THE OPERATIVE TREATMENT OF FRACTURES, INTRODUCING SOME ORIGINAL METHODS OF BONE-UNION BY SIMPLE MECHANICAL MEANS.

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In the year 1895, and again in 1897, Mr. Arbuthnot Lane delivered two characteristically original lectures, the one "Some Clinical Observations on the Principles Involved in the Surgery of Fractures," the other "The Treatment of Simple Fractures by Operation." These appeared at the time in the Clinical Journal, and were subsequently issued in book form, with many other striking articles on various unexploited subjects by the same author, and which, though unconventional and somewhat heretical, are all of absorbing interest.

In the two lectures dealing with the surgery of fractures to which I refer, the author emphasises the already prominent fact, that during the recent rapid strides in the general advance of surgery, that branch of it dealing with the treatment of fractures has persistently fallen behind; indeed, has, in his opinion, retrograded. He dwells on the entirely unsatisfactory results obtained in a large proportion of cases treated by the methods at present in vogue, "whose only claim to perpetuation is their extreme antiquity." Especially is this so in injuries near to, or actually involving, joints where the entire mechanics of the limb are altered, and where, unless the patient be young, growing, and adaptive, very serious impairment, loss of function and consequently of wage-earning capacity result, through mal-position of fragments whose axes are at variance, and their extremities not approximate. This is followed by traumatic and arthritic changes in the neighbouring violated joints, varying according to the age of the patient, and always more pronounced in the lower extremities, which must of necessity be constantly influenced by the body weight. Such active adaptive changes in the joints of the young, and the passive arthritic changes in those of middle and advanced age, are in the former sometimes, and in the latter always, associated with varying loss of control, physical incapacity, pain, wasting, oedema, &c., which make the sufferer's lot a hard one, and places his monetary prospects on a most uncertain footing.
These facts, and many others of a like nature, are displayed most forcibly and with mechanical detail. The final conclusion is that every fracture, whether simple or compound, whose fragments cannot be conclusively and accurately approximated by the usual non-operative methods, should be cut down upon, exposed, and united by mechanical device. To use the author's own vehement protest: "If we wish to consider ourselves scientific surgeons we must be guided in our practice by well-recognised mechanical principles, and not follow blindly a creed which can be proved by naked-eye evidence to be false, merely because we are imbued with the belief that it affords us such results as, in the past, we were satisfied to call good—meaning to imply not absolutely bad. Perfection, or the nearest approach to it, must be our goal, we must accept no compromise." And again, "It seems to me quite time that surgeons should throw off their prejudices, and let their actions be guided by facts and reason instead of by tradition and superstition."

These are indeed most rational conclusions; why are they not yet universally adopted? No surgeon, since the introduction of the operation by Lord Lister many years ago, hesitates for a moment to wire a fractured patella, yet the after-results of such an injury, dealt with by splints alone, are, Mr. Lane asserts, not so deplorable as those following a like treatment of Potts' fracture in the adult, of which Cheyne and Burghard, perhaps imbued with an optimistic belief in the results of conservative treatment, and overlooking an unpleasant reality, say, "In the case of Potts' fracture the trouble in the treatment is not so much in the reduction of the deformity and the promotion of coaptation, as in restoring to the patient a useful functional limb."

Again, this operation on the knee-joint is the most dangerous in surgery. Why then hesitate to explore a simple misplaced fracture, where the risks are far less, and the gain as great? Simply because of the "unreasoning, imitative, capacity of the human animal, which we inherit from our Simian ancestors." Some surgeons still, with a traditional dread, loudly decry the conversion of a simple into a so-called compound fracture, quite overlooking the vast difference in the two cases, a distinction between an aseptic intentional and a septic accidental wound. Times have changed since every compound fracture demanded immediate amputation, and every operation fomentations.

Before proceeding to the actual methods of bone-juncture, let us briefly consider what are the factors which militate against the
surgeon in his endeavour to reduce a fracture to its natural relation, or, in other words, what forces maintain sundered fragments in false positions. Primarily, there is the force of impact furthered by the unresisted action of gravity in a disabled limb, which, unless there is actual impaction, produces an initial displacement varying proportionately with the nature of the violence, whether direct, indirect or muscular, causing overlapping of fragments, inclusion of tissues, and frequently destruction of surrounding structures. This original displacement is maintained and even aggravated by an immediate spasmodic contraction of the muscles acting on the bone, which is, however, a transitory condition of little import, lasting only a few hours, and readily relaxed under the influence of an anaesthetic, or tired out by continued extension. There is, I am convinced, however, another far more important muscular action, which one might call, for purposes of distinction, the "secondary contraction or adaptation." This begins to exert itself within twenty-four hours, if the fragments remain displaced, and consists in the adaptation of muscular attachments to their altered and shortened bony supports. All muscle being elastic and constantly on the stretch when its opposing resistance is relaxed or completely overcome, tends at once to contract and shorten in length, soon permanently adjusting itself to altered conditions quite independent of any inflammatory exudation or contusion. This secondary contraction accounts, I feel sure, for the difficulty so often met with, even when the break has been exposed through an incision, in reducing fragments of several days' standing, even though there has been little or no hemorrhage, exudation or actual damage to the parts (Case 1, Plate II).

This muscular factor suggested to me the possibility of securing firm and accurate end-to-end union by means of a single medullary support penetrating both fragments, relying on such a stay and on the approximating force so exerted to maintain the re-established continuity. In violent injury, where there has been actual laceration, the chief factor, as Mr. Lane points out, is undoubtedly the hemorrhage poured from torn vessels and vascular bone into a closed elastic sack of tissues surrounding the bone and clothing the limb. Here the outward pressure exerted by the pent-up fluid generates a force which causes the severed fragments to overlap still more. This condition frequently imposes an insurmountable obstacle to complete reduction, and is only aggravated by prolonged and futile manipulation. If such be the case, a successful result can only be obtained by operation. (In compound fractures the
blood extravasated escapes freely, and this difficulty of reduction frequently does not exist.) Eventually, if left to Nature, inflammatory exudation and cell-infiltration ensues, the escaped blood coagulates around the fractured ends, fixing them firmly and forming a medium for the diffusion of lime salts, and the ultimate formation of callus, which is thus deposited in quantity directly proportionate to the severity of the injury, the amount of displacement, and the degree of mobility permitted. This point is emphasised by Mr. Lane, who says "The presence of callus indicates imperfect apposition, or a want of complete fixation, both evidences of unsatisfactory surgery." It is very useful in the savage and in the lower animals, but is a disadvantage in members of a civilised community, since it can only exist with unskilled work. Therefore, as far as we are concerned, callus is a thing of the past in the large majority of simple fractures treated scientifically.

It is this conspicuous absence of callus "in the majority of fractures treated scientifically" that, next to the absolute restoration of the normal bone, constitutes, to my mind, the greatest advantage in this operative procedure, and ensures the most complete and perfect results. Callus undoubtedly forms a natural and admirable splint in cases that are left entirely to Nature's cure; and when the displacement is virtually nil, or where restoration has been accurately accomplished and the damaged limb immobilised, no operation is necessary, nor indeed is justifiable; the small amount thrown out is then quite sufficient for the demands of security and forms a strong cement, the surplus of which is rapidly absorbed, leaving only a slight or no deformity. In other instances, however, where the displacement is not overcome, where deformity persists and mal-union occurs, the enormous quantity of callus formed round the fracture and necessary for its support takes years to absorb, and never completely, since its presence as new bone is essential to the future strength of the shaft. This surplus is then a grave danger to the patient's comfort and usefulness; not only does it increase existing deformity and further damage the mechanism of the limb, but gradually, as it hardens and contracts to bony consistency, it ensnares surrounding vital structures, hampering the movement of muscles and tendons, perhaps encroaching on the limits of joints, occluding vessels in their continuity, including and comprising nerves, and thus produces consequent limitation of use, chronic edema, mal-nutrition, neuralgia, and pain on pressure and exercise; in fact, all the changes attributed by Mr. Lane to violation of bony axes and
articular surfaces, but which I am convinced are as largely due to the actual involvement of the soft structures themselves by this new growth. Under such conditions the limb is rendered completely useless, and will remain so indefinitely. During the last three months I have seen two almost identical cases which exemplify this point, both old-standing oblique fractures of the tibia near its centre, caused by direct violence. In each bony union had occurred, with considerable misplacement and overlapping of fragments. There was considerable deformity, slight shortening and wide-spread deposit of new bone, giving rise to all the symptoms just described. The limbs were painful, deformed and useless, and their owners, otherwise healthy men, had, of necessity, to be invalided from the service.

We have now considered the difficulties met with in reduction, let us briefly review the ordinary routine of a surgeon in dealing with a simple fracture, say of one of the long bones. In the first place he examines the limb, elicits crepitus and one or more of the other classical signs of the lesion, judges its variety and estimates the amount and direction of the displacement as accurately as is possible on mere manipulation through, possibly, tense and swollen coverings. The limb is then supported temporarily and the patient sooner or later introduced to the dark room and subjected to that more piercing, surgical eye, the X-ray, which so frequently reveals a vast and unsuspected displacement. To obtain reliable information by this means the shadow must be cast in several directions, a single aspect being often quite misleading, and a lateral view frequently discounting the erroneous impression gained from one taken antero-posteriorly, or vice versa. An anaesthetic, which is essential to accomplishing satisfactory reduction, should, where possible, be administered while the patient remains prone on the canvas-covered radiographic couch, the rays being cast from below and falling on the silenium screen, which should, from time to time, be held over the injury by the operator, who can thus ascertain his progress towards approximation, and so the fracture is brought into accurate position and there retained by means of a plaster case or wooden splints; these he will remove on the third or fourth day and start systematic massage and passive movement, which measure, carried to great extremes, to the exclusion of other treatment, by some French surgeons, will, I am sure, be recognised as the one marked advance in the surgery of fractures. It is an all-important factor in securing a useful limb after splinting, since it ensures proper joint movement and nutrition, prevents wasting
and adhesion, and promotes the absorption of callus. This saving clause is well demonstrated among lower animals, who, relying on new bone and constant movement, frequently gain quite efficient limbs, despite great deformity and mechanical disarrangement, after severe and utterly neglected fractures.

Now this is an ideal procedure, as far as it goes, and in cases where there has been little or no displacement, or where existing displacement has been successfully overcome, is all that is necessary, and will give admirable results; but there are very many instances where, owing to the nature and severity of the injury, it will be found quite impossible to restore the fracture, in spite of every assistance. More commonly in oblique fractures, fractures at the end of bones, or involving joints, separated fragments, compound, comminuted, and fractures of two parallel bones, also almost invariably in severe Pott's and Colles' fractures, and, of course, in broken patellae, this simple treatment is absolutely inefficient, and, if persisted in, mal-union, with all its consequent disablement, must result. These then are the cases which, judged from a modern rational and scientific standpoint, demand operative interference. We have, with the aid of recent invention, reduced this branch of scientific surgery almost to a simple carpentering art; we have not only felt, but actually seen the support broken, and its fragments irrevocably displaced; we know cohesion to be essential, and are convinced that the unaided efforts of Nature towards this end, acting on such a complex and artificial machine as man, must prove disastrous. It remains then to decide what is the simplest means of securing union through an open wound.

Of the methods at present in vogue, the original, and still the most universal, is the junction of fractured ends by means of silver wire, or other less suitable plastic material, piercing the bone above and below the site of injury, or encircling it. More recently, Mr. Lane has introduced the ordinary carpenter's screw, and a slight modification of it designed by him. This is especially useful in separated promontories, and in very oblique or spiral fractures, the old-fashioned ivory peg having proved quite inadequate in these as in most other cases. The danger of the screw, however, is its liability to comminute the bone if carelessly applied.

The use of staples with serrated terminal spikes, introduced by Dr. A. Jacoel, is also an effective method of securing breaks in porous material, such as the patella and the extremities of long bones.

Now, the wiring of fractures, in spite of its general adoption,
is a proceeding fraught with great difficulties. I was at one time Mr. Lane's, and later Mr. Symonds' house-surgeon, and when assisting at a large number of such operations, I was struck by the many obstacles, checks, and minor disasters which may be met with, even under such master hands. Difficulties in passing the wire through the aperture in the second fragment, owing to the depth of the wound preventing its kinking, and getting it taut, and in twisting and hammering down the cut ends without snapping it—an accident which not unfrequently occurs—necessitating a fresh start and throwing a great strain on the fortitude of the operator. With these facts before me I have endeavoured to introduce some fresh methods of bone suture, which I hope may add to the simplicity of this operation and place it in its most recent and scientific light within the range of general surgeons like ourselves, who, in the Army especially, meet with such a large number of broken bones amongst soldiers, whose professional capacity and usefulness to the State depend entirely on physical soundness of limb.

These methods, which I must apologise for bringing to notice in their immaturity, involve the use of simple contrivances, and obviate the necessity for drilling bone and using wire, which demand much time and skill, and involve many risks. The contrivances are two:

1. The medullary spike.
2. The bone fracture clamp.

They depend for their effect in the one case, on the support of the medullary cancellous tissue alone, and in the other, on the sole support of the compact bone. They may be employed singly or in conjunction (fig. 1 and Plate I.), and will be described separately and in detail.

The medullary spike consists of a double-pointed steel spike, divided by a raised flange into two unequal lengths, each from a quarter to two inches, and varying according to the necessity of the case, alterations being made if necessary during the operation, by means of a file or cutters. I have been using the ordinary carpenter's brad-awl heads, which answer the purpose admirably, and can be bought at any hardware shop at the small cost of two a penny. These may be filed down at the rough end, cut to the required size, and electro-plated, if desired, before use. The variety employed in conjunction with the clamp is essentially the same, but perforated to admit the passage of the tension screw, as I shall describe later (fig. 1 b).
The fracture clamp is a simple instrument consisting of two toothed jaws, each formed by the junction of small parallel steel rods, armed at their extremities with sharp spikes, and joined centrally by a free pivot, so allowing their close adaptation to any inequality of surface or variation of position which may be considered advisable.

The jaws grasp the bone on either side of the fracture, and are placed, one superficially, the other deeply. They are joined by a tension-screw of fine steel, which pierces the pivots and passes directly through the line of fracture, to the obliquity of which it accommodates itself accurately. The tension wire, some three or four inches long, is finely threaded and provided with a minute nut, which can be screwed down, thus clamping the jaws firmly home to any required position, after which any surplus is filed off and discarded (fig. 1, c and Plate I., c).

Described in detail, the jaws, one superficial the other deep, consist of two parallel steel rods $\frac{3}{4}$ to 1 inch, by $\frac{1}{8}$ by $\frac{1}{16}$ inch, provided with sharp terminal spikes $\frac{1}{4}$ to $\frac{1}{16}$ inch long, turned downwards and inwards at an angle of from 75 to 80 degrees. They are hammered out and perforated centrally, and are connected together by means of a pivot, riveted or screwed into position, and so allowing of adaptable movement in either rod. The pivots vary slightly in each jaw. Both are a $\frac{1}{4}$ to $\frac{1}{2}$ inch in length and of circular section steel, $\frac{1}{4}$ inch in diameter; they diminish at their extremities, which are received into the corresponding slots of the rods. Being themselves pierced centrally, the perforation in the deep pivot is threaded to hold the extremity of the tension screw, whilst that of the superficial one is smooth bored and admits its passage freely. This latter is also sunk with a small facet on its superficial surface, for the intimate reception of a tightening nut. The tension screw provided with this nut is made of tough steel wire $\frac{1}{16}$ inch in diameter, 3 to 4 inches in length, and threaded throughout. It is, as I have stated, screwed into the deep pivot and checks flush with its lower surface, whilst riding easily through the superficial one, which can thus be adjusted to any desired position through a fracture of almost any obliquity, and grasping the bone on either side of the break holds its ends firmly together and maintains both jaws closely adapted to their adjacent bone surfaces, when it has been secured in situ by means of the minute hexagonal nut $\frac{1}{16}$ inch in thickness and about $\frac{1}{4}$ inch in diameter, which being eventually tightened down and buried in the facet for its reception, the surplus wire is filed off and removed.
In the use of any of these mechanical devices one must be guided essentially by the needs of the case, the nature of the break, whether simple, compound or comminuted, its direction, transverse, oblique or spiral, its position, bone or bones in question, and the time of its occurrence, whether recent or remote. Having considered these points in detail, it only remains to select the obviously appro-
prate appliance. I have already referred to the use of screws and staples in oblique and spiral fractures respectively; wire can, of course, be almost invariably employed should necessity compel, in spite of its attendant difficulties. For greater simplicity, however, the medullary spike, used by itself, is admirably suited to most cases of transverse or moderately oblique fracture in shafts with a small central cavity. These include all the long bones (Plate I., 3) with the exception of the femur, humerus and tibia (the centres of these shafts being so roomy and devoid of cancellous bone that under no condition would a medullary spike be of the slightest support), and also in all packed cancellous extremities and in one of parallel bones in which the sound bone acts as a natural splint to its broken companion. The efficacy of this method depends, in recent cases, on the "secondary muscular contraction" to which I have referred, and in those of longer standing to "inflammatory infiltration." These strong forces tend to approximate and overlap the fragments, and when once temporarily overcome, to keep them in close apposition, the inserted spike and roughened bone surfaces preventing any displacement.

I have used this device in its single capacity on several occasions, and find the result most encouraging (Cases 1 and 2, Plates II. and III.). Its application is simplicity itself, and a great saving of time is effected. Having exposed and isolated the broken ends through a free incision, strong traction is applied, and they are forced freely out of the wound. The most fixed fragment, which is generally the larger or upper, is now held firmly in a lion forceps, while the longer point of the spike is pressed firmly into the medulla until the flange is reached. There is considerable resistance to its entry, especially in the smaller bones and extremities, and markedly so in the patella, which it may even be necessary to drill for its reception. The lesser or more movable fragment is next slowly everted and extended until the free point of the spike is opposite its centre, when the traction is relaxed and both pieces gradually and evenly pressed into their natural position, allowing the lesser spike to sink in as the ends approximate, which they do, firmly, forcibly and, if care has been taken, accurately into position. The greater the resistance offered at the time the firmer will be the after result, the central support and the interval friction insuring security. If movement of the fragments is limited and the lesser end found too long for insertion, a portion of it can be filed off without removing the spike from position. The advantages of such an operation are its simplicity and rapidity. There is no delay in boring holes, intro-
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ducting, twisting and cutting wire, burying a screw, &c. No danger of splitting bone or breaking wire, and no subsequent interference or irritation of surrounding tissues or articular surfaces by a foreign body necessitating eventual removal.

The fracture clamps are suited to almost any break, if not too oblique or spiral in direction, and if in such oblique cases no more transverse lie can be utilised. It is introduced as follows: the ends having been exposed, cleared and brought into good position, strong extension is exerted, and the tension screw, with deep jaw attached, is slipped into the centre of the fracture. A small semicircle of compact bone having, if necessary for its closer lie, been filed or nibbled away from the edge of one fragment superficially and deeply, the jaw lying on the deep surface of the bone is secured in position, and its spikes pressed firmly in with a lion forceps. The superficial jaw is now slipped on to the protruding wire, and dealt with in like manner, the whole being eventually secured and tightened by means of the nut. When the ends are thus firmly united, the surplus screw is filed off and removed. These clamps may, when necessary for the sake of greater security, supplement the use of the medullary spike, which latter is then ovaly perforated to admit the tension screw in a vertical or oblique direction, and requires no flange (fig. 1 b). When the spike has been buried in position, as already described, the tension screw with jaw attached is passed through its perforation from within, the extension relaxed, and both jaws secured in situ. This combination used with a small modified clamp, should be admirably suited to fractures of the patella (fig. 1, d and Plate I., d). The medullary spike being inserted in the centre of the bone and the jaws, which are single, adjusted laterally, so that the articular surface is in no way interfered with, the instrument can, if considered advisable, be subsequently removed through small lateral incisions made under the influence of a local cocaine anaesthetic. When expedient, the more complicated though securer clamp may be replaced by bone staples, which are of the simplest possible construction, and within easy reach of any surgeon who possesses some steel wire, a file, and a hammer, the ends being turned down, flattened and serrated at will. They are only effective, however, in soft extremities and perhaps in fractured patellae, and are impracticable in the harder shafts of bone. Should sufficient support not be gained by staples alone, they may be supplemented by a spike or wire. In fixing them in position great care must be taken to steady the fragments by means of lion forceps. They should be hammered in with short
sharp blows distributed equally, and eventually driven home at the end of a steel punch.

There are two varieties of fracture which, though I have already referred to, require some further mention before bringing this paper to a close.

Firstly, the oblique and spiral, where no suitable lie can be obtained for spike or clamp. In these I am convinced Mr. Lane's method of screwing the fragments together is most reliable.

Secondly, comminuted fractures (and in such no fragments of bone should ever be discarded). Here I think it will generally be found advisable to secure the inlaid pieces by means of either longitudinal enclosing or circular binding wires, or both. In cases where two parallel bones of a limb are broken, it will generally be found sufficient to wire but one, and that the larger or more misplaced. This having been accomplished its fellow will usually regain a good position and require no further manipulation (Case 3, Plate IV.). So in Pott's fracture, when the inner malleolus has been separated, on joining the fibula alone the foot as a rule regains its natural position, carrying with it the severed bony fragment. Should sufficient support and reduction, however, not be gained by a single union, it becomes essential to effect a double one (Case 2, Plate III.).

Throughout this paper, from a point of view of mechanical treatment, I have included simple and compound fractures in the same category. No essential difference need exist, save that in the latter the adoption of a device that can be readily removed is necessary, hence the medullary spike is contra-indicated.

In conclusion, let me add that the only way of dealing with these cases satisfactorily and rightly is to make absolutely certain of the cleanliness of the means employed. Mr. Lane's rigid aseptic methods are of course ideal, but under less advantageous circumstances, and especially I imagine in foreign climates and with perhaps unskilled assistance, I am assured it is far safer to combine both aseptic and antiseptic routine.

Certain points of procedure are of paramount importance. Careful shaving and antiseptic compress of the entire limb at least twenty-four hours prior to operation (which of course in compound cases is impossible), strict exclusion of the rest of the body surface and the wearing of gloves by all who participate in the operation. The incision over the most accessible aspect of the bone must be free, avoiding all important structures, and the knife thus used immediately discarded before proceeding further. A thick layer
of cyanide gauze, slit to correspond with the length of the wound, is placed over it, and the edges sewn or pinned to those of the incision, which is then washed out with carbolic or weak mercuric lotion. The broken ends of the bones are then exposed, carefully freed and prised out of their bed, disturbing periosteum as little as possible. Any blood clot or lacerated muscle must now be removed and the entire wound washed out and packed deeply with antiseptic gauze, which diminishes the oozing, insures cleanliness, gives adequate support to the fragments in their exposed position, and protects surrounding tissues from injury during manipulation. The fracture is then dealt with as deemed advisable, the gauze plug removed, the wound again washed out with antiseptic and subsequently with saline lotion, the deep layers sutured, a drain inserted and the skin stitched with salmon gut, leaving several strands untied to be secured in twenty-four or forty-eight hours, when the tube is removed. This drainage is a most necessary and important precaution, and should, I feel sure, be adopted in every case, since it prevents dangerous collection of blood and lymph and undue pressure on stitches. Throughout the proceedings the hands of the operator must be, as far as possible, carefully excluded from the wound, and all assistance, sponging, &c., rendered by instruments only. Under such circumstances, the dangers of operation are reduced to an absolute minimum.

The most useful and comfortable support during convalescence is a plaster case, which should be applied when the patient is under the anaesthetic; whilst at the same time 20 to 40 cc. antistreptococcic serum may be usefully employed in compound cases—a routine practice in all operative dealings with bone and joints by some surgeons.

Should it be necessary, either from septic or irritative causes, to subsequently remove the mechanism employed, this can be done in the case of the clamp by exposing the superficial jaw through a small incision, removing it and the nut, and then loosening the deep jaw by pressing on the exposed end of the tension screw, passing a curved forceps round the bone and grasping the deep jaw, which is thus held firmly, while the tension wire is unscrewed from its pivot and the whole withdrawn piecemeal. Staples, screws and wires can of course be easily dealt with through small incisions; in the case, however, of the medullary spike it will only require removal in the unfortunate event of accidental infection, and should, therefore, never be used where the slightest uncertainty exists. Under such lamentable circumstances where there is a condition
of septic osteomyelitis, the rational proceeding will be, of course, as in any such case, to trephine the bone, when the spike can be readily removed and the parts drained freely.

Finally, the three following cases, which I shall give in some detail, together with illustrating radiographs, will, I trust, help to demonstrate points in the operative procedure and routine after treatment of the methods employed.

Case I (Plate II.).—Miss I. A., aged 12. Admitted October 2nd, 1905, into the Louise Margaret Hospital, Aldershot, suffering from Colles' fracture of the right wrist, caused by a fall on the outstretched hand. The typical deformity existed, and on X-ray examination the radius was seen to be broken transversely, three-quarters of an inch above its lower epiphysis, the lower fragments being displaced, backwards outwards and upwards.

An anaesthetic was administered within an hour of the accident, but on manipulation it was found quite impossible to satisfactorily reduce or maintain the fragments in apposition. On considering the great mechanical interference with the function of the limb, which must certainly result if the deformity were permitted to persist, it was considered advisable to deal with the fracture through an open wound.

Operation.—Undertaken October 6th, four days after the accident. Chloroform was administered, and the lower end of the right radius exposed through a dorsal incision four inches long. There was no appreciable laceration or extravasation of blood to be seen, nor was there bony impaction; yet the greatest difficulty was experienced in reduction, owing I presume to "secondary muscular contraction," which on traction could be distinguished in the tense and shortened "ties" which maintained the deformity. This was overcome, however, with the aid of instruments and the fracture isolated, reduced, and secured by means of a "medullary spike," the long limb of which penetrated the shaft of the bone whilst the shorter engaged its separated extremity without interfering with its epiphysis. Throughout the operation, which lasted thirty minutes, the wound was frequently flushed with antiseptic and saline lotion. The skin and surrounding tissues carefully packed off with cyanide gauze, and manual contact avoided as far as possible. The deep structures having been united with silk sutures, the incision was closed and a drain inserted (twelve hours). The limb was immobilised in plaster, applied during the anaesthetic.

Patient made an uninterrupted and rapid recovery, the wound healing by primary union; the stitches were removed on the eighth
day, leaving a linear scar. She was discharged October 24th, twenty-two days after admission.

Passive movement and massage commenced on the fifth day and were continued for four weeks, when, all splints having been discarded, a system of regulated exercises was advised. Seen two months after the operation. Patient had complete restoration of function. There was accurate bony union (vide radiograph), and no sign of irritation or mal-nutrition provoked by the presence of a foreign body.

Case 2 (Plate III.).—Private H., A.S.C., admitted July 8th, 1905, into the Cambridge Hospital, Aldershot, having been thrown violently from a traction engine. Patient had sustained serious injuries to the left forearm, the radius and ulna being fractured transversely near the centres of their shafts, and the ulna also within one inch of its lower extremity. There was great deformity, laceration and extravasation of blood. On X-ray examination the fragments were seen to overlap to the extent of nearly one inch, producing considerable shortening. An anaesthetic was administered and the bones, being reduced as far as possible, were immobilised in splints and extension applied for a fortnight. It was found, however, impossible to maintain good position, and as much functional derangement seemed therefore imminent, it was decided to operate.

Operation.—Under an anaesthetic the shafts of both bones were exposed through two latero-dorsal incisions, each about six inches long. The broken ends having been freed and isolated, the fracture of the radial shaft was found to be slightly comminuted, and was therefore sutured by means of a silver wire, that in the centre of the ulna being secured with a "medullary spike." The deeper structures were next united, the tissues carefully irrigated, the incision closed, a drain inserted (twenty-four hours) and a plaster case adjusted to the limb during the anaesthetic. In ten days' time, primary union having resulted, the stitches were removed. Passive movement and massage commenced on the seventh day and were continued until patient's discharge on furlough September 19th, 1905, when he had regained considerable use of the limb, though its function was at the time still considerably impaired owing to the severity of the injury.

Case 3 (Plate IV.).—Private B., R.F.A. Patient, who is a champion wrestler in the Army, was admitted November 19, 1905, into the Cambridge Hospital, Aldershot, suffering from an oblique fracture of the tibia and a transverse fracture of the fibula in the
Illustrating "medullary spikes" and "bone fracture clamps," used separately and in conjunction. (From photographs of dry specimens.) (A) Fibula trephined to expose "medullary spike" in situ, holding a transverse fracture. (B) Transverse fracture of the humerus, held by a single "bone fracture clamp." (C) Femur trephined to expose "medullary spike" and "bone fracture clamp," holding an oblique fracture. (D) Patella trephined to expose "medullary spike" and modified "bone fracture clamp," holding a transverse fracture. (E) Transverse sections of long bones, near their centres (radius, ulna, fibula and clavicle), demonstrating their diminished, and closely packed, medullary cavities.

To illustrate paper by Lieutenant R. GRENVILLE ANDERSON,

"The Operative Treatment of Fractures, introducing some Original Methods of Bone-union by Simple Mechanical Means,"
PLATE II.

Colles' fracture of the right wrist. Radiographed immediately before, and three weeks after, operation.

To illustrate paper by Lieutenant R. GRENVILLE ANDERSON,
"The Operative Treatment of Fractures, introducing some Original Methods of Bone-union by Simple Mechanical Means."
Transverse fracture of the left radius and ulna, near the centre of their shafts, and again at the lower extremity of the ulna. Radiographed before, and four weeks after, operation.

To illustrate paper by Lieutenant H. Grenville Anderson,
"The Operative Treatment of Fractures, introducing some Original Methods of Bone-union by Simple Mechanical Means."
Oblique fracture of the tibia, and transverse fracture of the fibula in the lower third of the left leg. Radiographed four weeks after operation.

To illustrate paper by Lieutenant R. Grenville Anderson,
"The Operative Treatment of Fractures, introducing some Original Methods of Bone-union by Simple Mechanical Means."
lower third of the left leg, caused by the direct violence of a kick at football. There was great laceration, extravasation, shortening and deformity; the lower fragments being displaced upwards, inwards and backwards, and the bony extremities overlapping to the extent of nearly two inches. The fracture was found incapable of reduction, even under an anaesthetic, and it was, therefore, decided to operate.

Operation.—Under chloroform, an anterior incision, six inches long, was made over the site of injury and the tibia exposed and isolated. Large masses of clot, intruding between the broken ends, having been removed, the fracture was reduced and secured firmly by means of a "bone fracture clamp" (as described in text). The fragments of the fibula falling into accurate apposition on reduction of the tibia (vide plate) required no mechanical interference. The wound being irrigated, sutured and drained (twenty-four hours), a plaster splint was applied during the anaesthetic. Primary union resulted and the stitches were removed in ten days.

Passive movement and massage, commenced on the eighth day, were persistently continued. When last seen, January, 1906, patient had secure, though as yet incomplete, bony union and was getting about on crutches.

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Photographs by Corporal Pell, R.A.M.C.