulley and suitable tackle will then stretch the muscles and reduce the over-riding by $2\frac{1}{2}$ inches on a single occasion (Fig. 3). Rotation deformity is, of course, corrected at the same time.

If open operation is employed, the simplest form of osteotomy is an oblique one through the callus between the original fragments of the shaft. Once these are cut through the greatest part of the remaining difficulty is in fully restoring the length of the limb by extension. The big muscles of the thigh can only be fully overpowered by the use of block pulley and tackle (Fig. 3). When this has been accomplished the leg is fixed in a Thomas's knee splint, the tuber ischii rests on the padded ring, the extension straps are secured to the bottom of the splint. We are then sure that, whatever happens, the muscles cannot contract and cause further overriding. The only thing the muscles can do is to give up the struggle, and, as a matter of experience, this is what always happens.

FIG. 19.—Fracture of upper third of femur. Diagram to illustrate osteotomy to correct common deformity.

FIG. 20.—Fracture of upper third of femur. Diagram showing removal of wedge of bone to correct adduction.

The surgeon finds on his next visit that he can get perhaps another half inch of lengthening by further extension on the straps. Further, in a Thomas's knee splint good general alignment of the limb can easily be secured—in fact, is obtained almost automatically. The only points to which the surgeon has really to attend are the position of the foot—to see that there is no outward rotation—and to keep up firm extension.

Locally, splints are applied to control lateral movement. In the first instance this is not difficult. When resetting a malunited fracture it is not so easy, for the callus already formed gets in the way.

In these malunited fractures of the femur of some weeks' standing with considerable overlapping, after refracturing the bone by force the pulleys should always be applied and a great effort made to secure both length and alignment. To render this less difficult, it may be wise to move the fractured ends freely in all directions to disturb and disengage the fibrous and bony exudate. The extension by pulley should be maintained for several minutes to lessen the resiliency of structure and to reduce the chance of telescoping. The limb is then maintained in extension by a Thomas's splint, and on two or three subsequent occasions the pulleys are applied. By these simple means overlapping of three or four inches can be overcome, and an open operation is avoided. The "damming" method already described is applied to assist osteogenesis, aided when necessary by percussion.

Whatever operation may subsequently be needed, I cannot too strongly urge the necessity of preliminary pulley traction in order to secure a better length, and in this way prevent the sacrifice of bone.

In cases in which union in the vicious position is so complete and firm as to render operative procedures neces-

sary, the procedure to be followed is influenced by the special type of union present. If it is a mere case of faulty alignment, with fair apposition, a small puncture and an osteotomy saw will do what is desired (Fig. 19). An x-ray photograph should be taken, and the section made through the angle.

The case is then treated as one of simple fracture. If there is overlapping of the fragments, with no excessive callus, the saw is introduced between the fragments and the lateral fixation undone. Pulley extension will then diminish or obliterate the shortening, and the subsequent treatment will maintain both length and alignment.

In other fractures higher up, with great thickening and lateral deflexion, a wedge is removed from the convex side of the bent bone, and a fracture at the point preferred may be produced some days later (Fig. 20). Extension and abduction of the limb should then be secured. In rarer instances, when unusual deformity and overlapping have occurred, it may be necessary to explore the fracture by a free exposure, to separate the fragments, to remove bone, and to plate.

FIG. 21.—Author's osteotomy saw with protected end.

CONCLUSION.

It may appear that in this paper I have dealt more with the treatment of fractures than with the treatment of malunited fractures, but a moment's reflection will satisfy us that there is only one problem before us—the restoration of function. Operation or manipulation to free the ends of the bones when union has occurred in a faulty position is only a preliminary step. In short, a malunited fracture cannot be cured by operation—all the operation can do is to reconstitute the fracture or make another fracture similar to the first.

If after this the subsequent treatment is not better than the treatment adopted in the first instance, an improvement in the result is not to be expected. This is probably why the statistics of late operations to correct malunion are often disappointing. The surgeon must not merely reduce the fracture, but must maintain the corrected alignment until consolidation of the bone is secured.

The fundamental principles applicable to simple fractures hold good in the case of compound fractures. The difficulties in carrying them out are obviously materially increased. Once, however, serious complications are past there will be ample time and opportunity to correct faulty alignment and to restore the best possible function to the fractured limb.

The fractures met with as a result of gunshot wounds are usually very serious, and I have witnessed with pride the splendid efforts made by the young surgeons in France to save these mangled limbs. Sometimes we hear criticisms at home, not always kindly, sometimes very unjust, because amputations are performed without flaps, and limbs still suppurating are not in the best position. If the whole truth were known, these mangled limbs and flapless amputations often represent surgical triumphs where every art and device has been concentrated upon the salvation of life and limb.

SURGEON-GENERAL GORGAS, with a party of medical men, is making an extended tour of South America to study methods of eradicating yellow fever. The expedition will visit Ecuador, Brazil, Colombia, and Venezuela. It is expected that the work will occupy four months.

In the *Deutsche medizinische Wochenschrift* for December 2nd, 1915, an account is given of negotiations conducted between the society of Frauenbildung-Frauenstudium of Mannheim on the one hand and the Medical Department of the German War Office on the other. To an inquiry why lady doctors were no longer required for military hospitals, the War Office replied that the lady doctors were discharged principally for general military disciplinary reasons, and that it was not to be assumed that this reflected on the medical capacity of the lady doctors. It was, however, the opinion of the War Office that the lady doctors were required rather for the civilian population (particularly for women and children) than for the army, which was already adequately supplied with medical aid.