Selected papers on injuries and diseases of bone / by Sir William Ireland and C. Wheeler.

INJURIES AND DISEASES OF BONE

W. H. DE C. WHEELER

SELECTED PAPERS ON INJURIES AND DISEASES OF BONE

SELECTED PAPERS ON

INJURIES AND DISEASES OF BONE

BY

SIR WILLIAM IRELAND DE C. WHEELER

(MOD.) B.A., M.D. (DUB. UNIV.), F.R.C.S.I., F.A.C.S. (HON.)

SURGEON TO MERCER'S HOSPITAL AND THE NATIONAL CHILDREN'S HOSPITAL, DUBLIN; PAST PRESIDENT ROYAL COLLEGE OF SURGEONS, IRELAND CONSULTING SURGEON TO THE MINISTRY OF PENSIONS HOSPITAL, BLACKROCK; LATE LIEUT.-COL. R.A.M.C.

LONDON

BAILLIÈRE, TINDALL AND COX

8, HENRIETTA STREET, COVENT GARDEN, W.C.2

1928

PRINTED IN GREAT BRITAIN

TO MY WIFE

PREFACE

In 1916, "Selected Papers on Surgical Topics" was published for private circulation by Messrs. Drought, Dublin. At that time no attempt was made at uniformity; the book contained communications on a variety of surgical subjects.

In presenting this little volume as a continuation of the first, it was thought desirable to confine it to one sphere of surgery, and thus it deals only with closely associated injuries and diseases of bone.

Primarily, the contents had their origin in lectures given at the bedside to senior students in Mercer's Hospital, Dublin; later they appeared in a different form as contributions to the *Lancet; British Medical Journal; Surgery, Gynæcology and Obstetrics; The Practitioner; The British Journal of Surgery;* the *Irish Journal of Medical Science,* and *Medical Annual.* To these journals the author is greatly indebted.

The first fifty-four pages are a synopsis of four lectures given for the University of London at St. Bartholomew's Hospital. The book is compiled to illustrate briefly a branch of the routine work of a hospital surgeon. For this reason the contents may interest senior students, post-graduates, and those embarking on general surgical practice.

As a preliminary to the original lectures, emphasis was laid as a rule on the necessity for travel for those who are trained and work in a small island. The wisdom of visiting the chosen workers in other lands, in order to keep pace with the rapid advance of modern surgery, was urged on every available occasion.

Introductory pages, devoted to remarks on this subject, have been included.

The author has endeavoured throughout the text to acknowledge the sources from which information was obtained. He has drawn freely from the stores of those who are recognised authorities, and is sensible of a deep obligation.

W. I. de C. W.

Dublin,
December, 1927.

CONTENTS

INTRODUCTION

THE NECESSITY FOR TEAM WORK AND TRAVEL.*

THE art of Surgery is as old as the existence of man. The most ancient remains bear the impress of the surgeon's skill. Skulls of epileptics were trephined to afford incarcerated evil spirits a chance of escape. The foundations of our surgical edifice were laid when man first appeared upon the earth. In a paper of limited scope it appears more profitable to deal with the present and think about the future, but we must be guided to some extent by the records of bygone days. Progress was indeed slow in the ages past, if none the less sure; for centuries we find one authority after another preaching the doctrines of his own forefathers.

Some few years ago I had occasion to review the works of Hippocrates and Galen, to search the writings of Dupuytren, Hamilton, and Malgaigne, and to see what Velpeau, Wiseman, and Ambroise Paré had to say on the subject of fractures.† The study was absorbing, and the trail was followed through the eighteenth century school led by Pott and Hunter to Sir Astley Cooper, Lister, and modern times. The result of it all was to find that the Egyptians, three thousand years before Christ, in the fifth dynasty, probably treated fractures by more successful methods than are often employed at the present time. Grooved splints were used in compound comminuted fractures of the shaft of the femur, pads and bandages of linen tied with reef knots secured them in position.‡ Three thousand years later, in the Christian era, treatment was the same, and another two thousand years found the Abyssinians adopting methods in no material way different from those of the ancients. A study of broken bones to its source takes us backwards past definite milestones, for a bone once broken forms a permanent index from which can be gauged the ideas and ability of the surgeons in the past, and from the earliest times there is an abundance of specimens from which this study can be made. Treatment, however, appears to have only undergone a real change in our own time;

* Extracted from the opening Presidential Addresses to Surgical Section, Royal Academy of Medicine in Ireland, November 1920 and December 1922.

† Presidential Address, Dublin University Biological Association.

‡ Elliot Smith.

through the ages it was regarded as a thing like "the law of the Medes and Persians, which altereth not."

In a study of this kind it is disappointing to find that the surgical supermen of the past were obliged to engage in a heart-breaking struggle in their effort to advance. Reaction and conservatism haunted them as they haunt their successors. There was the inevitable make-believe that the hands of the surgical clock could remain stationary, and then, as now, men with their heads in the sand were content to believe that their own methods, employed in hidden corners, represented the finality of perfection. It is usually from those who have not travelled that dogma in surgery is expected, but we find so renowned an authority as Ambroise Paré, who has been described by Moynihan as one of the greatest original minds our art has known, "Fearless, independent, alert, and inventive," referring to himself in these words: "There be few men of this profession which can bring so much authority to their writings, either with reason or experience, as I can. I have so certainly touched the mark whereat I aimed that antiquity may seem to have nothing wherein it may exceed us, besides the glory of invention, nor posterity anything left but a certain small hope to add some things, as it is easy to add to former inventions." He little foresaw Lister and the future in cultivating an attitude so detrimental to progress. Those who described their own work were egoists; praise of the work of others was regarded in the nature of hero worship, and criticism of faulty, ill-conceived effort was attributed to jealousy. The obstacles to progress appeared always in the ascendancy, but in reality existed only to be overcome.

In studying the present age of rapid advance and making plans for the future, surgical progress can be helped by taking to heart certain lessons. If not from day to day, at all events from year to year, the outlook of the operating surgeon must alter. It is no use when young deciding what is best in surgery and developing to the utmost a system based on the work of contemporary leaders in the belief that it will suffice for a lifetime. Think of the manufacture of motor-cars and compare the engines of to-day with ten years ago, the small improvements in carburettor, magneto, and essential parts have in a decade produced an almost perfect machine. The danger is that as we grow older and our minds less receptive we may miss in surgery the cumulative effect of small advances.

We learn another lesson by noting the merciless and destructive criticism which accompanied such epoch-making discoveries as anæsthesia and antiseptic surgery. Who knows but that we are on the verge of the solution of the cancer problem?

All of us have seen the melting away into thin air of masses of cancerous growth under the action of radium; it is almost past belief that an infiltrating ulcer in the tongue and mouth beyond the possibility of successful operation can be made totally to disappear in a few days, yet such cases are seen. Truly, it is not a cure, but it prepares the mind for vast possibilities. Although surgery is defeated by metastasis in cancer, in syphilis salvarsan and its derivatives can search every corner of the organism until the virus is rendered inert or finally destroyed. Research is only temporarily baffled; an army of workers are abroad in the laboratories, and clinical observers are everywhere on the alert. How interesting it is to speculate on the connection between a slight injury to bone and the development of sarcoma! We think of the great capillary supply of the cancellous ends of the bones and how a slight injury causing a capillary hæmorrhage within may set free the tubercle bacillus or other organism with results which can be accurately pictured. It is not so long since our ignorance on this subject was complete. We know that the same slight injury, in the same place, in similar individuals, will be followed by a malignant growth, and yet a severe injury causing fracture is followed neither by the one condition nor the other. The case of the breast is perplexing, for carcinoma is sometimes preceded by injury, elsewhere it seems to be the product of continued irritation. Will the observation that growth in cancer is stimulated by acidity and inhibited by alkalinity lead us anywhere?

Bland Sutton wonders if he could fathom the secret of the changes of pigmentation in the plumage of certain birds at the breeding season, how nearer he would be to a solution of the problem of melanotic sarcoma.

I do not know how far the experimentalists have carried us along the road, one thing only is certain that if the riddle of cancer is solved in our time and we resemble our ancestors, which God forbid, we will scoff for a generation and allow posterity to have the benefit. To those who would keep on the straight road and move as quickly as circumstances permit, Osler gives admirable advice. Teachers must have a full personal knowledge of the branch taught, not second-hand information derived from books. Men are required to have a sense of obligation, "that feeling which impels a teacher to be a contributor and to add to the stores from which he so freely draws." To do this it is necessary to know the best all the world over. He will burden an already overladen literature with faulty and crude observations unless he is familiar with the workers abroad. In another essay he tells us that when a man talks slightingly of the position and work of his profession in other countries, or when a teacher tells you that

he fails to find inspiration in the work of his foreign colleagues, in the words of the Arabian proverb, " He is a fool, shun him." Personal first-hand intercourse with the men of different lands when the mind is young and plastic is the best antidote against ignorance. Osler tells some home truths. He discusses the weakened receptivity and the inability of men over forty to adapt themselves to an altered intellectual environment. " It is this loss of mental elasticity which makes men over forty slow to receive new truths." It is well to recognise this unpleasant fact and to gain comfort by believing with so great a writer and physician that salvation lies " in living in and with the third decade in company with the younger, more receptive, and progressive minds." Thus it is essential to travel to see the work of others at frequent intervals, to cultivate discriminate reading, and to contribute from time to time knowledge gained by experience for the benefit of others.

Hole-and-corner surgery will disappear, and playing to the gallery is already dead. " Surgery of the brilliant kind," says Moynihan, " is a desecration. Such art finds its proper scope in tricks with cards, in juggling with billiard balls, and nimble encounters with bowls of vanishing goldfish."

Some dreaming, a little hero worship, and speculation as to what we are aiming at and living for is not unprofitable, but there are many who will desire to approach the subject of surgical progress from a more practical and utilitarian point of view. To do this a fundamental contrast must be drawn between our ancestors and ourselves. Every epoch in surgery is associated in the past with the names of individual men. All, from Hippocrates to Lister, in the great procession answer their names to the roll-call, and each one marks a notable period in surgical advance.

That day is passing, and from now on progress will have in all probability little or nothing to do with individual supermen, unless so far as they are the organisers and centre-forwards of a thoroughly efficient team. The art of surgery is now so wide that no one man can expect to be expert in all branches, and yet a knowledge of all branches should, in the interests of science, be brought to bear on almost every surgical or medical case. The logic of it is that from henceforward work will be best done in teams and groups. Craftsmen and biologists, physicians, gynæcologists, biochemists and pathologists, those skilled in the use of X-ray, radium, and the cystoscope, with sub-divisions such as neurologists, abdominal surgeons and the like, must work as units in groups and teams so that they may fully understand their interdependence, one upon the other, in the search for truth. To some extent such a system pervades the atmosphere in every large general hospital, but it is by no

means complete, and the close co-operation necessary to produce real results is conspicuous by its absence. The private patient often is deprived of anything approaching scientific method.

To illustrate exactly what is meant I will give you the impressions left on my mind after visiting the clinics of outstanding surgeons every year regularly, with the exception of the years of the great war.

It was difficult to understand at first why, for example, the late Professor Kocher of Berne stood head and shoulders above his neighbours and colleagues, men apparently with equal opportunities and a corresponding amount of grey matter. The same could be said of surgeons in England and Scotland, in France, and elsewhere.

In one clinic an immense amount of operative work would daily be completed. One case after the other would reach the operating room as if those responsible for the preparation and anæsthesia could see through closed doors and always be ready at the psychological moment. Seldom at the operation was it found that an incorrect diagnosis had been made. The physician, radiologist, biochemist, and all concerned were generally present to watch their observations put to the test. One could see the wheels working in a well-oiled machine. A visit would be paid the next day to some other clinic. A few words with the surgeon perhaps would leave the impression that the coming performance was to be headed by a genius. But in this case the anæsthetic was not taken well; after the first abdominal incision the recti fought against further interference and there was a delay. The X-ray photographs did not correspond with what was actually found, some vital point in the blood or urinary examination had been omitted, and those from whom information was required were not forthcoming. When finally the next case was expected in the theatre there was confusion, hurried orders, and the third patient appeared instead of the second. It is just the difference between the work of a well-trained team and the inco-ordinated action of isolated individuals.

What is meant by team work? I will answer by saying what is not meant. Consultations, as we know them, have no connection with the modern conception of team work as applied to a surgical case. Sending specimens to a laboratory at a distance, and placing reliance on the report received—the surgeon never seeing the pathologist, and the pathologist never seeing the patient—is not in keeping with modern thought. It is a dangerous practice, unfair to the patient, to the pathologist and to the clinician in charge. Such methods have no place in co-ordinated clinical effort, but clinicians are to blame if they

are content with counterfeit coin. I think perhaps medical pathology, leading up to vaccine therapy, is better understood than the modern conception of gynæcological pathology and surgical pathology as it exists in the living.

If space permitted, I could give many examples of how the detachment of the pathologist from the clinician and the clinician from the pathologist has led either to disaster, or nearly to disaster, in the management of a surgical case.

In Blackrock Ministry of Pensions Hospital, where we had our septic cases isolated as if suffering from the plague; where the best theatre sister and nurses were selected because of a splendid record of efficiency and training, and were never changed, and where, by common consent, a miniature team became established, we were able to obtain results which are more difficult to obtain in the rough and tumble of a small teaching hospital. Really good results in the strictest sense can be secured in private practice if the surgeon insists upon the patient having the best surroundings from his (the surgeon's) point of view: all other considerations must be turned down. It requires a surgical gymnast to operate one day in one place and the next day in another, with the consequent change of the attendant personnel. No one except a juggler can do justice to surgery under such conditions.

I think our salvation lies in travel, and that those who are coming on to take our places should be encouraged to see the surgical world before undertaking appointments on the staff of a hospital. Travel stimulates the mind, and is an antidote against "the soporific effect of self-contentment and self-esteem." "You are probably by no means sufficiently alive to your deficiencies," says Lister; "for it is an unfortunate property of ignorance that it is ever unaware of its own existence."

For some years back progress has been far in advance of this team system which could be seen long ago at selected clinics near and far. It is better to refer to the more modern idea as group work. Very interesting group work is carried out in Rochester, Minnesota, under the guidance of those two master surgeons—William and Charles Mayo.

Let us take a hypothetical case and follow in our imagination a patient with a goitre from the time she reaches Rochester to the day she is discharged cured. All the particulars are taken down at an office, preliminary forms are filled up, until enough information is obtained to pilot the patient to some junior clinician or laboratory worker. The clinician requires a blood count, and by pressing a button the patient is transferred by a lift to one of the many laboratories. Let us suppose the blood count does not in this case give the lymphocytosis picture to which Kocher at

one time attached so much importance as a diagnostic sign in hyperthyroidism. Yet it is believed by the clinician that the case is one of commencing Grave's disease. Only slight importance is attached to the blood picture, and many cases of colloid goitre in neurotic girls are mistaken for hyperthyroid cases ; the doubt must be cleared, and the patient travels on. By the waft of a wand she now finds herself blowing in and out of a complicated-looking machine having an estimation made of her basal metabolism. To this test the very greatest diagnostic importance is attached. From a prognostic point of view, however, it is often found that patients with only a slightly increased basal metabolism respond badly to treatment, and *vice versâ*, so the clinical picture is in this respect a better guide. The junior clinician in charge, provided the patient has no complications or other obvious condition apart from the goitre, has now got sufficient data for a *primâ facie* diagnosis. When all the preliminary investigation is complete, one of the leading physicians or surgeons, such as Dr. Plummer or one of the Mayos, sees the patient and analyses the deductions made. Treatment is then advised which in this case will be operative. In this clinic physicians, surgeons, and laboratory workers appear to agree that surgery is the only really successful treatment for hyperthyroid cases. Taking them all in all the mortality is less than 2 per cent. After operation the patient again passes through the laboratories, the basal metabolism has come down to normal, and the blood picture, if altered in the first instance, has now resumed its proper character. It is more easily imagined than described what a fund of scientific information is obtained by such thorough methods.

Once a week *post-mortem* examinations are made and every doctor concerned in the case is present. The patient may have died after gastrectomy for cancer of the stomach. There is evidence, perhaps, that the X-ray picture was inaccurate. The radiologist explains the fallacies of his critics. How was it in his case—cancer following chronic ulcer—that no hydrochloric acid was found at one examination and on the same day hyperchlorhydria was reported on the chart? Those responsible come forward and give details of numbers of cases where secretion of hydrochloric acid is inhibited at the time of testing, perhaps from the sight of the tube, perhaps in relation to the time of the last meal. Hence the necessity for fractional gastric analyses and tests at quarter-of-an-hour intervals when the results of such an examination are considered of importance. So the discussion at the *post-mortem* goes on, until finally the cause of death is attributed to, say, leakage at the line of anastomosis, and the onus is placed then on the

surgeon to explain why in this case he had adopted a certain operative technic which had failed.

It would be impossible in a short time to describe the operating theatres and surgical technic. In a place where team work is a religion it goes without saying, that it is simple, effective, and thorough. From 30 to 40 major operations are performed each morning in six theatres; illuminated signals in the corridors announce the name of each operation as it proceeds. Visitors are thus enabled, without disturbing the operators, to know exactly what variety of work is progressing in each room. The pathological laboratories in immediate connection with the operating theatres are freely used. During operation specimens are constantly passing for examination and the operative procedure is determined by the report received a few minutes later. Great importance is attached by the workers in the laboratory to the examination of fresh living material. The cell picture of sections made on living tissue is often quite different from that shown when dead cells are examined. For example, lymphocytes seen in smear preparations may not be lymphocytes at all, the change of cells into what appear to be lymphocytes is a *post-mortem* effect. The old pathologist is comparable to the anatomist, the new to the surgeon.

In massive tuberculous peritonitis in the female the abdomen is opened and the finger is inserted through adhesions into the pelvis, a line of cleavage is found and—*mirabile dictu*—after a little manipulation, reminding one of prostatic enucleation, the Fallopian tubes—the *fons et origo*—appear in the conjuror's hands. There is no cutting or blunt dissection and no ligature is used. These cases do excellently well.

The Talma-Morison operation for ascites is combined with splenectomy, for in this way about 30 per cent. of the total blood is prevented from ever reaching the liver. Splenectomy was tried some years ago in cases of pernicious anæmia, but the results at that time did not justify the continuance of the operation. After a long interval, however, certain cases reported themselves and had recovered sufficiently from the disease to justify the question being reopened.

The Gasserian ganglion operations appear to the onlooker like minor work; there is no blood, no shock, no hitch. The patient is anæsthetised, as is the custom, by a nurse. He is placed almost in a vertical position, his head being on a level with the head of the operator as he stands on the floor. A straight incision is made half an inch in front of the ear, the lower extremity being on the zygoma. The skull is then opened with Hudson's drill and the opening enlarged with nibbling forceps. A little cerebro-spinal fluid is withdrawn to render

easier the lifting up of the dura. The middle meningeal artery is tied and the dura propria is incised. The afferent root is divided with a specially constructed guillotine and the operation is over. The ganglion is not avulsed nor interfered with, no trophic disturbance follows the operation, therefore it is assumed the trophic centre may be in the ganglion or peripheral to it. Anæsthesia follows in the cornea as is to be expected, but there is never a recurrence of symptoms.

One could proceed *ad infinitum* mentioning points of interest, how the active principle of thyroid secretion was discovered almost by accident in the laboratories after examination of some tons of thyroid obtained from meat factories. This substance administered to hypothyroid and myxodœmatous patients produced results far in advance of any other known preparation, but was too expensive for general use.

Radium is used a week before operation in suitable malignant cases, the interval between application and operation is short owing to the adhesions and cicatrix found when a longer time is allowed to elapse Very small capillary glass tubes are often used containing half a millicurie of radium emanation, and these are left permanently *in situ*.

I was in a laboratory when a demonstration was being made showing that thyroid extract produced by one firm had five times the iodine content of that produced by another. Some popular preparations were useless because bacterial action had probably destroyed the active principle in the drying process to which the gland was subjected.

What a lesson to ponder over when we write prescriptions containing the names of drugs, perhaps potent, perhaps not, but always with hieroglyphics and symbols, and thus we carry on the old idea of mysticism associated with the medicine of mediæval times !

" You humbugs of doctors," says one of Charles Reade's characters, " couldn't speak plain to save yourselves from hanging."

" After fifteen years given to the science of obscurity Mr. Sawyer literally could not speak plain in one moment." It is suggested to the reader that the science of Æsculapius is guesswork, but the patient " goes on hoping and hoping something from traditional remedies, even when they fail and fail and fail before his eyes." The surgeon is pictured at each visit feeling the pulse and writing a prescription, " for it is a tradition of the elders that at each visit the doctor must do some overt act of medicine." Thus thinks the man in the street and he has been justified to some extent in doing so.

My last word is to urge the necessity for all in the common

cause to throw the searchlight on the defects in work and in the institutions in which we work. By constantly drawing attention to conditions which are a handicap and thwart good intentions and ambitions, a remedy may be found. Wherever efficient surgical and medical work is carried out it is better to let the splendour lie in subdued light for the moment; it is the dark and dusty corners which require illumination if perfection is to be gained. The plan of emphasising defects in the hope of improvement does not lead to popularity, but we can say of unpopularity what has been said of jealousy: " It is the tribute paid to youth for successful enterprise in thought or in action by minds which suffer from the atheroma of advancing years " (Moynihan).

FRACTURES OF THE LOWER EXTREMITY*

A Synopsis of Four Lectures delivered for the University of London at St. Bartholomew's Hospital

LECTURE I

THE views of the older writers on the subject of injuries to bones are worthy of study. In the process of our literary excavations we come across some useless débris, but here and there are found nuggets of pure gold.

In these lectures I will allude only to the management of cases of fracture of the lower extremity,† directing my remarks to those who will have to deal with them under conditions where elaborate apparatus cannot be obtained by a nod, where highly skilled consultants are not always available, and where the results of after-treatment depend largely upon the doctor himself.

FRACTURES OF THE PELVIS

General Considerations.—When I was a student, I was taught by the late Prof. E. H. Bennett—a really great authority on the subject of fractures—that extensive fractures of the pelvis were rare and that recovery seldom followed. Twenty-five years have elapsed. Under modern conditions both statements must be amended. Fractures of the pelvis have increased in frequency with the development of industrial machinery and rapid transport. The crushing injuries associated with accidents to motor-cars, aeroplanes, and the modern factory supply us in bulk with this morbid material. Nor is the former gloomy outlook justified to-day, for surgery has not lagged in the race, and injuries contemplated with awe by our predecessors are confronted without misgivings and treated with success by modern methods.

Figures given by older authorities, such as Von Bergmann, Mikulicz, and Bruns, indicate that fractures of the pelvis constitute only 0·3 per cent. of all fractures. From my own

* From the *Lancet*, Aug., 1925, *et seq.*

† The cases referred to were illustrated by lantern slides.

1

experience alone the percentage appears to be greater. To illustrate these lectures I had no difficulty in recalling seven comparatively recent cases, without going through the hospital records. It must not be taken for granted that fractures of the pelvis arise only from severe injuries. Cases have been recorded from a slight fall on the hip, and death has followed in such cases from visceral injury and peritonitis.

I have searched through the writings of the eighteenth and nineteenth centuries—Dupuytren, Hamilton, and Malgaigne, also the works of Percival Pott and Astley Cooper, and on through the writings of Erichsen, Bennett, and others, to the more modern textbooks, to find that every or any portion of the pelvis may be fractured. No single bone can be said to be immune.

In Malgaigne's classical double vertical fracture, the flanges of

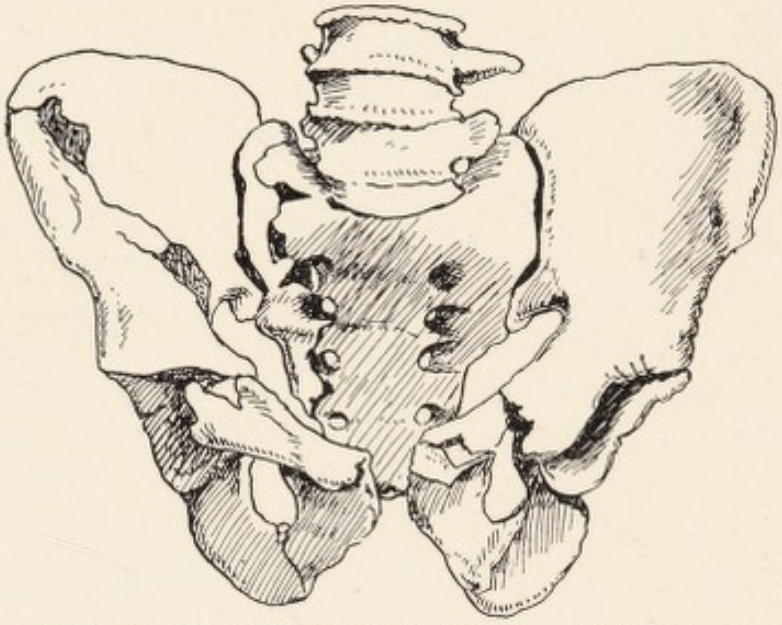

FIG. 1.—Comminuted fracture of the pelvis. (Spencer and Gask.)

the ilia are approximated, the anterior portion of the pelvic arch breaks, and posteriorly there is either separation of the sacro-iliac joint or fracture of the ilium vertically downward from the crest to the greater sciatic notch (Fig. 1). The fracture in front is often on one side and the fracture behind on the other. When one side of the pelvis is thus broken away from the rest of the bone, it and the attached lower extremity are necessarily connected with the rest of the body only by the soft parts which unite the pelvis to the spinal column and trunk. These soft parts are liable to severe stretching, laceration, and other injuries, which will be mentioned later on. The symphysis pubis or the sacro-iliac joint may be torn asunder, and, in a few cases, separation has occurred both at the symphysis and at the sacro-iliac joint. Separation of all three pelvic joints, not associated with fracture, is an injury the existence of which is doubtful, but I have seen

a case with Dr. Gibbon FitzGibbon, late Master of the Rotunda, in which there were very wide independent movements of one side of the pelvis upon the other due to laxity of the ligaments of all three joints, with no history of injury and not connected with pregnancy.

Of the isolated fractures of the pelvic bones which do not break the continuity of the pelvic ring, fracture of the acetabulum is the most interesting. I have in Mercer's Hospital at the moment a case of dorsal dislocation of the hip which, owing to a fracture of the posterior rim, slipped out of place after several reductions. The reduction was subsequently made by direct extension and swinging movements and maintained in position by fixed extension in a Thomas splint. This is one of the two common types of fractured acetabulum. The second type is illustrated in the case of a man admitted into Mercer's Hospital in 1909 after a severe injury to the hip. An impacted fracture was diagnosed, but X-ray photographs showed the head of the femur driven through the acetabulum into the pelvis.

In the first group of cases the fracture of the rim is associated with backward dislocation of the femur, and the symptoms are those of dorsal dislocation with difficulty in maintaining reduction. In the second group the head is forced into the acetabulum, causing fracture ; sometimes the head passes through the fracture into the pelvis, sometimes not. The diagnosis is, in consequence, sometimes easy and sometimes difficult. In the more severe type the trochanter is less prominent than normal, the shortening is slight or absent ; there is, of course, severe pain, and motion is restricted in every direction.

In differentiating between fracture of the acetabulum and fracture in the region of the neck of the femur, it will be remembered that in fractures of the neck from severe violence the limb lies extended and usually rotated outwards, and that impaction comminutes and makes the trochanter prominent. In fractures of the acetabulum with penetration of the head of the femur, the trochanter is much less prominent, but the difference may not be sufficient to make a diagnosis. In both conditions there is usually absolute loss of function. In most cases help may be obtained by making a rectal examination, but most surgeons will reserve judgment until an X-ray photograph has been obtained.

In the one case of central dislocation through the acetabulum into the pelvis which I have seen, reduction was impossible, but a fairly good functional result followed. The man, on leaving hospital, was able to continue his occupation as a hackney car driver.

Amongst the seven cases to which I have referred is one of

isolated fracture of the sacrum and fracture of the coccyx in a child of 12. She fell from a swing on her sacral region. The interest in this particular case was the absence of symptoms except for some local pain. The patient was brought in casually for examination three weeks after the injury. An X-ray photograph showed a transverse fracture of the sacrum between the third and fourth segments without displacement. She was seen four years later and had no pain or trouble of any kind.

When displacement of the fragments occurs in such a case the injury is extremely painful and some of the sacral nerves are likely to be involved. There may be also interference with defæcation and urination in some cases due directly to the displacement of the fragments, in other cases to paralysis following injury to the sacral nerves. The displacement of the fragments can be felt per rectum, and under an anæsthetic the alignment can sometimes be restored. Fractures of the sacrum alone are very rare.

Fractures of the coccyx, owing to the mobility of the bones, are also extremely rare, and are of importance owing to the probability of subsequent coccydynia, necessitating removal of the bone. Fractures of the ilium are not uncommon. They involve the upper expanded portion, including the crest, and cases are reported in which the anterior superior and inferior, and posterior spines have been torn away by muscular action. With the body bent forward and the thighs flexed upon the pelvis, there is sufficient muscular relaxation to detect a fracture, and a good X-ray picture can be obtained by placing the injured side upon the plate and passing the rays obliquely from before backwards. In treating these fractures care must be taken not to press the fractured portion of the ilium unduly inwards.

Isolated fractures of the ischium are extremely rare. Many standard authorities are silent upon this subject. Bennett* described a case in which the ischium was detached from the left innominate bone by fracture with displacement backwards and upwards. The great sciatic notch in this case was reduced to a mere slit, and the displaced bone was united to the side of the sacrum. The head of the femur participated in the displacement (see page 18).

Treatment.—The treatment of fractured pelvis resolves itself into treatment of the injured soft parts and of the fractured bones.

Injury to the Urethra, Bladder, and Soft Tissues

The urethra and bladder are the organs which suffer most frequently and, as compared with these, injuries to other parts

* *Trans. R.A.M.* in Ireland, 1887.

are of little practical importance. The rectum and vagina may be injured, or the large veins of the pelvis may be torn—an accident rapidly followed by death. In a case recorded by Bell and Fischer a diffuse traumatic aneurysm of the gluteal artery developed after fracture of the pelvis. Bryant reported three cases in which thrombosis of the external iliac artery followed a fracture of the pelvis. This was due to over-stretching of the artery by the displaced fragments. The internal and middle coats had been torn, the external coat remained intact. In one of these cases gangrene of the leg developed.

Large extravasations of blood after injury to the pelvis may undergo suppuration. The sciatic and obturator nerve may be crushed, with subsequent prolonged and intractable neuralgia. It is, however, the complication of rupture of the bladder and rupture of the urethra, or of both, which is of most practical importance and requires urgent attention. If such complications are recognised without delay and treated along rational lines, the immediate and ultimate results are not at all so depressing as many would have us believe.

Rupture of the Bladder.—Rupture of the bladder may follow injury apart altogether from fractures of the pelvis, or the rupture may be associated with fracture of the pelvis without being actually produced by the broken bones. The site of the lesion may be either above or below the peritoneal reflection. If below, the tear is on the anterior surface, either in an accessible position or out of reach low down in the neighbourhood of the trigone. If the rupture is intra-peritoneal, it is placed more often on the fundus of the bladder or posteriorly. According to the position, the urine either escapes into the space of Retzius and percolates towards the anterior abdominal wall, or it is freely extravasated into the peritoneal cavity.

In the surgical works of Spencer and Gask, to which I am indebted for much information on the subjects under review, it is stated that wherever stale urine spreads it produces inflammation and sloughing. This statement applies, however, as is made clear in the text, to the more familiar types of extravasation following the ulceration and rupture of the urethra behind an old-standing stricture. The urine under such circumstances is foul and infected. On the other hand, the onset of peritonitis, cellulitis, and suppuration, with accompanying rigors, rise of temperature, and general symptoms of toxæmia, may be delayed for a period of even two or three days in cases of leakage from the urinary bladder containing healthy urine.

A case came under my care in a casualty clearing station in France, in August 1916. The patient had fallen from the roof of

a house, fractured his jaw and both forearms, and, so far as it was possible to ascertain, had sustained some fracture in the region of the pubes. He had abdominal tenderness, and made ineffectual attempts to pass water. Ruptured bladder was diagnosed, but on passing a catheter a full quantity of urine was withdrawn and it contained blood. The amount withdrawn appeared to us to justify delay. The abdomen became more rigid in a few hours, but his pulse remained between 80 and 90, and there was no vomiting nor rise of temperature. The inability to urinate continued, and a catheter was passed every four hours. Blood was present only on the first occasion, and urine was withdrawn at every catheterisation in moderate quantity. The patient's aspect became gradually worse. Rigidity was more marked, vomiting had commenced, and early signs of peritonitis became evident.

When I operated upon this patient 24 hours after admission a large rent was found on the fundus of the bladder, and the abdomen was full of urine without odour. The rent was stitched and the abdomen closed without drainage. A catheter was passed while the abdomen was still open, and it became obvious that on each occasion the catheter had gone through the rent in the bladder and the urine had been drawn from the peritoneal cavity. The first diagnosis on admission had been correct, but the result of catheterisation was so confusing that there was uncertainty and delay. Notwithstanding the multiple injuries and the lapse of 24 hours before operation, the patient did well.

The diagnosis of ruptured bladder is not as a rule difficult. There is always a strong but ineffectual desire to urinate. A catheter passes freely through the urethra, but only small quantities of blood-stained urine return. To make a diagnosis, some authorities suggest that a measured quantity of fluid should be injected and the quantity returned carefully noted and checked. The disadvantages of such a procedure are obvious. If the injected fluid leaks through a rupture into the peritoneal cavity the desired information is obtained, but the shock from which the patient suffers becomes more pronounced. On the other hand it may have passed through an extra-peritoneal rupture into the space of Retzius and return without appreciable diminution of quantity. Under such circumstances the surgeon is misled.

With an inability to void urine, associated with the free passage of a catheter and the return of only small quantities mixed with fresh blood, the case is one for immediate operation. The differential diagnosis between intra- and extra-peritoneal rupture is difficult in the presence of shock, tenderness, and rigidity, but the treatment is the same. Some suggest that the first exploration should be above the pubes, below the peritoneal reflection, but I agree with Keyes, who recommends the peritoneum to be opened in the first instance. The intra-peritoneal

rupture is more common, and, furthermore, in dealing with extra-peritoneal injury in the presence of blood and extravasated urine and an empty bladder, sufficient room can scarcely be obtained by the usual extra-peritoneal suprapubic route.

If the abdominal cavity is found to contain urine and blood, it is syphoned off through the simple aspirator (Fig. 2) now used largely for the withdrawal of accumulations of fluid of any origin, and the rent in the bladder is closed and covered, if possible, by a piece of omentum. A small corrugated rubber drain is passed to the line of suture. A self-retaining rubber catheter is introduced per urethram. In some of the earlier cases described by Walsham death followed operation owing to leakage at the point of suture, and on this account some recommend

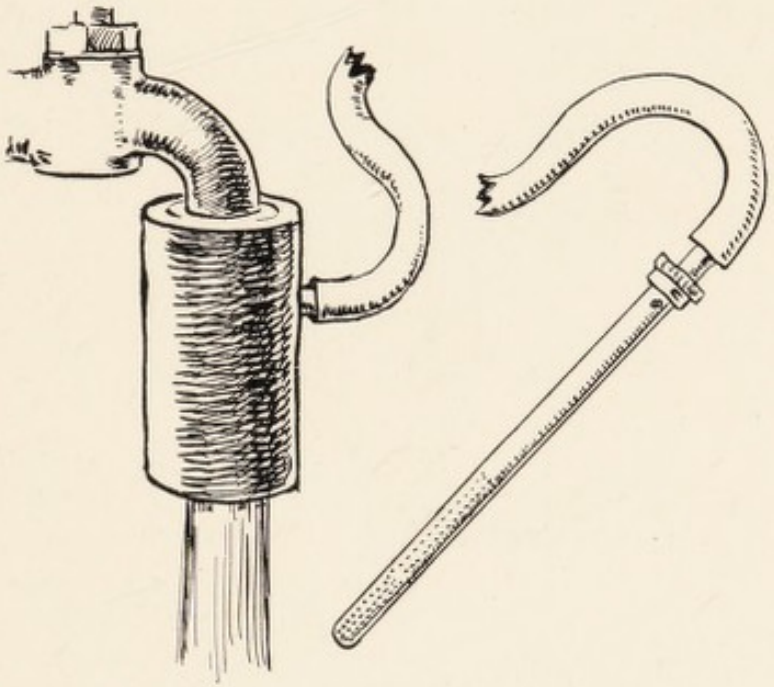

FIG. 2.—Aspirating pump attached to water tap.

that fluid should be injected through the urethra to make sure of a water-tight closure while the abdomen is still open. I think such a procedure adds to the time and leads to confusion during operation, and that the use of a self-retaining catheter is a sufficient safeguard. If, on the other hand, it is found that the rupture is not into the peritoneum the abdominal contents are packed away, and the injury usually will be found on the anterior surface of the bare area of the bladder and should be sutured in the ordinary way. A tongue-shaped portion of omentum (Fig. 3) pulled through the line of peritoneal reflection is laid flat over the surface to secure a firmer union. The space of Retzius is drained and a self-retaining catheter introduced.

In certain cases where the rent is inaccessible for accurate

suture and where bleeding has been free, suprapubic drainage with a tube in the bladder is the operation of choice.

Rupture of the Urethra.—I will give two examples of recent cases of fractured pelvis brought about by a horse rearing and falling backwards on the rider, in which the urethra was ruptured. They illustrate the difficulties of treatment under one set of circumstances and the satisfactory outcome and ease of operation when conditions are favourable.

In the first case the patient, aged about 28, was injured in the manner indicated above early in September 1921. He was seen late at night in the country, after an accident in the early morning. He had been making intense but ineffectual efforts to pass water, and there was consequent extravasation. It was impossible to pass a catheter beyond the region of the triangular ligament. Urine and blood were penetrating into the perineum, scrotum, and from the space of Retzius

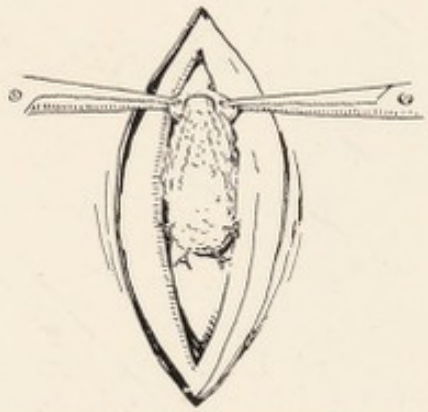

FIG. 3.—Opening in bladder covered by omentum.

forwards towards the anterior abdominal wall. Both layers of the triangular ligament were apparently torn.

The operation was of the emergency variety. The bladder was opened above the pubis and drained, and free incisions were made into the infiltrated tissues of the perineum. After ten days the patient was brought to Dublin, and an X-ray photograph showed a double vertical fracture involving both rami of the pubes on one side and the region of the sacro-iliac joint on the other. The acetabulum was involved, a complication which subsequently led to bony ankylosis of the hip. Eleven days after the accident, in the presence of many drainage incisions, a successful attempt at secondary suture of the urethra was performed by a colleague, who kindly took charge of the patient during my unavoidable absence from Dublin.

An operation after such a lapse of time and in the presence of infection is often very difficult and unsatisfactory, and is followed usually by traumatic stricture. The hip-joint, which was involved by the fracture became infected, a condition which added considerably to our difficulties. Extension and abduction were employed until the patient was discharged from hospital five months after admission.

It was necessary to pass sounds frequently, generally under an

anæsthetic, for nearly two years. Four weeks ago I received the following letter from this patient. He had failed to report regularly for over a year: "Sounds were last passed on me on October 8, 1923 (two years after the injury), and the last abscess was opened in November 1923. Since then I have had nothing done, and have been very well indeed. I cannot yet manage to ride, but find every time I try I can manage better. There is a great strain when my legs are across a horse. I play a fair amount of golf and dance a bit, and I have great hopes of riding again some day." From this letter it would appear that the ankylosed hip is the main disability. It is a satisfactory report three and a half years after so serious an injury treated primarily under most unfavourable conditions.

The second case arrived in hospital a few hours after his accident, and illustrates the happy results which follow when surgical interference is early and when ideal treatment is possible.

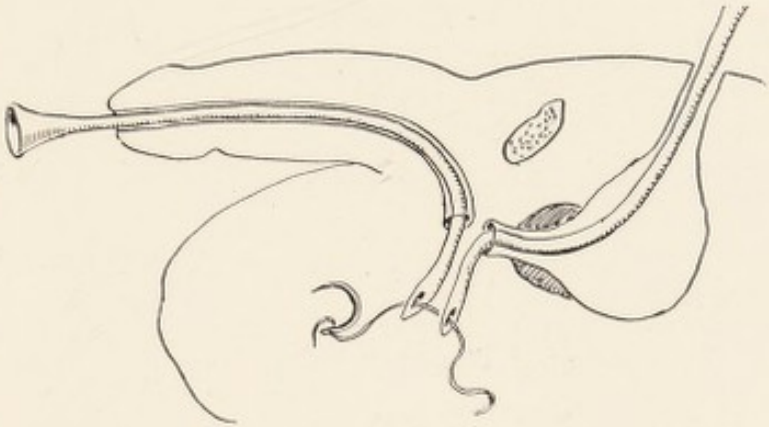

FIG. 4.—Catheters passed and made to point in perineum. (The eyed instrument passed in retrograde fashion should be metal.)

A young officer fell with his horse on top of him while hunting. The pubes appeared to be pulled apart, and X-rays showed a stellate fracture along one margin of the joint. Again, there were all the signs of urethral rupture—a great but ineffectual desire to urinate, a desire which his medical practitioner in the first instance wisely warned him to curb. Efforts to pass a catheter completely failed.

The line of treatment adopted is the line I would recommend in cases seen early. Instead of opening up the perineum through infiltrated and bruised tissues in search of the proximal end of the urethra, it is best, I think, to open the bladder in the first instance, and to pass a metal catheter or eyed probe in retrograde fashion down through the proximal portion of the tear. An assistant holds this instrument while the end of it is exposed through a perineal incision. A rubber catheter is now passed through the penile portion, and the eye is attached by a silk thread to the instrument passing from the bladder. The bladder instrument is withdrawn, pulling with it the rubber catheter, the eye of which now appears through the suprapubic wound. The urethra is then accurately sutured end to end with the rubber catheter as a guide (Figs. 4 and 5). A good headlight is essential for accurate work. The perineal wound is cleansed, preferably with some of the chlorine preparations (such as "Fecto") or treated with bipp. It is then

sutured closely, a small superficial rubber drain being left in situ. A long fixation thread is attached to the point of the catheter coming through the suprapubic opening and then the catheter is gently manœuvred into the lumen of the bladder by a pull on the penile end. This thread may be conveniently tied to one of the skin sutures to prevent the catheter slipping out. The bladder is drained by a small suprapubic tube. At the end of four or five days a fresh catheter is attached by a stitch to the meatal end of the one already in position, and by pulling on the suprapubic thread the new catheter takes the place of the old. This process can be repeated for a fortnight, when a catheter is passed in the ordinary manner and the suprapubic wound allowed to close.

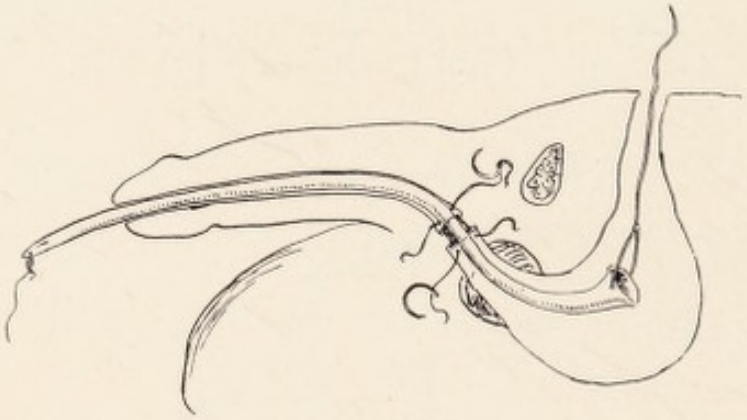

FIG. 5.—Urethra sutured with catheter as a guide. Note the thread coming through suprapubic wound. (The ends of the catheter are reversed in error.)

The patient so treated was admitted to hospital in January 1924. He was up and about at the end of five weeks, and left hospital six weeks and two days after admission. On a few occasions afterwards an instrument was passed without difficulty, and he rejoined his regiment apparently well.

A third case of ruptured urethra from falling straddle-legs across a beam was treated in December 1925 in the same manner, with the same satisfactory results. The convalescence was retarded by transient pulmonary embolism. The perineal wound healed per primam and there was no difficulty in passing a full-sized sound.

FRACTURE OF THE PELVIS WITHOUT DISTINCTIVE SIGNS AND NO COMPLICATIONS

The third illustrative case shows a double vertical fracture in a lady who was in a motor-car when it overturned, and who had apparently no injury to the soft parts beyond bruising and ecchymosis. At the first examination she stated she felt bruised and sore, and had some pain in her back. Movements of her

knees and hip-joints did not cause pain; no shortening could be found. The crests of the ilia were in normal position; pressing them inwards caused no special pain. Rectal examination revealed nothing and I came to the erroneous conclusion, in agreement with the local doctor, that there was no gross bony injury. An X-ray examination was made as part of the routine examination, and a fracture was found on the left side, splitting the ilium from the lower angle of the sacro-iliac joint to about the middle of the crest (Fig. 6). The pubic arch on the right side was broken above and below the obturator foramen. The patient was kept in bed for six weeks, and after two months was

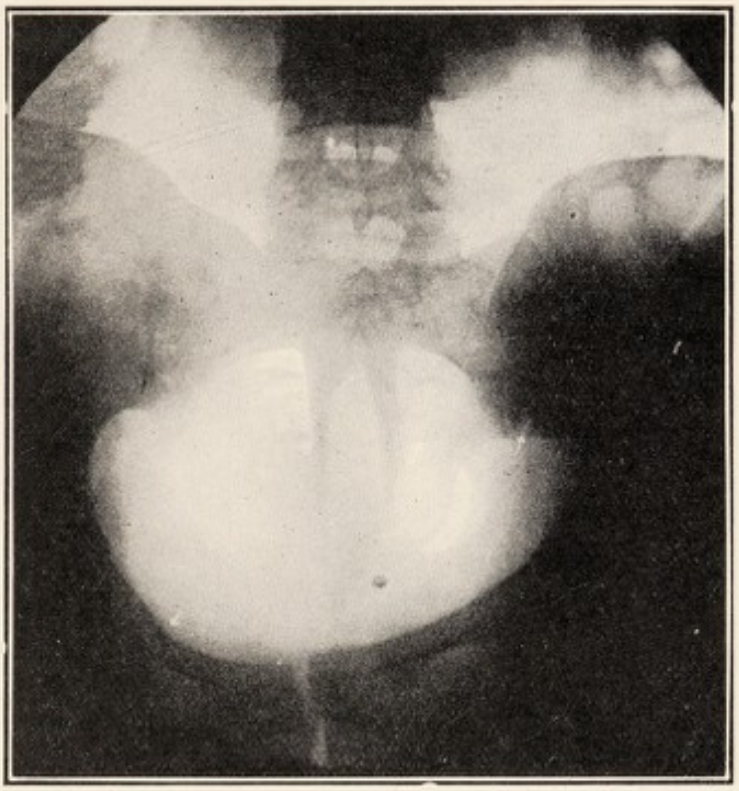

FIG. 6.—Double vertical Fracture in which there were no indications of bony injury before radiograph was taken.

able to move about apparently well. She wrote to me as follows:

"I am glad to say I feel absolutely no ill-effects in any way. I am not the slightest bit lame, and can dance all night; I have danced four nights this week into the early hours of the morning. I had not ridden for eight years, and rode for the first time recently, and went for a short gallop about a mile, and never felt anything. In fact, I can do anything I ever did before."

TREATMENT OF FRACTURED PELVIS APART FROM COMPLICATIONS

When a double vertical fracture exists, or when the bones are much comminuted, some effort must be made (1) to reduce

displacements, (2) to give stability to the fragments, and (3) to assist nursing.

The muscles attached to the broken bones can be relaxed to some extent by flexing the leg at the hip and at the knee. Both legs should be slung in Thomas splints in this position. (The splints in the illustrations should be shown bent at the knee.) A girth or strong bandage is strapped tightly round the pelvis between the trochanter and the ilium. Strong cords are attached to a ring on each side of the girth (Figs. 7 and 8) and passed over

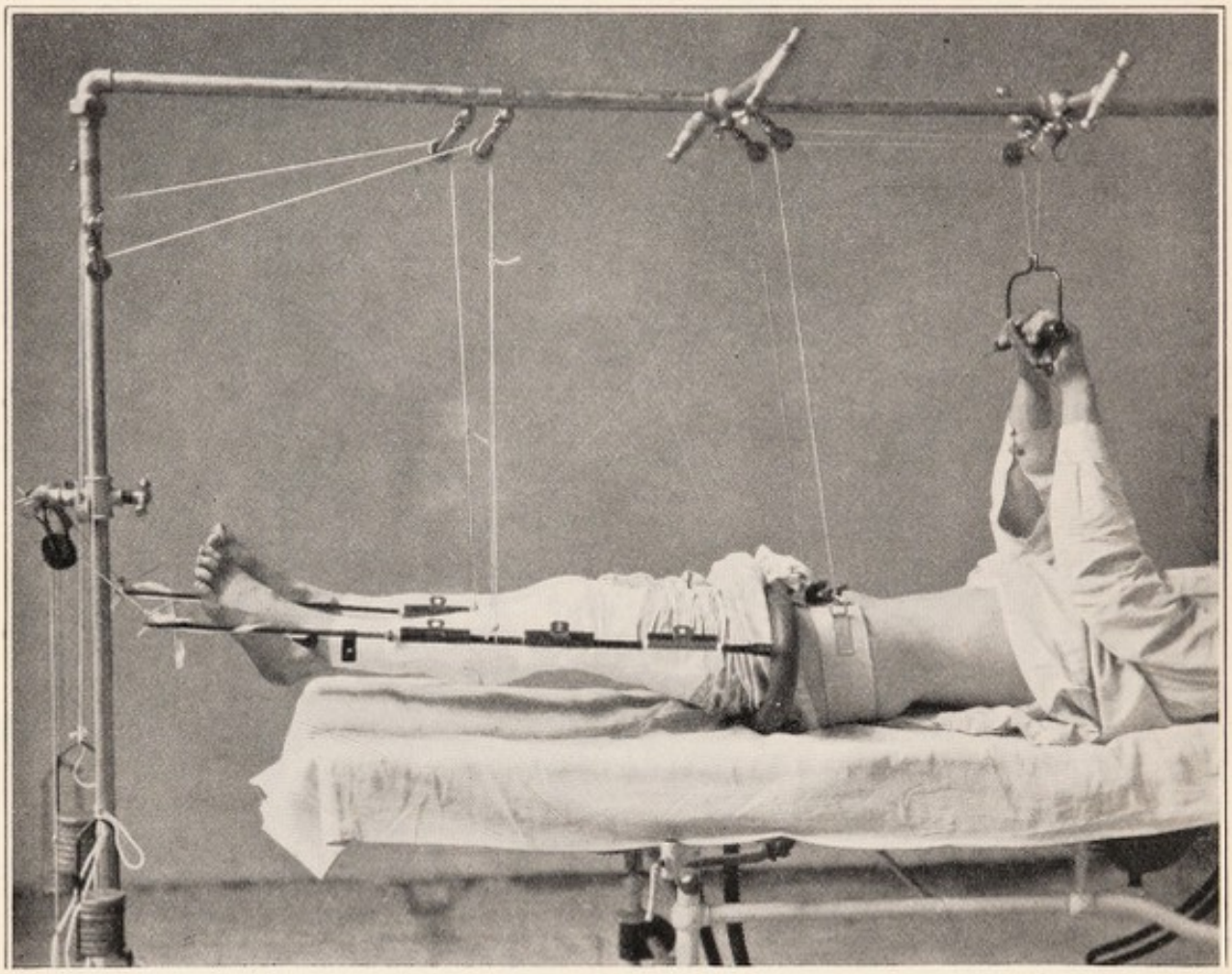

FIG. 7.—Convenient arrangement for treatment of pelvic fractures.

pulleys towards the head of the bed, where they are connected to a handle which the patient grasps when changing position. The raising of the pelvis for nursing purposes is thus rendered easy. If one side is displaced upwards, extension is applied to the corresponding leg by weight and pulley. As an alternative the double Thomas frame, as recommended by Jones, leaves little to be desired.

Isolated fractures of the pelvis must be treated intelligently. In the case of fracture of the posterior rim of the acetabulum, the dislocated hip, as already stated, can be easily reduced by direct

extension with the patient lying on the floor under an anæsthetic. Extension can be maintained, and recurrence of the dislocation prevented, by the application of a Thomas splint with fixed extension. Cases have been described where a central dislocation of the hip with fracture of the acetabulum have been successfully reduced and treated. No routine manipulation can be described. Ordinary traction in the long axis of the limb and slight abduction may succeed. Lateral traction is indicated, but if the head has perforated the pelvis it will be necessary forcibly to disengage it from the encircling acetabulum before lateral traction will become effective.

In the rare case of fractured ischium, which involves the

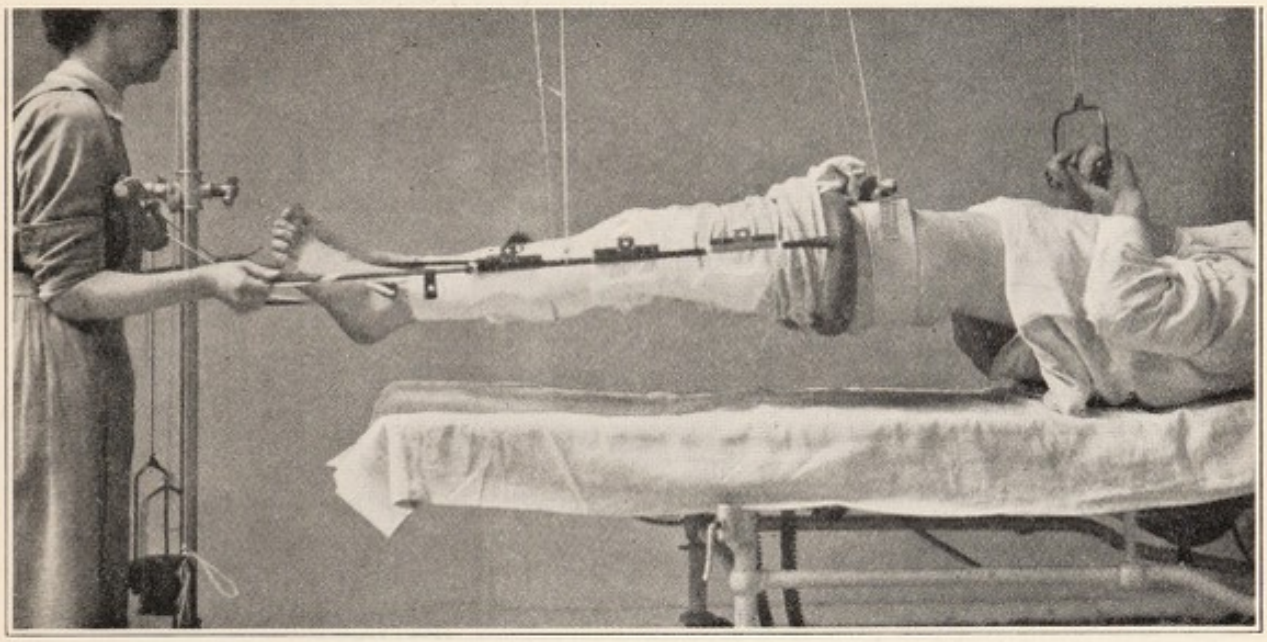

FIG. 8.—Patient raised by his own aid for nursing purposes.

acetabulum and in which the head of the bone is drawn towards the sacrum, obliterating the sciatic notch, heavy weight and pulley extension seems the obvious remedy.

LECTURE II

FRACTURES OF THE NECK OF THE FEMUR (HISTORICAL)

Astley Cooper, whose investigations are so imposing in the history of the surgery of bones, explicitly states that in all cases of transverse fracture of the neck of the femur which he has had the opportunity of examining, he has never seen one in which there was union by bone. "The dissections which I have

made," says this illustrious surgeon, "have convinced me that fracture of the neck of the femur, when it is situated within the capsule, is never united by bone. The union is solely effected by means of ligamentous substance, as in fracture of the patella." "This celebrated surgeon," says Dupuytren, "has since modified his opinion, as we find him remarking that, as a general rule, fracture of the neck of the femur within the capsule is united by ligament and not by bone, as in the case of the olecranon and the patella, but that it would be a rash assertion to deny the possibility of ossific union, and to maintain that the general rule laid down admits of no exception."

This was more or less the teaching up to our own time. Fifteen years ago I treated an aunt of my own, aged 70, in a plaster case with abduction and internal rotation, and obtained bony union.

One of the first statements made by Dupuytren, in an essay on fractures of the femur, is that he never saw a fracture of the neck of the femur in a child. We know now this injury is not uncommon, and after such a statement we wonder whether it is worth while referring back to authorities of the pre-X-ray era. The reason I do so is this—that credit must be given to Dupuytren for anticipating to some extent the modern work of Whitman, Jones, and some other authorities for whom we all have such deep respect.

Dupuytren points to specimens in the Museum of the Faculty of Paris and of the Hôtel-Dieu, where numerous examples of intracapsular fractures united by bone are to be found, and states that he regarded osseous union of intracapsular fracture of the neck of the thigh bone as demonstrated beyond doubt. He disproves and discounts all arguments advanced at the time against the possibility of bony union. He denied that the upper fragment was devoid of sufficient blood-supply, and showed that the vessels passing to the head via the ligamentum teres were sufficient. The importance of the ligamentum teres in preserving the viability of the head of the femur has been established beyond doubt by Bonn.* Dupuytren showed that the neck of the femur is not devoid of periosteum, as stated by some contemporaries, and that the bathing of the fragments in synovial fluid could not be a determining factor in connection with non-union, as it does not affect the union of fractures into other joints.

But then comes this significant statement. "The fact is, that the great difficulty lies in the perfect and accurate adjustment and relation of the fractured ends of the bone," and he insinuates that if this can be accomplished bony union may be expected. He was a shrewd observer, for he realised that union

* *Arch. f. klin. Chir.*, 1924.

in this situation must be slow, and suggests as an axiom that fractures of the neck of any bone should be kept at rest twice as long as ordinary fractures of the same bone, and even after that period displacement might occur.

He does not seem to have realised the full importance of abduction, but his description of the reduction of a fracture indicates that he was not oblivious to its significance. He describes his procedure thus : " The patient being placed on his back, and the pelvis being fixed by assistants, I bend the thigh on the belly by raising it, and then gently draw it from the body, the knee being at the same time flexed. This is immediately followed, without difficulty or the employment of violence, by the limb resuming its natural length and the foot its normal direction." By flexion he relaxed the abductors which produce eversion of the foot, and the glutei and others which draw upwards the shaft of the bone. He adopted the principle of Percival Pott, who introduced the flexed position of limbs in the treatment of fractures generally. He designed a double inclined plane splint, the thigh being fixed at nearly a right angle to the pelvis and the leg forming a similar angle with the thigh. He says by this method union takes place without shortening, and quotes some convincing cases.

Although abduction is the essential feature in the treatment of fractures of the femoral neck, the arguments of Dupuytren in favour of the double inclined plane are impressive. His reasoning is so persuasive that I wonder why this old method fell early into disuse and was supplanted by so unsatisfactory a treatment as weight-and-pulley extension. If I have anything to be proud of in the treatment of fractures over the last 20 years, it is this—I have never used a long Liston splint, and I have never treated a fracture of the neck of the femur by Buck's extension.

It is interesting to note that in 1921 Moore contributed an article in the *Boston Medical and Surgical Journal* recommending that the fracture be reduced under an anæsthetic, and the leg put up in right-angle flexion of both hip and knee in a plaster cast. In this way the patient can sit up and be moved about in a wheeled chair from the very first. Out of 42 cases so treated by this method, the average age of the patients being 65 years, 60 per cent. gave a good result.

If the thigh is flexed at right angles with the abdomen and the knee at the same angle with the thigh, the relaxation of the muscles tends to prevent shortening, and any progressive power of contractility which follows after this position is assumed cannot assert the direct pull which produces shortening when the limb is extended. Flexion of the leg corrects eversion of the foot, as

was pointed out by Dupuytren in 1846, and again in an excellent paper by Russell as recently as January 1924, in which he says: "That upward lifting of the bent knee is the natural way of inverting the limb when we wish to correct eversion. Instinctively we first bend the knee and then lift it upwards. The practical fact is that eversion gives no trouble."

Treatment

Fractures of the Neck of the Femur in Children.—First importance attaches to the partial fracture-separation of the epiphysis of the head of the femur. The condition is most often found in or about puberty, more often in boys than in girls. It may arise out of some comparatively trivial and forgotten trauma. Any displacement which occurs may be gradual, the diaphysis yielding in an upward direction and becoming gradually rotated outwards in relation to the head. Solid union takes place, leaving behind a traumatic coxa vara.

It is a difficult injury to diagnose early, even with the help of X-rays, and Sir Robert Jones says it is the most often overlooked of all hip injuries, even by extremely good surgeons. It is suspected when rotatory movements are extremely painful, and when abduction beyond a short range is impossible. There is, at first, no shortening, and the symptoms disappear with rest, but later on, when activities are resumed, shortening occurs, and separation of the epiphysis, partial or complete, will be then recognised. In contrast to this, there may be a complete separation of the epiphysis, a fracture through the neck, or a fracture involving both neck and epiphysis.

Whitman calls special attention to fracture of the neck of the femur in children. The fracture occurs after traumatism to the hip, probably more frequently than separation of the upper epiphysis. It is generally impacted or of the greenstick variety, but the signs and symptoms are much the same. The immediate results are good, but yielding at the point of fracture will produce a coxa vara if the limb is not protected from weight-bearing for many months by a calliper splint. The immediate treatment, whatever the position of the fracture may be, is the same as in adults. Shortening and eversion must be reduced, with subsequent fixation in the position of abduction.

To obtain reduction; flexion and inward rotation followed by traction and abduction, or abduction alone, are required. Seven cases of ununited fracture of the femur in early life are mentioned by Whitman, to prove that non-union may follow this injury in childhood if the treatment is inefficient. Thus he shows that

non-union is not accounted for by deficiency of blood-supply, nor by advancing years, but by inefficient treatment. Plaster-of-Paris fixation is the best, and after six or eight weeks the child may be allowed to walk on a calliper splint for two or three months. If the fracture is diagnosed early and no displacement has occurred, a short period of rest followed by ambulatory treatment with a calliper splint is sufficient.

Fractures of the Neck of the Femur in Adults.—I do not think, from the point of view of treatment, that it is necessary to say more than this—that if, in a strong adult, a fracture is impacted, and there is more than half an inch shortening with marked eversion of the foot, the impaction should be forcibly broken under an anæsthetic, the deformity reduced, and the treatment carried on as in unimpacted cases. Rotation outwards of the foot matters much more than a little shortening. If the foot is in good position and the shortening is inconsiderable, then it is not necessary to disimpact. If there is impaction in an old person, all the circumstances must be carefully weighed before the impaction is broken down to reduce moderate deformity; but it must be remembered that the so-called impacted fracture from indirect violence in elderly people is very incomplete, and functional disability will certainly follow weight-bearing in the absence of proper reduction. A decision must be made as to whether, in an exceptional case, the risk of reduction and fixation, is too great. Under such circumstances, crippling, non-union, and deformity must be the result, mitigated to some extent if a calliper splint can be worn.

The object of treatment of this, as of all fractures, is to restore the symmetry of the broken bone, thus eliminating the primary cause of non-union, deformity, and loss of function. Henderson states that of 120 cases of ununited fracture of the hip seen at the Mayo Clinic, not one had received proper treatment at the time of the injury.

The modern treatment can be summarised in one sentence—reduction of the deformity and fixation in the abducted position. Whitman deserves due credit for insisting upon these conditions. Abduction is checked by tension on the capsule, by contact of the upper border of the neck with the rim of the acetabulum, and of the great trochanter with the side of the pelvis. In abduction the neck of the femur is normally in a horizontal position. In fracture of the neck the fractured end of the proximal fragment points laterally, and it is only by bringing the distal end of the neck into a horizontal position that accurate apposition of the fragments can be made. Not only are the fragments brought into apposition by full abduction of the leg, but the tight capsule

provides for direct mutual pressure of the fractured surfaces, and acts as an efficient splint. The trochanter being in contact with the pelvis, any muscular effort likely to displace the fragment is impotent, and fixation is complete.

If absorption of the neck and shortening and stiffening in the movements of the hip result after the abduction treatment, the tilt downwards of the pelvis on the affected side, in order to bring the two legs parallel for locomotion, will correct the shortening. If adduction follows treatment of an injury to the hip, the reverse is, of course, the case. The abduction treatment is now the standardised routine. To encourage us further, Whitman points out that the fracture in the aged is usually at the base of the neck, and that the central fracture is more common in the young

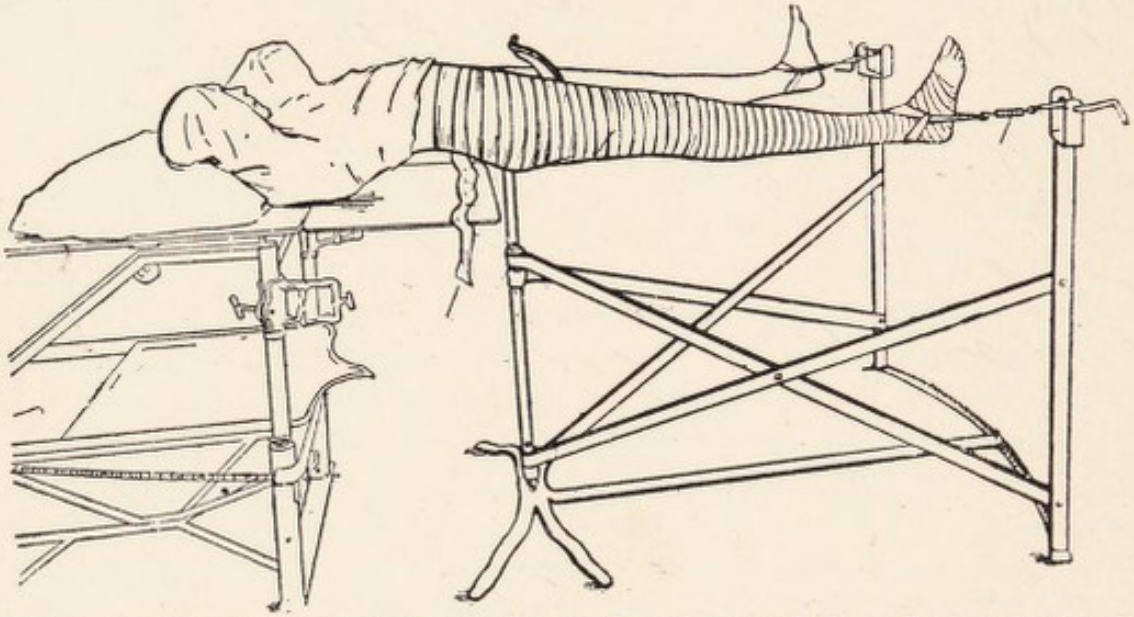

FIG. 9.—Patient with both limbs abducted and extended ready for the application of a plaster cast. The sling flexing the knee and thigh is omitted for clearness. The clove-hitch should not be applied until the foot is in plaster

and the vigorous: the reverse of what was formerly believed. Bearing this in mind, and also that fractures elsewhere unite readily in aged subjects, we have every ground for optimism when considering the prognosis in these cases.

It may be confidently predicted that the immediate and efficient treatment of fractures of the neck of the femur by the abduction method will be followed, in most instances, by repair. If union fails when accurate apposition of the fractured surfaces has been maintained for a sufficient time—as confirmed by X-ray examinations—it indicates a low vitality in the tissues, and Whitman advises in such cases a reconstruction operation which will be mentioned later.

In 1905 * I designed an apparatus for the reduction of fractures of the lower extremity which resisted manual traction, and in the

* *Medical Press and Circular*, March 8, 1905.

absence of one of the more perfect tables of the Hawley type, I still find it useful. The original cost was £2 10s. (Fig. 9.)

The apparatus consists simply of two iron gates, about $4\frac{1}{4}$ ft. long, swung on an upright which carries a perineal bar, attached to which is a small support for the sacrum of the patient which is included in the plaster, but afterwards removed. This pelvic support and the upright on which it sits are supported by a heavy stand. On the distal ends of the gates are rollers, square on section, in order to obtain a firm hold on the cords or bandages when extension is being applied. By pushing the handle inwards the square bar fits into a hole of the same shape and diameter, and so locks. This is a simple substitute for a ratchet. Fixed to the stand, and running at right angles to it along the floor between the two gates, is a bar, and the distance of the gates from this bar indicates the exact amount of abduction and enables plaster to be applied with both legs spread from the pelvis at equal angles. In this way there can be no obliquity of the pelvis. If it is desired to note the exact amount of extension required to hold the fracture reduced two Salter's sportsmen's balances, registering at least 50 lb., are necessary additions.

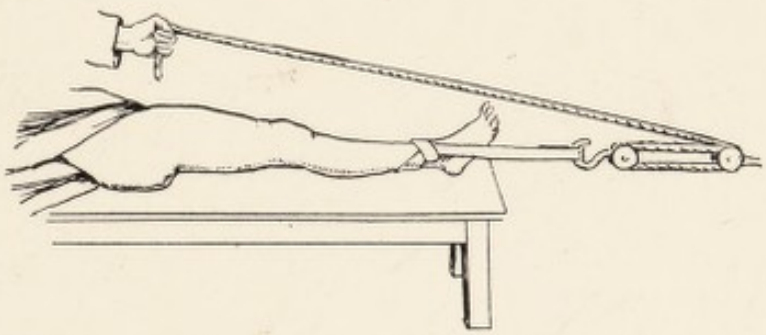

FIG. 10.—Block-and-tackle extension. (Jones.)

I have found the apparatus useful in recent cases of fractured femur in any position where shortening could not be reduced with ease, and in the treatment of malunited fractures. It provides a substitute for the block-and-tackle pulley arrangement as a means of reducing the overlapping and shortening in the latter group, and it facilitates the application of plaster of Paris when employed during the treatment (Figs. 9 and 10).

Reduction of an Intracapsular Fracture of the Neck of the Femur and Fixation by Plaster.—The patient is anæsthetised. The gates are brought to the end of the table, and the patient is put astride the padded perineal crutch. Manual traction and manipulation is usually sufficient for reduction, but by attaching the foot to the end of the gate, extension and abduction are readily obtained, and the application of the plaster of Paris rendered very simple.

It is best to apply the plaster to the foot and lower third of the leg in the first instance, and when this has set a clove-hitch or a wet skein of wool, passed round the ankle and over the foot in figure-of-eight fashion—as recommended by Watson Cheyne—is connected with

the ratchet. These connections may be incorporated in the plaster bandages before the extension is released. Or, alternatively, a steel pin is passed in front of the tendo Achillis in contact with the os calcis to act as a connecting link between the foot and the ratchet. The steel pin is removed when the plaster casing is complete (Fig. 27).

The limb on the sound side is held abducted to the normal limit by an assistant who stands at the end of the gate, or it may be attached to the rachet by a clove-hitch. The surgeon notes the normal range of abduction on the uninjured side. The knee and the thigh are kept slightly flexed by a sling under the knee from the upright bar which is attached to the gate. (See Fig. 16.) This flexion corrects the inversion of the foot. The injured leg is extended by tightening the ratchet, slowly abducted by moving the gate, and rotated inwards with

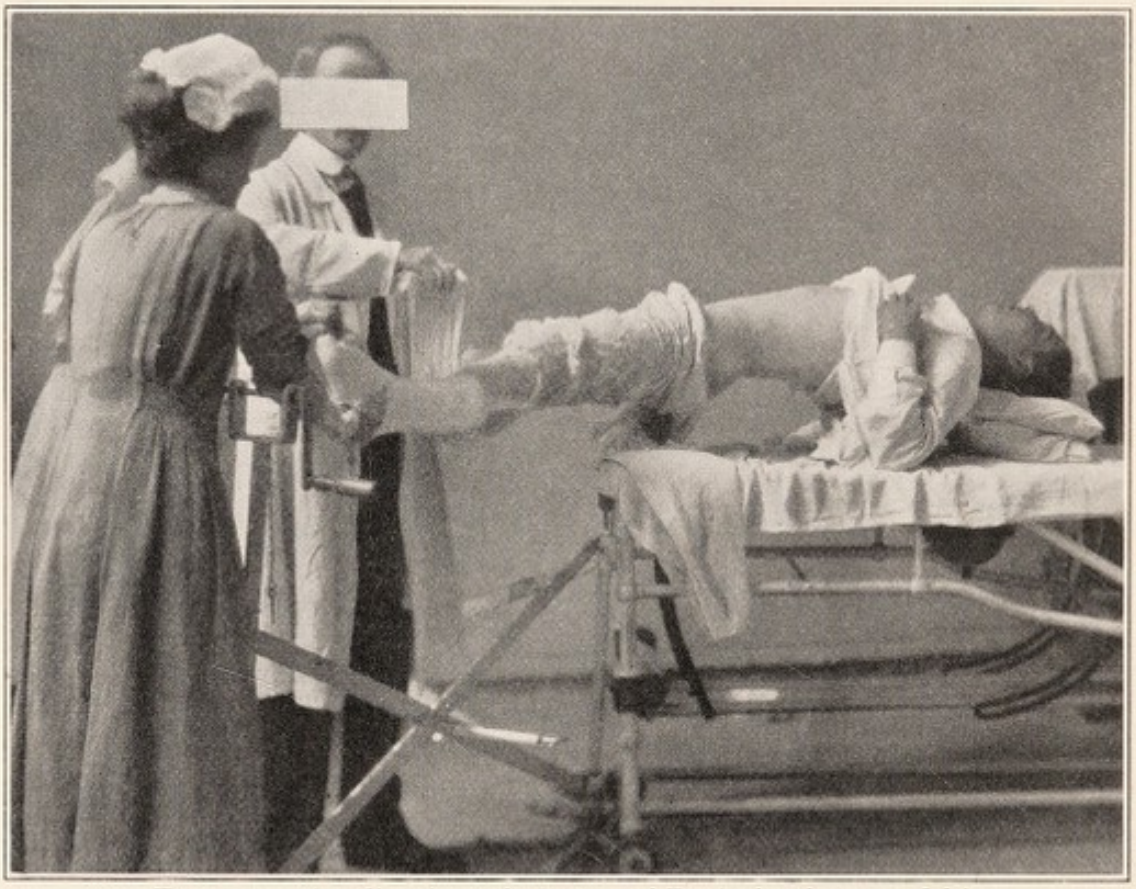

FIG. 11.—Application of plaster of Paris for fractured hip.
(For clearness the wool padding round the pelvis and lower portion of the chest is omitted.)

the hands. The surgeon or an assistant supports the joint and presses the trochanter gently downwards. The neck of the bone is first felt to hitch on the upper border of the acetabulum, but this obstacle is easily overcome. Abduction is continued until the normal range is obtained. The trochanter rests against the side of the ilium, and the anatomical relationship between the shaft and the neck of the femur is now restored. The limb is in the Whitman attitude of extension, complete abduction, and slight inward rotation. Plaster of Paris is rolled on with great facility, with the aid of this apparatus. The plaster is allowed to dry with the patient still in position on the gates (Fig. 11).

In the ward the head of the bed is raised one or two feet, an inclination the reverse of that required for traction. It is more comfortable,

and Whitman thinks that the influence of this position on the blood-supply makes the chances of repair more favourable.

The completed spica (Fig. 12) is retained in position for from 8 to 12 weeks, and several more weeks are spent in bed for treatment with massage and the restoration of movements in the joints. Weight-bearing is not permitted until the movement of the joints are free and painless, and X-ray photographs indicate the stability of repair.

Jones treats these cases on his abduction frame slightly modified (Fig. 13).

Waldenstroem * says there is a marked difference between the results obtained when the fracture is held by a plaster cast and when it is held by extension. When a plaster cast was used, out of 15 cases 11 gave good results, 8 with bony union. In

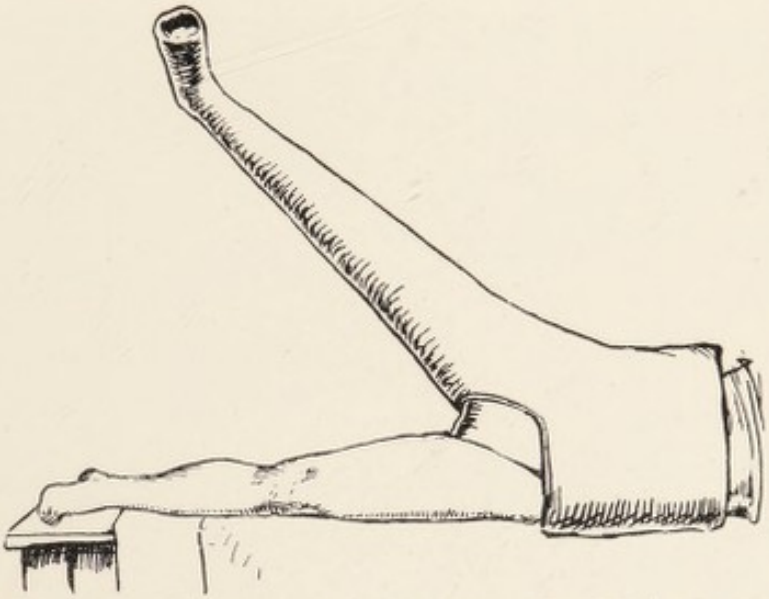

FIG. 12.—Completed plaster case (after Whitman).

13 cases treated by extension methods there were three good results. Bony union resulted in two.

The treatment of fractures of the neck of the femur may be summarised as follows :—

1. In all subjects, of whatever age, reposition of the fragments should be attempted, unless the patient is too frail for treatment, and then the fracture must be neglected. Sometimes, but not often, such a patient can endure walking on a calliper splint, but in the majority the rest of their lives will be spent either in bed or in a chair.

2. When the fracture is reduced under anæsthesia, a plaster-of-Paris splint, as described by Whitman, is the most effective appliance.

3. To apply a plaster case properly for this fracture, some form of orthopædic table is most desirable, but a perineal prop with

* *Jour. de Chir.*, 1924.

pelvic support which clamps on to any table, gives immeasurable help.

4. In the absence of a perineal prop, counter-fixation of the pelvis during reduction is accomplished by passing a strong bandage round the groin on the sound side, and tying it to the table near the patient's head.

5. In cases unsuitable for plaster, good abduction and extension can be maintained on Jones's frame (Fig. 13), or the injured limb may be slung in a Thomas splint in abduction over the side of the bed, and tilting of the pelvis prevented by supporting the sound leg in abduction with sandbags.

6. The position of abduction should be maintained for at least two months.

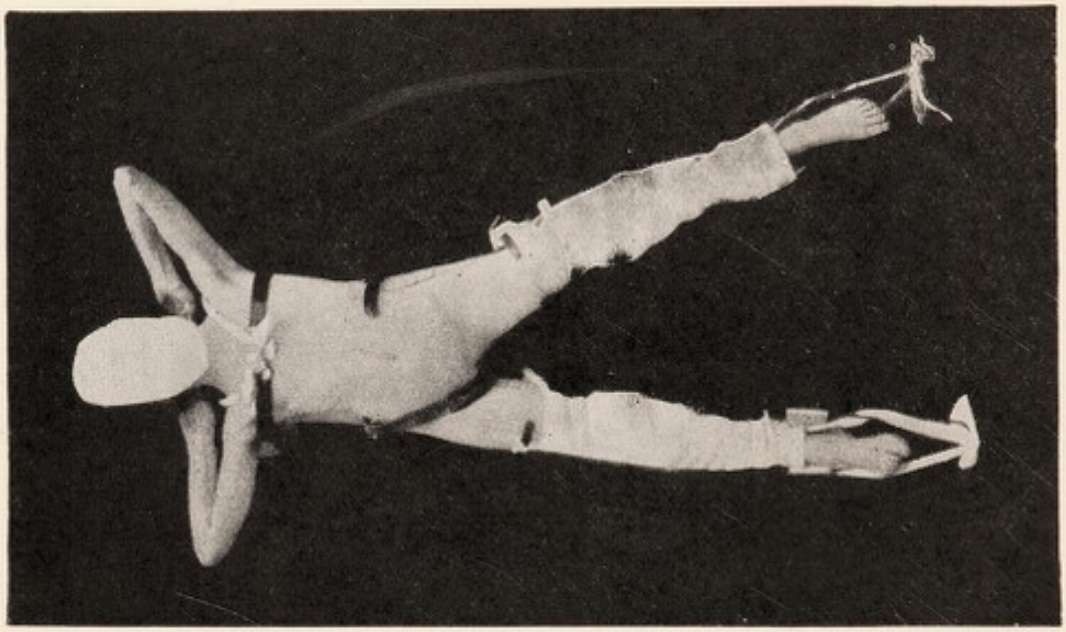

FIG. 13.—Abduction frame applied. (From Jones's *Injuries to Joints.*)

Two cases illustrate the above remarks.

A woman, aged 79, was knocked down by a bicycle in 1923. The narrow portion of the neck was fractured, with the usual deformity. She was treated by the abduction method after reduction under an anæsthetic. She has firm bony union, there is no shortening, and no loss of movements in the hip-joint. A year later I wrote asking her to report. She replied as follows: "My injured hip is as well as ever. I have no lameness, do not use a stick or crutches, I have no pain or limp, and have full movements."

A man, aged 70, was admitted to hospital in 1923. He was feeble and difficult to manage, and was treated by a Thomas splint slung in abduction over the side of the bed in extension; he was under supervision for three months in hospital. A year later he was walking on crutches, with slight crutch palsy. He would not wear a calliper splint; $1\frac{3}{4}$ in. shortening. Full movements of flexion and extension; strong fibrous union. With a little encouragement he discarded the crutches, but now walks with a marked limp.

In this last case no anæsthetic could be given, and there was no attempt at orthodox reduction. An X-ray plate showed clearly an atheromatous artery in the pelvis, which is an indication of the senility of the patient, although nine years younger than the first case.

Whitman's Reconstruction Operation.—Whitman has designed a reconstruction operation for old-standing cases, where absorption of the neck has taken place and where the functional result is poor. He believes that this operation is to be preferred to pegging the fracture with a bone-graft. The operation is designed to relieve pain, and to restore early capacity in vigorous subjects. The base of the trochanter is cut through in an oblique direction with a chisel, the obliquity corresponding to the angle of the neck. A neck is thus formed, and is thrust into the acetabulum with the leg in abduction. The trochanter is drawn downwards and is secured by a peg to the femur at a lower level.* The head of the femur is removed.

Fracture of the Trochanters

In subjects under 18 years, epiphyseal separation of the great trochanter is not uncommon. Fracture of the great trochanter is rare. When it occurs the trochanter is displaced upwards, and the best apposition can be obtained by the abduction method of treatment.

Langdon † reports two cases of fracture of the lesser trochanter. Only 25 are recorded in the literature. Langdon's cases were those of boys 12 and 16 years of age. The cause is said to be a sudden strain on the ilio-psoas muscle, causing avulsion. The pathognomonic sign is inability to flex the injured limb in the sitting position. Poston ‡ also calls attention to this injury, in a boy aged 14. The treatment in the early cases was very variable, but notwithstanding the difficulty of getting accurate apposition and reduction, the results were uniformly satisfactory. Operations are therefore contra-indicated. In Poston's case a plaster spica with the thigh flexed at the hip was applied for 14 days, and afterwards treatment was carried on by massage and passive movements. He had full recovery in 36 days.

Fractures of the Shaft of the Femur

General Considerations.—Seventy-five per cent. of the fractures of the femur seen at the Mayo Clinic present mal-union, non-union, delayed union, chronic osteomyelitis, or joint stiffening following treatment elsewhere. This is the statement of Meyerdine in the

* A complete description of the operation appeared in *Surgery, Gynecology, and Obstetrics*, June 1921.

† *Surg., Gyn., and Obs., Abs.*, October 1924.

‡ *Brit. Jour. of Surg.*, October 1921.

" Mayo Clinics " of 1923, and it is a severe commentary on the treatment of recent fractures elsewhere.

To obtain satisfactory results in fractures of the shaft there are two alternatives open to those surgeons who prefer non-operative methods :—

(*a*) The shortening and deformity may be reduced under an anæsthetic at once by means of powerful traction, if necessary, on a suitable orthopædic table (or by means of the gates already described). The limb—including the foot and the lower part of the body—is then encased in carefully applied plaster of Paris. (I do not practise this method apart from cases of fractured hip.)

(*b*) The deformity may be reduced under an anæsthetic, with the knowledge that the reduction will, in most cases, not be maintained completely by any form of splint, but good position will gradually be restored under the influence of traction and simple contrivances to correct lateral or antero-posterior deviations.

The methods of treatment are much the same, whatever the position of the fracture. When the fracture is in the trochanteric region, it is necessary to remember that the upper fragment is usually abducted, the lower fragment drawn upwards and inwards. Occasionally, when the obliquity runs from above downwards and inwards, the upper fragment may be pushed inwards instead of outwards. It is best to treat these high fractures in abduction, although it is doubtful if the upper fragment remains abducted once the limb is placed in a position of comfortable extension. Notwithstanding this, I think abduction is the best position on the principle of " safety first "—for if union takes place with the lower fragment adducted the functional result is unsatisfactory, owing to the necessity of compensatory raising of the pelvis on the injured side.

Russell * holds that there is only one circumstance which can justify operation in recent fractures of the shaft ; that is, mechanical impediment to the reposition of the fragments ; this is a sound doctrine.

I would like to say here that in simple fractures of the shaft of the femur, or of any other long bone, it must be an extremely difficult matter for soft structures to impose themselves between the fragments if sufficient extension is applied. All the muscles and other tissues run, for the most part, in a parallel line to the long axis of the bone, and the more they are pulled upon the more there is a tendency to disengage themselves from the line of fracture. When the patient is out of the anæsthetic, muscular tone comes into play, as if there were bands of elastic reaching from the pelvis to the tibia and fibula, and in fracture of the long bones tonic shortening of the muscle will be progressive.

* *Brit. Jour. of Surg.*, January 1924.

"Our first aim, then," says Russell, "will be to pull out these muscles to their correct length, and when we have accomplished this we may be sure that every other structure of the thigh will be in its correct position, including the fragments. This does not mean exact anatomical reposition, which is neither necessary nor even, in my opinion, always desirable." This is another fundamental truth, for every one with experience of the treatment of fractures knows that a slight lateral or antero-

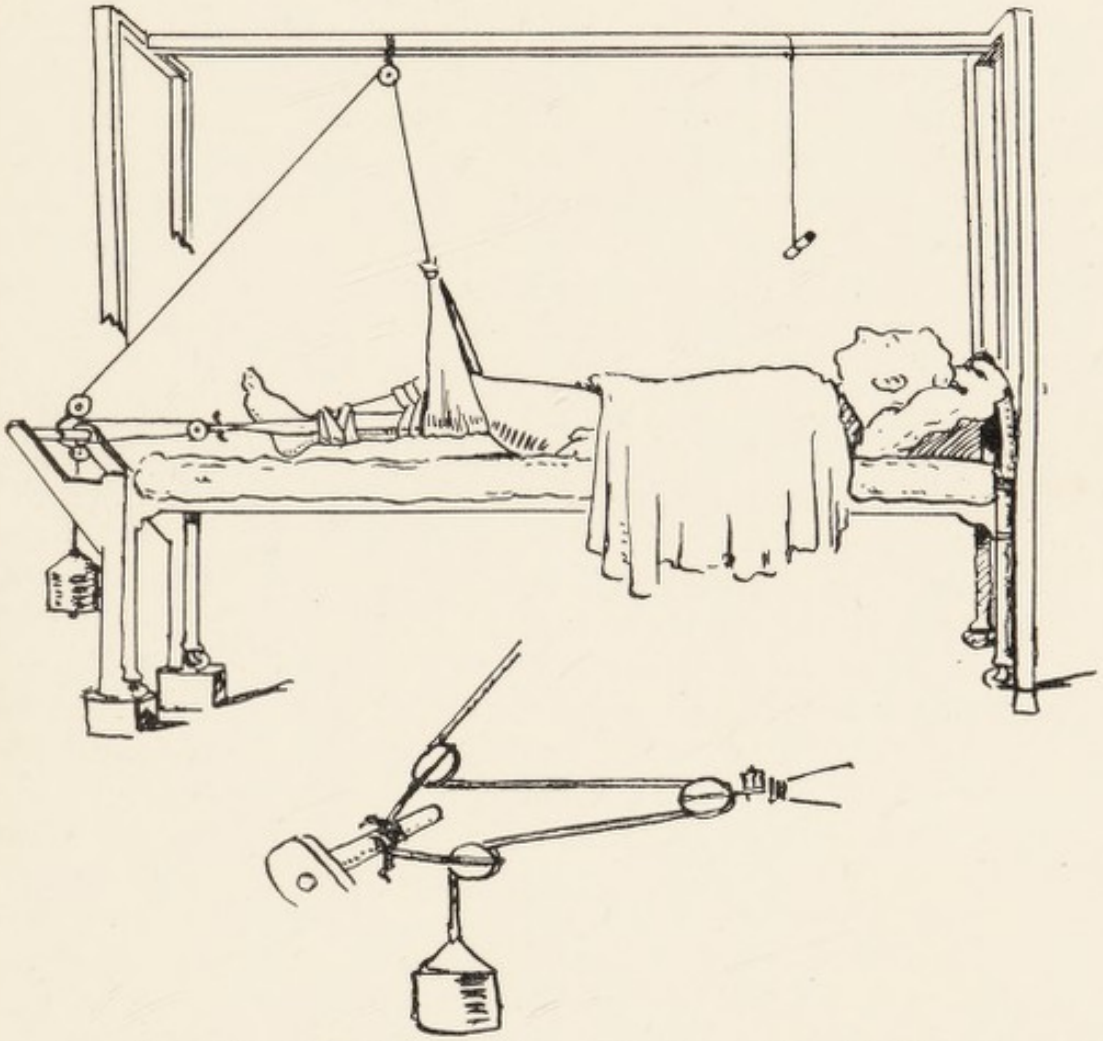

FIG. 14.—Russell's method of applying extension and maintaining flexion at the knee.

posterior displacement of fragments is of no account, provided there is no abnormal angulation or rotation.

There are many observations in Mr. Russell's paper worthy of note. "What must we pull upon?" he says; "clearly the tibia and fibula, seeing the muscles are attached to them. We are going to use strapping and bandages for the extension, and we shall, accordingly, not carry them above the knee for reasons that are obvious. I think that the practice, which seems universal, of carrying the strapping up the thigh indicates some confusion in our mental picture of the object to be attained. Anxiety as

regards the ligaments of the knee is quite needless, for, being attached to a fragment, they cannot be subject to stretching. The whole of the extending force will fall on the muscles, none at all on the ligaments. To convince ourselves of this, we only have to reflect that if the muscles were severed at the seat of fracture the limb would drop off." Mr. Russell might have gone further and said that if the ligaments of the knee were pulled upon and loosened after partial union, they very quickly took up the slack during convalescence (Fig. 14).

In high-up fractures of the shaft the upper fragment is usually rotated out flexed and abducted ; the lower fragment is drawn up and adducted. A long-axis pull will correct the shortening, and simultaneously with the pull the limb must be brought into abduction to get proper alignment. These fractures do well in a Thomas splint slung by pulleys to a Balkan frame, with either fixed extension, as recommended by Jones, or a 10- to 15-lb. weight-and-pulley extension attached to the end of the Thomas splint (Fig. 15). The sound leg is kept in slight abduction with sandbags (or slung in a Thomas splint) to prevent tilting of the pelvis, and the foot of the bed should be raised. The foot should be maintained straight, as the temporary rotation outwards of the upper fragment need not be considered.

We must not think too seriously about the displacement of fragments of the shaft by muscular action. It was pointed out by Lucas-Championnière, more recently by Sir Robert Jones, and again by Russell, that the displacement caused by muscular spasm is only a transient phenomenon tending to disappear when the fracture is reduced and the limb placed in a comfortable position free from pain, but if shortening is not reduced and the extension apparatus is inefficient, progressive contraction of the muscles is to be expected. The temporary nature of muscle spasm is particularly noticeable in fractures of the lower third. Much attention is drawn to the fact that the lower fragment is displaced backwards by the gastrocnemius muscle in dangerous relationship to the popliteal vessels. It is taught that these muscles must be relaxed in the treatment of such fractures, but numbers of surgeons, including myself, reduce them with strong extension without any misgivings whatever. The action of gravity or the tendency to fall backwards, obliterating the natural convexity forwards of the femur, with perhaps resultant genu recurvatum, is easily countered by a sling behind the point of fracture. So much attention has been paid to this in my own cases that many times I have obtained a slight increase of the natural bowing of the femur forwards, but without any undesirable after-effects as regards function.

We should remember that comfort is an essential in the

treatment of a fracture. Spasms and counter-spasms occur in the search for relief and the muscles are never at rest, the fragments are distributed and displacements result.

We have been recently reminded by Stern of Cleveland that Hilton's book on rest and pain is still a classic.

Treatment of Fracture of the Upper Third of the Shaft.—If the shortening can be reduced by manual extension and abduction

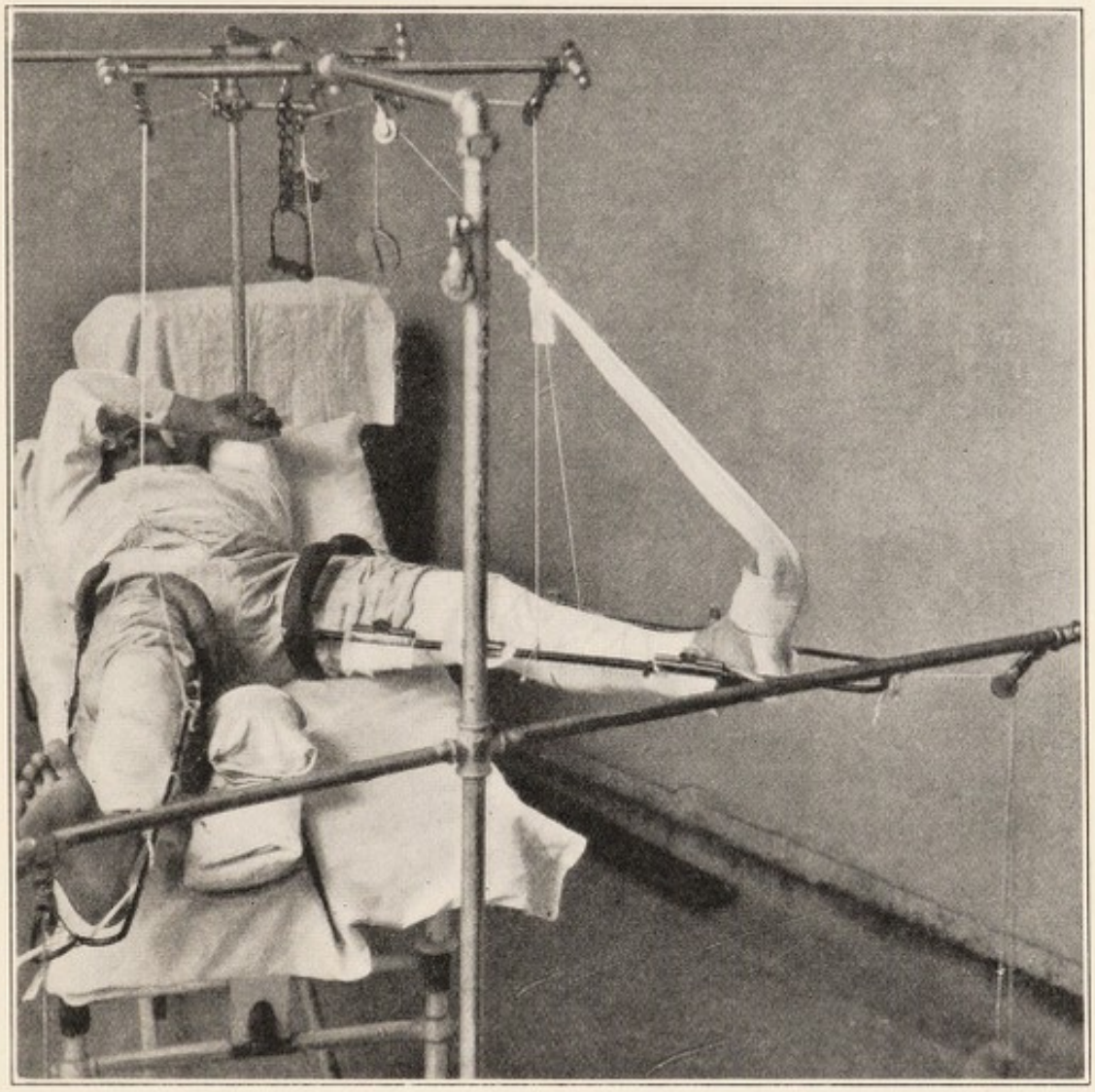

FIG. 15.—Fracture of the femur (upper third). Patient in bed after reduction. Note gauze glued to sole of foot to support it at right angles.

under anæsthesia, a Thomas splint is applied and the extension tapes secured to the end of the splint while traction is maintained. If there is difficulty in overcoming the shortening at the first try, it is probable that with sufficient and continuous extension the proper length will be obtained within the first week. The Thomas splint is slung over the side of the bed on a Balkan frame in a position of abduction with the sound leg slung or supported by sandbags (Fig. 15). In some cases reliance will

be placed on fixed extension—*i.e.* tightening up the tapes frequently as the muscles relax, in others a weight-and-pulley attachment is fastened to the end of the splint. If the strapping tends to slip during the first 10 to 14 days, an assistant grasps the ankle and extends while new strapping is applied. I have had no trouble in obtaining union without shortening by these simple means.

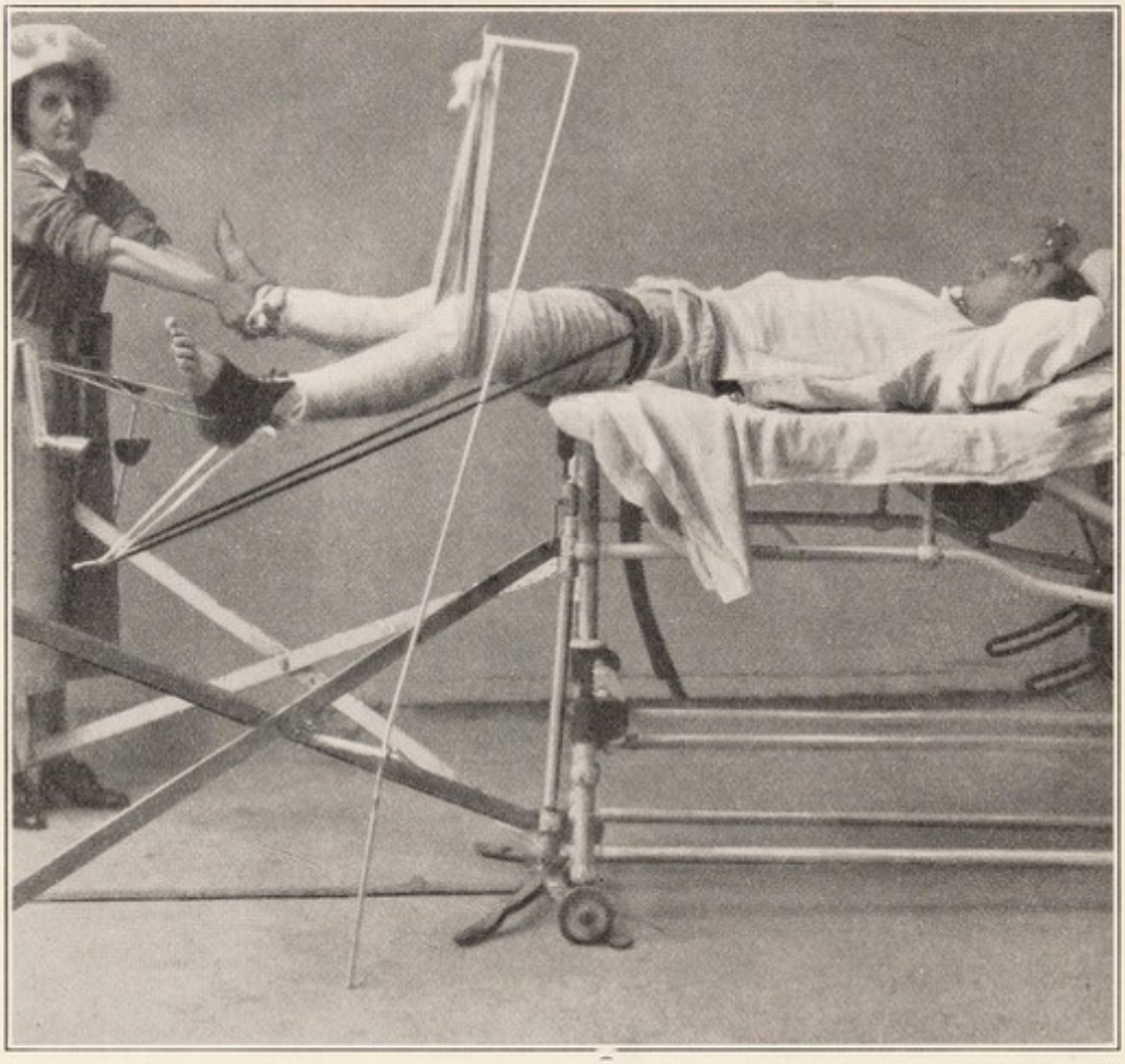

FIG. 16.—Powerful extension can be applied from a spat to the ratchet. The Thomas splint is then fixed in position, the tapes tied, and the spat removed. A steel pin passed in front of the tendo Achillis may be substituted for the spat.

Fractures of the Middle of the Shaft.—There should be no difficulty in the treatment of these cases with a Thomas splint slightly bent at the level of the knee. The shortening is reduced, or as nearly reduced as possible, under anæsthesia, and either a fixed or weight-and-pulley extension is rigidly maintained to the end of the Thomas splint by means of the orthodox strapping and tapes. The action of gravity, causing sagging backward of the fragments and bowing of the femur, must be countered. In rare cases shortening may still persist at

the end of a week, and powerful stretching with pulleys or special appliances may be required (Fig. 16). To prevent bowing backwards, a tight strip of bandage is clipped to the bars of the Thomas splint directly behind the fracture point ; nothing more is necessary, but this band throughout the treatment must be kept tight. If an X-ray photograph shows some lateral deviation of fragments, a pull may be exerted from one bar to the other by a loop of bandage round the limb, above or below the fractured bone according to the displacement. Some Thomas's splints are fitted with lateral pressure pads adjusted by a screw arrangement attached to the bars by means of which lateral deviations can be controlled.

Sir Robert Jones recommends (Fig. 17) that for further control a gutter-shaped sheet-metal splint, extending from the buttock fold to the lower third of the leg with a good wool pad in the

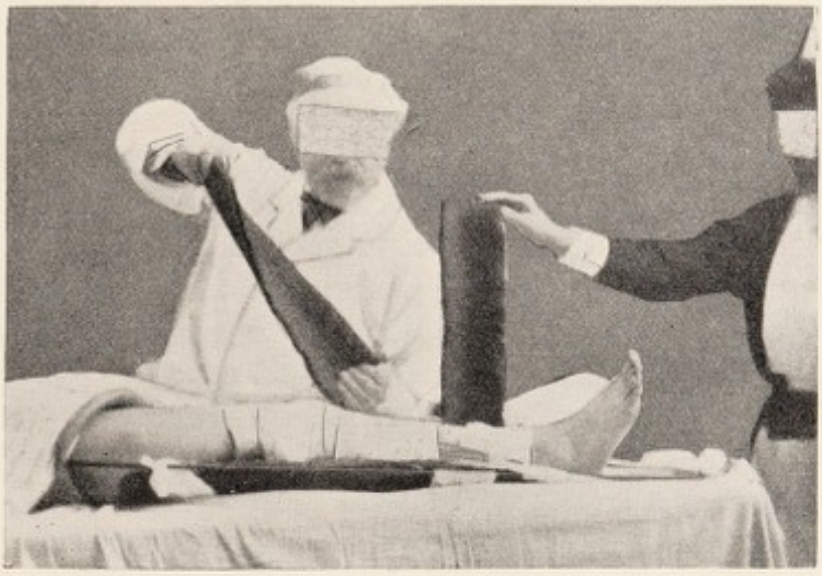

FIG. 17.—Application of local splints. (Jones.)

hollow of the knee, should be applied. Another grooved splint on the front of the thigh, stopping short above the patella, gives further support. Instead of fixed traction, in certain cases it may be necessary to apply a weight and pulley of from 15 to 20 lb. attached to the end of the splint. Fixed traction with counter-pressure against the tubes ischii will not be borne by some patients.

Fractures of the Lower Third of the Shaft.—The interest in connection with the treatment of these fractures is owing to the displacement of the lower fragment backwards as a result of the spasm of the gastrocnemii muscles. The upper fragment is usually adducted.

Again it must be pointed out that muscular spasm is only transitory, and Sir Robert Jones quotes an interesting case of

compound fracture in the lower third in which the limb was put in comfortable straight extension, and the spasm was actually seen to pass off with the gradual disappearance of the flexion deformity of the lower fragment. Nevertheless, when the shortening has been reduced under an anæsthetic, by full extension, the Thomas splint should be bent to half a right angle at the knee before the tapes are secured at the end. A strip of bandage is kept tightly applied under the lower fragment to ensure gradual restoration of alignment. If backward displacement persists, which is unlikely, division of the tendo Achillis is indicated.

Fracture of the Shaft of the Femur in Children.—I have most experience in the oblique or spiral fractures of the shaft in children, and I was surprised to find in how many cases it was difficult to maintain a good reduction of the fragments. Whatever methods were employed, immediate X-ray photographs showed a disappointing result. The final result, however, was all that could be desired.

The Bryant suspension frame is not satisfactory in children over the age of 6 years, as the weight of the body tends to tear off the extension straps and frequent reapplication is necessary. When used in younger children more traction will be obtained when only one limb is suspended, but the patient is more uncomfortable and the nursing is more difficult.

In a large series of cases described by Burdick and Siris * the favourite method was a plaster spica and traction—118 cases treated. Bryant's frame and suspension was next in popularity —96 treated. Fourteen were treated with a Thomas splint and traction, and two with a Hodgen splint and traction. It was necessary in a few cases to resort to operation.

In my early days I operated on these cases, but subsequent experience showed that in the case of children an apparently bad primary result was followed by an extremely good final result, and X-ray photographs taken a year or two afterwards barely indicated the line of the original injury. Not infrequently a child who was discharged from hospital with shortening ultimately presented itself with slight lengthening of the injured limb. In children, more than in others, it is necessary to emphasise the fact that perfect anatomical reduction is not essential for perfect functional recovery. There appears to be a stimulation of the growth of bone in its longitudinal direction, irrespective of the location of the fracture in the shaft.

One of the best methods of treatment is to place the child across a perineal prop, reduce the shortening, apply adhesive plaster

* *Annals of Surgery*, June 1923.

strapping for subsequent extension, and over this a plaster of Paris spica from the malleoli to the ribs, with the limb in moderate abduction. A weight-and-pulley extension of 10–15 lb. is employed. The plaster is removed in about six weeks. The continuous skin traction is used not so much to reduce shortening but to try and prevent any change in the relative position of the fragments. In children under 6 years of age extension of the leg in a vertical position to a horizontal bar over the bed is better than the method just described. A small Thomas splint—even small enough to fit a new-born child suffering from obstetrical fracture—also gives good results. A simpler method in infants is to bind the thigh and the extended leg to the front of the abdomen with a bandage. In the process of growth faulty alignment becomes corrected. Union is very rapid in these cases, and all fixation methods may be abandoned in less than three weeks.

In August 1919, I was consulted by an anxious mother about her only boy, aged 9, who had broken his thigh bone in May 1918. It was lamentable to hear the history. The bone was set by a local surgeon, in what manner I do not know, but X-ray photographs taken some weeks later showed, as is usual, some malposition of the fragments. The boy was taken to a consulting surgeon, and he recommended open operation, and something in the nature of an ivory peg was introduced into the medullary cavity of the fragments. A month later it became necessary to remove the peg, either on account of suppuration or displacement. In May 1919, one year after the accident, a large Lane's plate with eight screws was introduced. Three months later I could feel the Lane's plate making an effort to extrude itself through the scar, and obviously no solid union had taken place.

There was nothing for it but to remove the plate and screws and begin again. The child was treated in fixed extension on a Jones's abduction frame. Five months later, in January 1920, union appeared to be slowly taking place, and the child was allowed to walk upon a calliper splint. All appeared to be going slowly, but well, and he was being treated by massage and allowed to have hot baths, but always in the intervals wore a walking calliper.

Two years had now passed. In May 1920, about nine months after the plate had been removed, he raised up his leg while in a bath; this slight effort was followed by severe pain. I thought that the soft callus which was binding the bone had yielded, but an X-ray photograph showed that a new fracture had occurred just below the site of the old lesion. The bone had become greatly atrophied as a result of the three operations and prolonged inactivity, and broke from slight violence distal to the old fracture line.

I decided to spare the mother by saying nothing, and after a few days' rest in bed I allowed him again to walk upon a calliper, but insisted upon it being worn at night as well as during the day. There was never any considerable displacement at the site of the new fracture, and finally strong union was obtained.

There was one consolation about the second fracture—it showed that the position of the primary injury was at least as strong as the portions of the shaft in the immediate neighbourhood. Notwithstanding all the catastrophies in this case, the final result was not bad.

I have a letter from his mother, dated February 5, 1925, with this comment: "He is tall for his age, and broad and strong. He is hardly lame on the raised boot, and can walk any distance. He plays tennis and golf, and is a keen dancer. Eighteen months ago the shortening was $3\frac{1}{4}$ ins. The leg seems as strong as ever, and he never has any pain."

A boy, aged 11, was admitted to hospital in 1921 with a transverse fracture of the humerus and a transverse fracture of the femur. Perfect alignment was obtained in the first instance with ease, by means of a Thomas splint, but later lateral displacement of the fragments occurred with $\frac{1}{4}$ in. shortening. The mother wrote to me in January 1925, as follows: "He has had no trouble of any kind from it, and now plays football at school. There is no shortening or defect."

This is another illustration of how absolute anatomical position is not necessary for perfect function; and slight displacements, when the alignment is correct, may be ignored much more so in children than in adults

LECTURE III

Fractures about the Knee-Joint

Fractures of the lower end of the femur into the knee-joint are not uncommon. They resemble closely articular fractures of the lower end of the humerus. The condyles may be comminuted, or there may be simple fractures through either condyle. Replacement of the fragments usually takes place under extension. A Thomas knee-splint, applied in the classical fashion, is the best apparatus for the purpose (Fig. 18). Traction on the tibia pulls the condyles into correct position by the tension of the lateral and crucial ligaments. By separating the joint surfaces during treatment adhesions are prevented and early movements facilitated. Stretching of the ligaments during treatment does not produce any permanent disability.

It is best for the surgeon to manipulate the condyles with his hands while the assistant is applying extension in these cases. "So long as the tibia is not allowed to bump up against them," says Sir Robert Jones, "they will not be again displaced. If immediate reduction does not occur, quite often after a 12 hours' extension on the Thomas splint the displaced fragment will find its proper position." Fractures of the tuberosities of the tibia and T-shaped fractures into the joint are dealt with in the same

way. About six weeks after these injuries the patient may move about on a calliper splint.

Epiphyseal Separation.—The lower fragment is usually displaced forwards, and the ragged end of the upper fragment is pushed backwards in relation to the popliteal vessels. The injury is sometimes compound, and in many recorded cases amputation has become necessary.

Reduction is accomplished by strong flexion until the heel touches the buttock, combined with traction on the tibia and direct manipulation. In order to save the limb open reduction

FIG. 18.—Application of the splint. Passing the limb through the ring. (Jones.)

may become necessary. Union usually takes place by bone, and is followed by some shortening and interference with growth. The injury should be treated in full flexion, as in similar fractures involving the elbow-joint. In the latter case the triceps, with the limb in flexion, provides a nicely grooved natural splint for the prevention of backward displacement and, in the case of the knee-joint, the quadriceps extensor, when the limb is flexed, forms a naturally moulded anterior splint which admirably controls the fragments and prevents forward displacement.

In epiphyseal separation of the lower end of the femur the limb, after reduction, should be carefully watched lest anything

in the nature of tight bandaging or tight compression produces swelling of the feet. The condition of the circulation in children, when firm fixation is required, needs strict attention. "Look well to the blood-supply of the limb below the point of injury, more especially in *all* fractures of the lower extremity," is the advice of Bryant and Buck in the *American Practice of Surgery* (vol. iii).

Traction by Pins, Callipers, and Stirrups.—Before dealing with the treatment of mal-union and non-union after fracture of the femur, it is necessary to refer to the question of extension applied by means of metal appliances attached to, or passed through, the bone. These appliances consist of various pins, callipers, and stirrups; each surgeon has his preference for one or the other. The transfixion pin is the only one I myself employ, and quite often it takes the form of a long nail, such as is used for the temporary fixation of joints after excision. The skin is pulled upwards towards the hip to prevent subsequent traction pressure on the skin below the pin. The point of election for transfixion is just above the condyles at their junction with the shaft. If a pin is driven through the compact tissue of the femur at the point indicated, it can be left in place without inconvenience or pain for from six to eight weeks. A handle improvised from wire is attached to the pin. In the cases I have treated I have passed the pin through the tibia, not the femur. It is passed through the shaft of the tibia just behind and below the tubercle. In this position the bone is thick and hard, and the pin can be left in position for two or three months (Fig. 19).

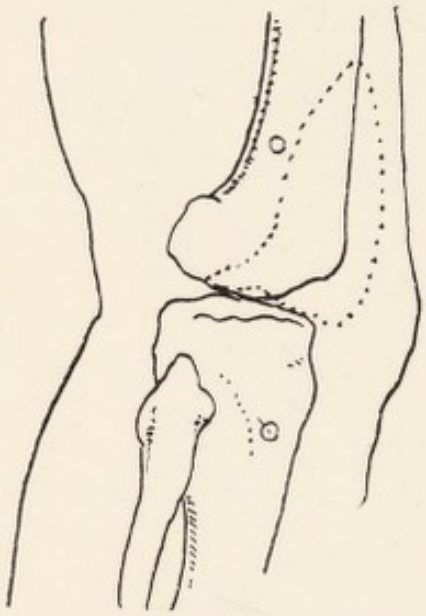

FIG. 19.—Positions for transfixion-pins. (Hey Groves.)

In the case of fractures of both bones of the leg, when this form of extension becomes necessary, the pin is passed by some surgeons above, but in the line of, the malleoli, well clear of the ankle-joint, about three finger breadths above the tip of the external malleolus. The pin is passed one inch below and behind the tip of the external malleolus, downwards and inwards in such a way that traction produces inversion of the foot.

Full information on this subject is to be found in the excellent work on *Modern Methods of Treating Fractures*, by Hey Groves.

Mal-Union and Non-Union

Mal-union and non-union are due, probably in 90 per cent. of cases, to mal-treatment. They are a reproach to surgery, and can always be avoided. It is no use blaming constitutional disease, or the interposition of soft tissues between the fragments for these unpleasant sequelæ. The primary treatment is practically always at fault, and is thus the main causative factor. The early management may be good, but if the patient is allowed to bear weight too early, yielding of the callus with angulation and overlapping will take place.

The time of strong union in a fractured bone varies in almost every case, and the length of time given for solid union in the text-books never errs on the safe side. In a small percentage of cases twice as much time is required as in a typical case. To allow walking without a calliper splint in the case of a fractured femur before three months have elapsed is asking for trouble, and under certain conditions a much longer period is required. Cases of non-union are often unrecognised cases of delayed union, and the dividing line between the two is very obscure. For some reason or another union is slow, and at the end of five or six weeks the surgeon becomes anxious, and moves the fragments one upon the other ; in another four or five days he tries again, and, by a continuation of this process, it is made impossible for the slowly-forming permanent callus to complete the union.

The treatment of definitely ununited fractures must, of course, be operative, but the surgeon should feel morally certain that it is a case of non-union, and not delayed union, before operation is undertaken. In this matter I have tried to follow the teaching of Sir Robert Jones. His usual practice is simply to begin again and wait, and to try and induce osteogenetic activity by Thomas's so-called " percussion and dam " method. After hammering the whole region of the fracture with a padded or indiarubber mallet, a tight elastic band is applied both above and below the fracture at a distance of several inches. The limb between the tubes swells to much more than its normal girth, expanding all the capillaries and lymph paths in the fibrous tissue, and allowing a new process of repair to start. The indolent callus may thus be transformed into an osteogenetic factory. The rubber tubes can be worn only for about 20 minutes each day at first ; afterwards they can be borne for several hours at a time. They should be kept tied sufficiently tightly to produce considerable swelling and stasis. Local congestion between two tubes is much more effective than when one proximal tube is used. There is no doubt that non-operative treatment should be tried in cases

of apparent non-union, in the hope that they are cases of delayed union. Only when efficient conservative treatment fails should the case be condemned as one of non-union. Bone-grafting and reconstruction operations are then undertaken.

It is surprising what good results can be obtained in cases of mal-union of the femoral shaft with 3 in. or 4 in. shortening.

FIG. 20.—Mal-union of femur (lower third) three months after the injury. $3\frac{1}{2}$ in. shortening. (Lateral view.)

Even after three or four months it is not difficult to re-break the fracture manually. In most of the cases I have seen the knee was stiffened by the previous treatment, and the mal-union could be broken down by forcible bending of the knee over the edge of the table. The worse the position of the bones, the less firm will be the exuberant callus. In old-standing cases of mal-

union it may not be possible to re-fracture a bone, and the simplest method to employ is an oblique osteotomy through the callus between the original fragments of the shaft.

When the mal-united fracture has been re-broken and thoroughly freed manually, forcible extension by some means or

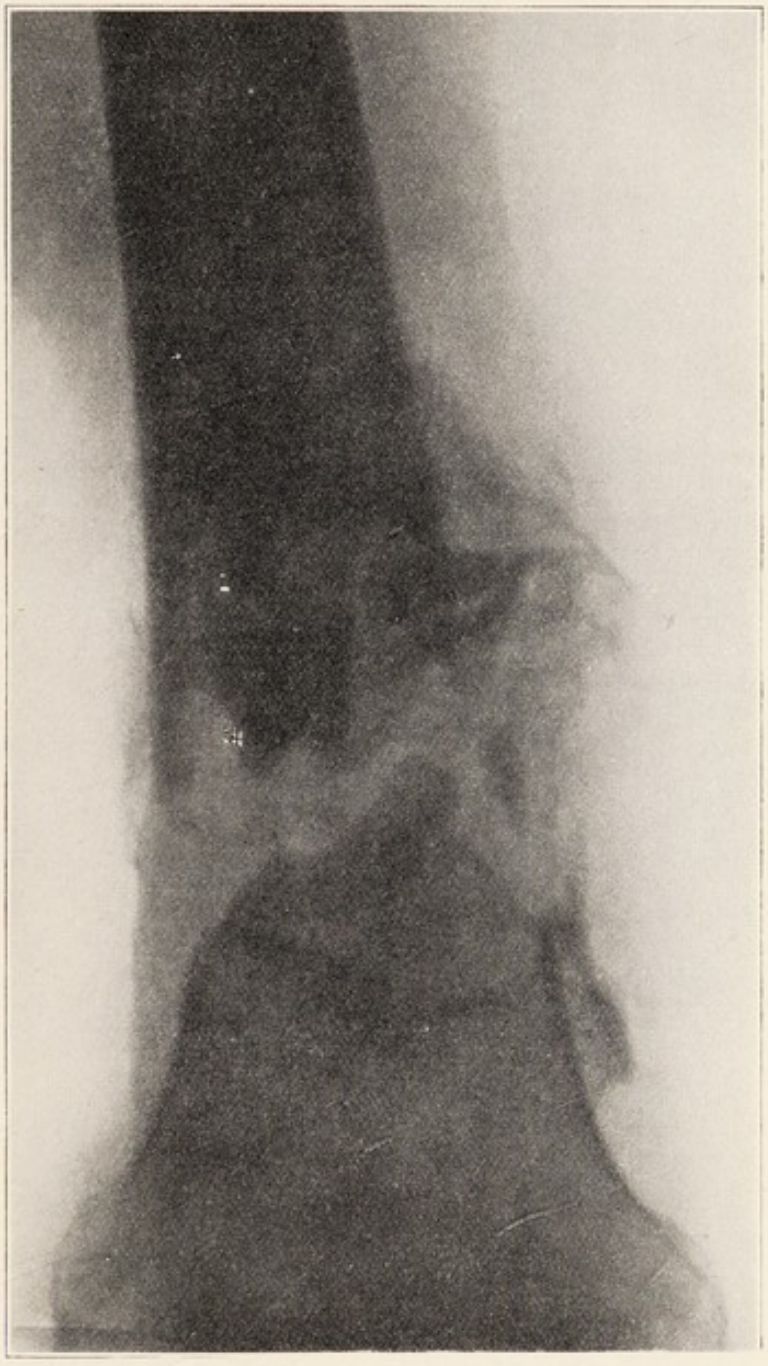

FIG. 21.—Position after two extensions on " gate " apparatus and traction from a pin through the tibia. The injured leg is now longer than normal.

another will reduce the shortening at one sitting by from 2 in. to 3 in. It has been my practice, after re-fracturing the bone, to forcibly stretch the limb for a few minutes on the gate apparatus (see Fig. 16), and while still stretched to apply a Thomas splint with fixed tape extension. While the limb is stretching on " the

gates," and before the tapes are tied to the end of the Thomas splint, a nail or pin is passed through the tibia, as recommended by Hey Groves, just behind and below the tubercle. When the patient returns to the ward a cord is tied to the end of the Balkan frame, is brought round a pulley, attached through a wire loop to the nail, and passed over a pulley at the end of the bed (for pulley arrangement, see Fig. 27); 20 lb. weight is at first employed, but with this arrangement of pulleys, apart from friction, the resultant weight is equivalent to 40 lb. If, in a week's time, the shortening has not been completely corrected, the patient is brought to the theatre, anæsthetised, and the limb again stretched on the gate apparatus. It is seldom necessary to repeat the process more than once, and quite often the treatment will result—if not carefully watched—in the leg becoming too long (Figs. 20 and 21). Block and tackle gear (Fig. 10) is most helpful.

I have had in my private hospital during the last year a man, aged 70, whom Mr. Hey Groves kindly saw with me. He fractured the lower third of his femur when in a state of alcoholic exuberance, and did not think seriously of treatment for three months after the accident. The lower fragment was in the usual position behind; the upper fragment impaled the soft tissues at the outer side of the patella like a bayonet, and there was over 3½ in. shortening. Three months had elapsed, but there was no difficulty in breaking down the fracture by manipulating the knee over the edge of the table. The first stretching on the gates reduced the shortening by 2 in. For a week he was treated in fixed extension in a Thomas splint. Shortening to the extent of 1½ in. persisted, and further forcible extension on the gates was employed. The shortening was this time completely reduced. With the assistance of Mr. Hey Groves, a pin was passed through the strong portion of the tibia in the region of the tubercle, and 40 lb. extension applied when the patient returned to bed. The weights were gradually reduced after the first fortnight to about 15 lb. Two months later the injured limb was found longer than the other.

Late or Secondary Displacement.—With calliper or pin extension, over-lengthening of the bones may be produced more readily than when other methods are employed. Care must be taken lest deformity recur after two or three months, owing to the plastic condition of the intervening callus, even though the patient is still kept in bed. There should be no interval between the removal of the extension and the application of a calliper splint. The latter should be worn both night and day for a considerable period. In the case just mentioned, the full length obtained and the good alignment were partially lost by allowing the patient to lie for a couple of days with the limb free after two months of continuous extension.

I had experience recently of another case, in which a transverse osteotomy was performed in the lower third in order to correct outward rotation of the foot following gunshot injury to the hip (Figs. 22 and 23). A Thomas knee-splint was used for fixation, but was removed at the end of five or six weeks in order to fit

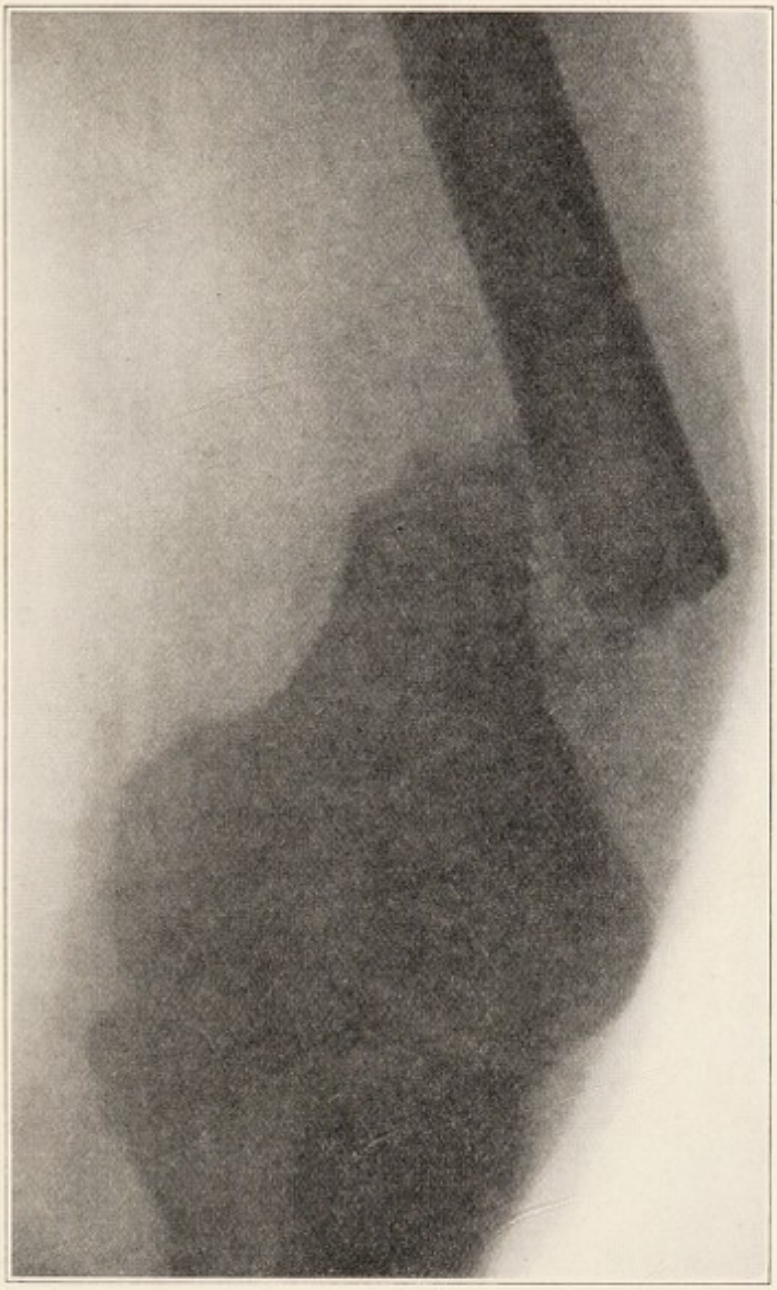

FIG. 22.—Late or secondary displacement. After six weeks the splints were removed in order to fit a calliper, with the result shown.

a calliper. Before the latter was completed lateral displacement and overlapping of the fragments occurred, although the patient never left bed. This was subsequently corrected by re-breaking, stretching on the gates, and pin traction. After consolidation it was found that the leg had been lengthened by $\frac{1}{2}$ in. beyond normal.

This question of later or secondary displacement requires some attention. It was new to me until recently, and I used to think of it as occurring only when patients were allowed to walk too soon without support. In both the cases to which I have alluded, the broken ends were held in good alignment, but in the

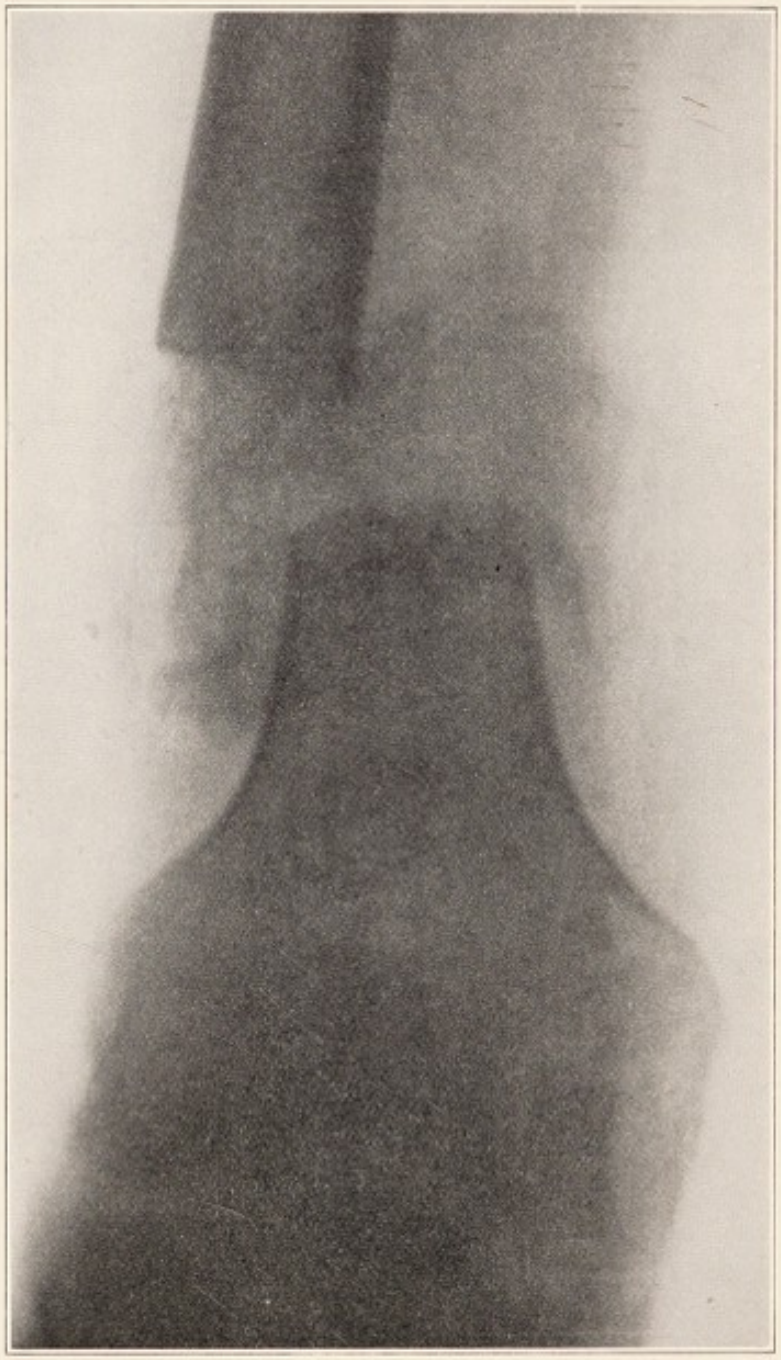

FIG. 23.—Same case as Fig. 22, showing femur ½ inch too long after "gate" extension and pin traction.

first there was not close apposition, and a large gap remained to be filled up with reparative material. Such repair tissues undergo ossification in the adult very slowly, and probably at the end of six or eight weeks they are quite plastic. In a day or two the muscular tension may slowly deform the seat of fracture, so that

the final result is very far short of that which was promised by X-rays in the course of treatment. Hey Groves comments on this, and states that displacement is specially liable to occur in the femur of adults.

One would hardly think it possible that an interval of a few days without apparatus, while the patient is still in bed, after six or eight weeks of extension, would lead to shortening and displacement, but that such may occur—especially where the treatment was for mal-union or where too much lengthening has been produced—is beyond doubt.

LECTURE IV

Fractures of the Patella

There are certain cardinal points in connection with fractures of the patella to be borne in mind. (1) In comminuted and longitudinal fractures conservative treatment is followed by bony union. (2) Transverse fractures should be treated by operation, but nevertheless an excellent functional result may follow with wide separation of the fragments. I have an intimate friend who fractured his patella about 30 years ago. He has wide separation of the fragments, but walks without a limp and without inconvenience, and takes strenuous exercise. (3) Operation followed by bony union is not always followed by a good functional result. (4) If the fracture occurs near the ligamentum patellæ, the knee-joint may not be opened, as the synovial membrane is reflected from the posterior surface of the patella some distance from the inferior tip of the bone. (5) Circumstances will arise when a fractured patella cannot be sutured under favourable conditions, and if the conditions are not ideal the attempt should not be made.

The first part of conservative treatment is to get rid of the effusion. To accomplish this, the limb should be elevated to relax the quadriceps extensor muscle and a tight bandage applied over several layers of wool. A practical way of helping absorption is suggested by Scudder :

> Two slightly moistened bath or carriage sponges are allowed to dry under pressure sufficient to flatten them. These are placed upon each side of the knee and over it, and are held by a few turns of a roller bandage. Cold water is then poured over the whole. As the sponges absorb the water they enlarge, causing equal and firm pressure on the knee, thus very materially hindering the accumulation of fluid and

favouring its absorption. This dressing is repeated every day. When the effusion has disappeared a calliper splint can be applied, in the manner recommended by Jones. The fragments are brought together with the fingers, and a loop of bandage is passed tightly from bar to bar above the upper fragment, and a similar loop below the lower fragment. A small felt pad under each loop helps to maintain the position. If there is any tilting of either fragment a pressure pad can be bandaged on the front of the knee. The calliper splint should be worn for about two months. Full flexion of the knee should then be restrained for a time by a knee-cage, to prevent gradual separation of the fragments.

There are many other methods employed, the "Middlesex Hospital" method being one of the best. Fig. 24 shows the upper

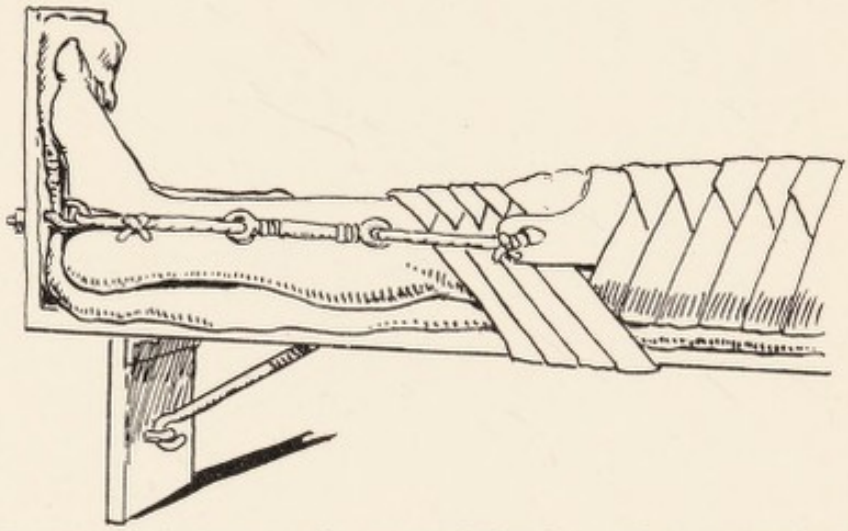

FIG. 24.—Fracture of the patella treated by horse-shoe strapping and back splint. (Cheyne and Burghard.)

fragment pulled down by a horseshoe-shaped strapping to the foot-piece of a back splint.

Operative Treatment.—In dealing with fractures of the patella by operation we must be certain that the largest synovial cavity in the body is not exposed to the slightest risk of accidental infection. If a disaster occurs the knee will be partially or completely stiff. If partially, the joint will be painful. Amputation of the thigh may become necessary in severe sepsis.

I have never performed any complicated operation, such as plating or bone grafting, for fractured patella. A simple procedure is adopted :

The joint is opened between the two fragments by a curved or transverse incision. Clots and torn tissues are cleared away from between the fragments. Doyen's or Reverdin's needle is passed through the quadriceps tendon in close contact to the upper margin of the patella. The needle is threaded with a fine loop of aluminium bronze wire and pulled through. The loop is cut and the needle is passed through the ligamentum patellæ in close contact to the lower

border of the lower fragment ; the double wire is again threaded and pulled through. The ends of the wire are now twisted and tied tightly, bringing the two fragments into apposition by an encircling suture. The torn portions of the capsule and aponeurosis are stitched with a few points of catgut. The wound is dressed. No splint is applied, and the patient is allowed to practise voluntary movements in bed from the beginning, so far as he is able to do so without pain. (Fig. 25, A, B, and C.) A double loop of strong catgut or a strip of fascia from the thigh may be substituted for wire.

I have found that these cases walk about with the help of a stick after a fortnight or three weeks, and that they return to

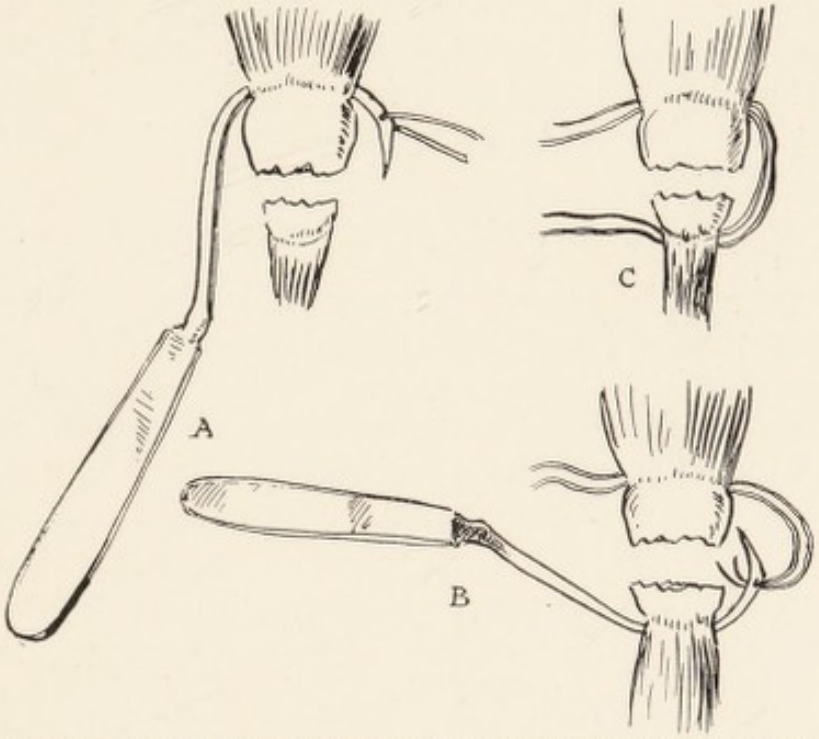

FIG. 25.—Simple method of encircling fragments with wire.

report in two or three months with bony union and full movement of the joint.

The patient should be warned not to slip. Violent extension of the other leg in trying to regain equilibrium has frequently resulted in fracture of the patella on the opposite side.

Refracture of the patella after apparent consolidation is quite a common accident.

FRACTURES OF THE TIBIA

Fractures of one or both condyles of the tibia occur either as the result of distortion or from direct violence, just as in the case of fractures of the condyles of the femur. They may or may not involve the joint, and the treatment is identical with that already outlined for fractures of the femoral condyle.

Fractures of the spine of the tibia, associated with rupture of the crucial ligaments, are not very uncommon. It is impossible to say if the crucial ligaments are ruptured or the spines pulled off without the aid of an X-ray photograph. Jones mentions 25 cases. I have seen them from time to time at Mercer's Hospital as the result of severe violence. In one case the tibia was completely dislocated backwards.

The knee-joint should be immobilised in plaster of Paris, and neither active nor passive movements allowed until two months have elapsed. Then very gradual and gentle movements are commenced. A Thomas walking calliper may be substituted for plaster fixation. If, following this treatment, movements are restricted as a result of a bony block produced by a detached spine uniting by callus, the knee-joint must be exposed by longitudinal division of the patella, and the bony block removed.

Osgood's or Schlatter's Disease

The condition is sometimes spoken of as "Rugby knee." Pain and tenderness rapidly disappear under rest treatment, and a knee cage should be worn limiting flexion of the knee and the activities of the patient for some months. The epiphyseal strain may exist without much difference between the X-ray appearance of the normal and abnormal bone.

Fractures of the Tibia and Fibula (Upper Third)

These injuries have received but scant attention, owing to the ease with which treatment can be carried out. The treatment is identical with that of fractures of the condyles of the femur, and consists in manipulating the fragments, while an assistant is fixing the extension tapes to the end of a Thomas splint. Loops of bandages are applied to control any lateral or antero-posterior deviations.

Fractures of the Lower Third

It is when we come to the common broken leg, that is to say, an oblique or spiral fracture of the lower end of the tibia with a fracture of the fibula at a slightly higher level, that real difficulties in conservative treatment arise. Fractures of the tibia alone, or of the fibula alone, are already splinted by the uninjured bone. A little extension and manipulation will easily correct any slight displacement, and the limb can be encased in plaster of Paris from the foot to above the knee. At the end of six weeks, weight may be borne on a walking calliper.

Fracture of the fibula alone, without displacement of the foot, is only of interest because the diagnosis may be missed. Special attention should be paid to the ecchymosis which appears some time after the injury, and often extends up along the line of the fibula. The same ecchymosis arises in all fractures, including fractures of the base of the skull. In doubtful cases of fracture of the long bones without displacement, ecchymosis following the line of a bone should put the practitioner on guard. If extensive ecchymosis coexists with a point of maximum tenderness, a fracture is almost certainly present.

These remarks apply to fractures of the fibula, both in its upper and lower thirds.

Walking may be allowed when it is possible to do so without causing pain. No form of splintage is necessary. When the fracture is near the ankle-joint it is wise to wear an outside iron, or to raise the inner side of the boot, so as to anticipate any possibility of valgus deformity occurring under the strain of weight-bearing.

Treatment of Fractures of the Lower Third of the Tibia and Fibula.—With the oblique and spiral fracture I have had more difficulty and seen more bad results than in any other fracture of the lower limb. Any one with experience in setting these fractures knows that manual extension of the foot is very unsatisfactory. If it is a recent case, and it is decided to fix the limb in plaster from the foot to well above the knee, the hands of the assistant get in the way at every turn of the lower part of the bandage, and displacements occur. It is impossible for an assistant to keep up sufficient extension and to keep the fragments in alignment during the application and setting of the plaster in a difficult case. On the other hand, there is not sufficient of the limb below the fracture to apply adhesive strapping for fixation to the end of a Thomas splint.

Sinclair's foot-piece and glue, as a means of putting extension on the lower fragments, has given satisfaction to many surgeons, but, after failures by this and other methods, I have adopted the following plans, sometimes singly and sometimes in combination.

1. In certain cases with the patient under an anæsthetic, and the knee held flexed by an assistant, extension and manipulation of the foot readily reduces the shortening, and corrects the alignment. If steadily held, there is no great tendency to recurrent displacement of the fragments, and the assistant experiences little difficulty while the limb is immobilised in plaster.

2. The deformity can only be reduced with difficulty, and the slightest move of the foot brings about slipping of the fragments. In such cases the sectional plaster of Paris method, as recommended

by Cochrane, is useful (Fig. 26). By the sectional plaster method is meant that separate plaster casings are applied and allowed to set above and below the injury. The injured area remains exposed and free for manipulation. The first section of plaster should be applied from just above the fracture to the middle of the thigh, with the knee slightly flexed. The second plaster encases the foot. The two sections are allowed to set, and the plaster is trimmed at the edges. The foot is now fully dorsiflexed in slight inversion by the assistant, while the surgeon unites the two plasters by a few turns of a third plaster bandage. If more extension is required than can be obtained comfortably by manual traction, a clove-hitch is placed round the foot encased in its plaster and attached to the gates (see p. 19), or pulled by means of a block-and-tackle arrangement. The two plasters are then united as before.

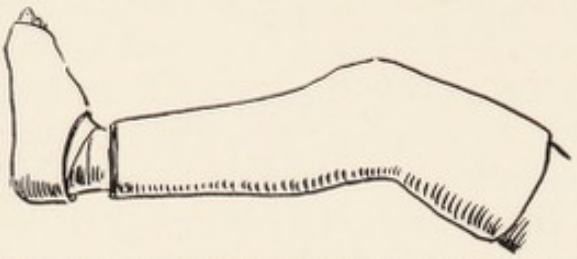

FIG. 26.—Sectional plaster of Paris in the treatment of fractures of the lower third of the leg.

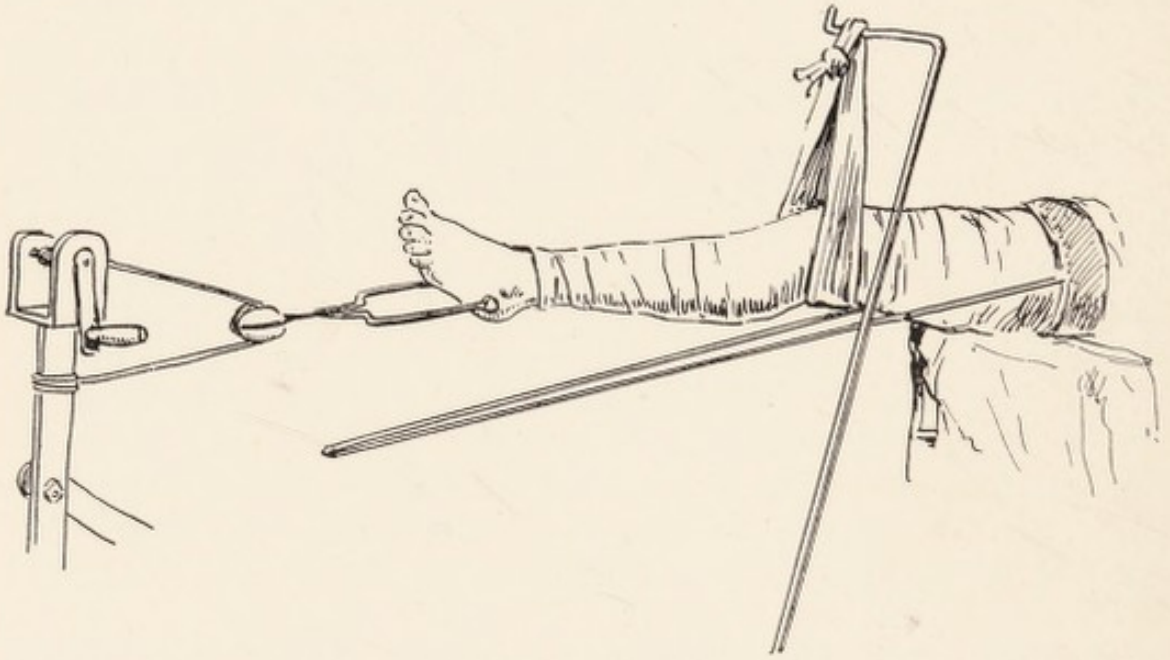

FIG. 27.—Forcible extension by means of transfixion pin and loop of wire prior to application of plaster or fixation in a Thomas splint. For continuous traction in bed the same wire loop and pulley is used. One cord is tied to the upright of the Balkan frame, the other passes over a pulley with a 20-lb. weight attached.

3. When more than manual traction is necessary, the clove-hitch over the plastered foot is a somewhat clumsy, though effectual, method of reduction. It is better, I think, to pass a long nail under the tendo Achillis in contact with the os calcis, and connect this through the medium of a wire loop to the end of the gates, or to block and tackle, so that forcible extension may be applied. The surgeon simultaneously manipulates the fragments into position, and takes care to pull the heel well forward. There is now no difficulty whatever in

applying plaster of Paris and the extension is not released until the plaster is set. The pin and wire loop are partially encased in the plaster, but can easily be removed (Fig. 27).

4. It will become obvious in certain cases that nothing but continuous traction will reduce the overlapping and shortening. In such cases the nail is passed *through* the os calcis, and after forcible stretching on the gates, the loop of wire is fixed tightly to the end of a Thomas splint until the patient is back in bed. This fixed extension may be continued, but in these cases heavy weight-and-pulley extension is better through the medium of the nail—the Thomas splint merely acting as a sling. It is best to pass the nail obliquely through the os calcis on a slightly higher level of the outer side, so that as traction is employed the tendency is slightly to invert the foot.

5. Operation with internal fixation should be the last resort. Probably the best way of securing the fragments is by means of Parham's bands. These bands sometimes cut through the bones and cause late secondary bending or fracture.

Quite often after open reduction no internal fixation will be found necessary, and the treatment can be continued by any of the methods mentioned above.

Pott's Fracture

Sir D'Arcy Power has written a monograph on Percival Pott of St. Bartholomew's Hospital, and relates the interesting tale of how Mr. Pott suffered a compound fracture of the tibia, and narrowly escaped amputation.

The original description of Pott's fracture, as given in 1768, has been quoted recently by Sir D'Arcy Power, and is well worth reading. To this day Pott's fracture, in the wards of the big hospitals, constitutes a favourite subject for discourse to students, yet the treatment and the results are far from being universally satisfactory. It is the old story: Want of proper reduction at the time of the injury and want of precautionary measures to prevent displacement when weight-bearing is permitted.

The fracture is produced by violent eversion. The astragalus is thrown against the external malleolus. The ligaments binding the fibula to the tibia remain intact and act as a fulcrum, and the shaft of the fibula breaks at the weakest point near the ankle. The importance of the fracture lies in the fact that the astragalus is displaced outwards, perhaps half-way across the articular surfaces of the tibia as well as backwards. The thrust of the foot, if the deformity is not corrected, is between the tibia and the fibula, and not squarely on the tibia. The backward displacement prevents dorsiflexion of the foot, by the contact of the neck of the astragalus with the anterior edge of the tibia.

A patient with an improperly reduced Pott's fracture can

never walk without pain in the ankle and pain on the inner side of the knee with a tendency to knock-knee. The distortion outwards of the foot leads to a condition of flat-foot, a further addition to the misery of the patient. If there is much displacement outwards of the foot, the internal malleolus or the internal lateral ligament must, of necessity, be torn. Pott's fracture may be transformed into a Dupuytren's fracture by displacement of the astragalus up between the tibia and the fibula. The astragalus may carry with it a portion of the articular surface of the tibia ; a piece may be

FIG. 28.—Fracture of fibula with portion of tibia detached and blocking dorsiflexion.

knocked off the anterior portion of the tibia and block dorsi-flexion, or a portion of the back of the tibia may accompany the backward dislocation of the foot. (Figs. 28 and 29.)

Whatever the complications the treatment is the same. Under an anæsthetic the outward and backward displacements must be reduced. As in fractures of the lower third of the tibia and fibula, relaxation of the tendo Achillis by flexing the knee is an advisable preliminary. The foot is then forcibly twisted inwards in order to bring the astragalus squarely under the

articular surface of the tibia, and at the same time the heel is pulled steadily forward until the foot can be dorsiflexed with ease beyond a right angle. The foot must be maintained in this position of dorsiflexion and exaggerated inversion.

The displacement does not readily recur after reduction, and any form of splint intelligently applied will secure fixation. A board or gutter splint secured to the outer side of the leg and well padded at the lower extemity will, by a thrust, keep the foot inwards. Dupuytren's splint and Syme's splint are still employed. Plaster of Paris in a recent case is an admirable means of fixation. It should extend—as in fractures of the lower third of the leg—

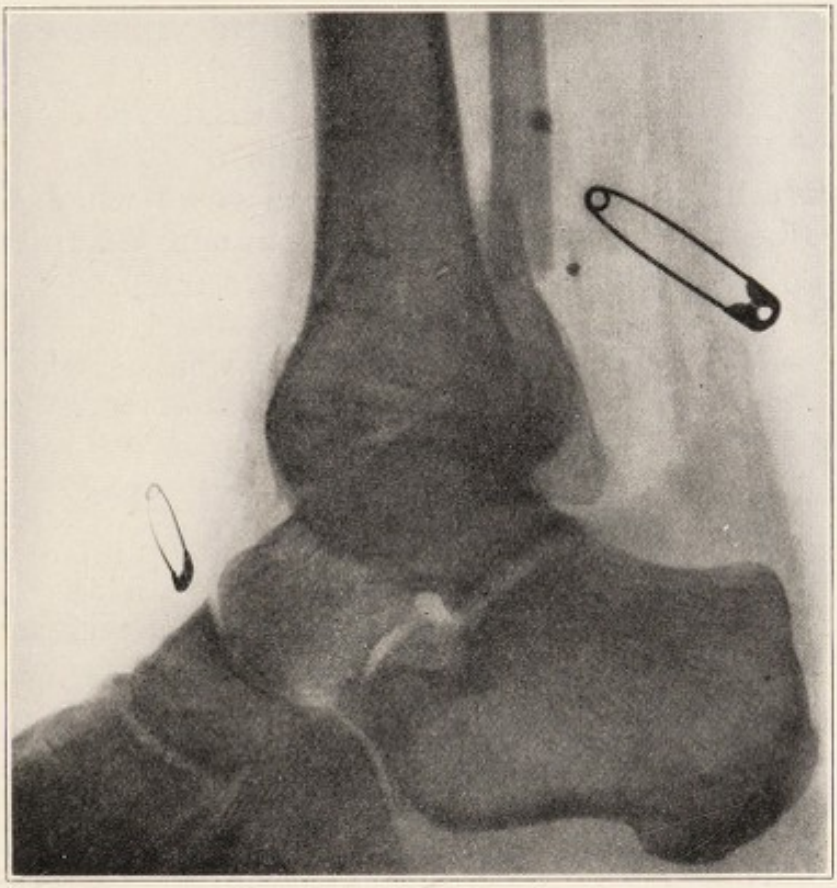

FIG. 29.—Same Fracture reduced and treated in plaster of Paris.

from the foot to above the knee. It is best to make two plaster splints composed of several folds of superimposed bandage. One strip is made into a posterior splint, which extends from the toes along the sole, round the back of the heel, and up beyond the knee-joint behind. The other strip is moulded in position while the foot is held in inversion, and extends from the external malleolus over the dorsum of the foot to the inner side under the sole, and upwards along the outer side of the leg to the same height as the posterior splint. The posterior splint is applied first, and both are secured in position by a roller plaster bandage. The foot must be held in the correct position during the setting of the

plaster of Paris. They can be easily removed in about three weeks for massage and movements, but should be reapplied in the intervals until another three weeks have elapsed.

The displacements in Pott's fracture have so often recurred from too early weight-bearing that it is best to prohibit walking for at least two months from the original injury, and before walking is allowed the inner side of the heel and sole of the boot should be raised so as to maintain a slight varus position.

In dealing with patients who are not helpful, or in heavy subjects it is wise always to prescribe an outside iron and an inside cross strap, so as to ensure support and inversion. I will mention three cases, but I have had many, in which the patient was treated accurately while in hospital, but when weight-bearing was resumed the callus was not strong enough to bear the strain, and the patient returned with pain and disability consequent on gradual yielding in the direction of the original displacement. It is important to know what to do in cases which have been allowed to walk after the accident without support and who come back suffering from pain and a valgus deformity.

CASE 1.—The patient was a big, heavy woman, who refused to stay in hospital more than a week. The displacements were reduced, and the foot put in plaster of Paris. She commenced weight-bearing at the end of a month, and then returned to the extern department of the hospital, with pain and some slight eversion and tenderness at the site of fracture. An X-ray photograph showed no displacement. The boot was raised on the inner side, and an outside iron fitted so that the foot was well inverted. In this case, a recurrence of the deformity was anticipated and prevented.

CASE 2, a private patient, came for advice seven weeks after her accident. The fracture was reduced correctly by her local doctors, but she began to walk without permission and without support after the lapse of a month. An X-ray photograph showed the astragalus displaced outwards and somewhat backwards. The patient was anæsthetised, and thorough wrenching in an inward and forward direction was carried out with a Thomas wrench. This procedure did not appear to bring the foot satisfactorily into position, and an osteotomy of the fibula was done. Further wrenching after the osteotomy completely corrected the displacement. Three weeks later she was discharged in a light plaster case, and shortly afterwards was fitted with an outside iron and a crooked heel. Her progress was quite satisfactory.

CASE 3.—This patient came back a year after recurrence of the displacement. The fibula was divided, and a cuneiform osteotomy performed above the ankle on the inner side of the tibia, after the method of Jones, so that inversion of the foot could be obtained and the weight thrown on the outer side of the foot. No attempt is made to reconstruct the joint.

This simple form of osteotomy has given me good results. I have never undertaken the reconstruction of the fracture, as recommended by Murphy and others.

The patient is seldom quite well and free from pain after a Pott's fracture in less than six months. It may sometimes be necessary to do an open operation, when a portion of the tibia, either in front or behind, is torn off and mechanically blocks the movements of the ankle-joint, but in cases seen early forcible manipulation will usually secure a right-of-way in every direction.

Fracture of the Astragalus

Sometimes from heavy falls on the feet the astragalus may break instead of the tibia and fibula. There is often an irregular comminution of the body, or the neck may be fractured, and to all intents and purposes the latter fracture is outside the ankle joint. Forward dislocation of a fractured astragalus can be reduced by traction on the foot, and, if necessary, the tendo Achillis is divided in order to pull the os calcis away from the tibia. In some cases the fractured bone gets so twisted and displaced that astragalectomy becomes necessary. In cases of fracture of the neck, as distinct from fractures of the body, there is usually little displacement, and treatment should consist in placing the foot in full dorsiflexion in plaster of Paris for three weeks. Weight-bearing should not be allowed for two months.

Sometimes a little ossicle of bone, described by Pirie, is seen between the astragalus and scaphoid as if detached by an injury ; a comparison with the sound side will sometimes show a similar condition. The recognition of " Pirie's ossicle " is of medico-legal importance ; it is not the result of injury.

Thurstan Holland, in the *Journal of Anatomy*, July 1921, deals with the significance of this ossicle.

Fracture of the Os Calcis

The bone may be torn by muscular action at the point of insertion of the tendo Achillis. It may be crushed, fractured transversely or longitudinally, and may be associated with fracture of the astragalus. Complete plantar flexion of the foot may be needed to bring the fragments well into position and to take the pull of the tendo Achillis from the posterior fragment. A traumatic flat-foot often results from unreduced fracture of the os calcis or astragalus.

The treatment in the first instance should anticipate this possibility, and after attempted reduction the foot should be placed in slight inversion.

Fractures of the os calcis give unsatisfactory results, a painful heel often persisting whatever treatment is adopted. The treatment of this unsatisfactory late result was discussed by Cotton in *Annals of Surgery*, 1921. He regarded it as being due chiefly to excessive new bone formation on the outer side locking the fibula to the os calcis, and he recommended a U-shaped incision under the external malleolus, the turning up of a subperiosteal flap, and a wide removal of bone in this area.

Fractures of the Scaphoid

Bennett described two examples of fractures of the scaphoid bone of the foot in 1884. The articular surface which receives the head of the astragalus presented lines of ununited fracture, but on the opposite surface—in contact with the cuneiform bone—the lines of fracture were quite indistinct.

Thurstan Holland draws attention to the presence of a distinct skeletal bone situated at the posterior external side of the tuberosity of the scaphoid which has been mistaken, after injury, for a fracture of the tuberosity of the scaphoid. To assist in the diagnosis, the other foot should always be examined. The bone is usually known as the "tibiale externum."

Fracture of the Metatarsal Bones

Fracture of the metatarsal bones usually causes flattening of the transverse metatarsal arch. Treatment is directed to restoring this and maintaining fixation for some weeks. A pad should be applied in the cavity of the arch, and the latter kept in position by a circle of adhesive strapping. To prevent metatarsalgia, weight can be prevented from falling on the fractured bone by a transverse metatarsal bar across the sole of the foot. It must be remembered that a small portion of the base of the fifth metatarsal bone may be detached normally and remain as a separate bone throughout life—"the bone of Vesalius"; it appears in an X-ray photograph as if a fracture.

Fracture of the Sesamoid Bones

The sesamoid bones must not be forgotten. Cases have been reported by Hall Edwards, by Scales, and by Muller, which were operated upon and the diagnosis of fracture confirmed. Kellog Speed lays great stress on these injuries, and says they are usually due to a heavy object falling on the foot, or sudden increase in weight-bearing force when carrying heavy objects.

Physical examination reveals little, but by finding persistent

tenderness under the head of the first metatarsal, the possibility of this fracture should be considered. Out of five cases, four were found to be fractures of the internal sesamoid, which is more distinctly in relation to the head of the metatarsal bone. The best treatment is removal by operation.

Thurstan Holland states that, developmentally, the inner sesamoid may be in two, three, or even four separate bony pieces. Many times, says Holland, such a bone has been described as fractured when there has been a history of injury, but, in his experience, fracture must be a very rare occurrence, and most of the so-called fractures are really nothing of the kind. Comparison should be made with the other foot. In the same paper, he reminds the surgeon of the bone of Vesalius, referred to above, which is probably a persistent epiphysis, part of the spur-like process at the base of the fifth metatarsal bone. At first sight it looks like a chip of bone separated as a result of injury.

Operative Treatment of Fractures

In these lectures I have confined my remarks to the conservative treatment of fractures, but operation may be part of the conservative treatment, and in a number of cases, especially when necessary appliances are not available, the displacement of fractured extremities may be reduced without internal fixation by open operation. Afterwards the treatment along conservative lines is continued.

In very few cases within recent years have I found it necessary to apply plates, screws, metal bands, or bone grafts.

I think the internal fixation of fragments with foreign bodies served a useful purpose during a period when splints, such as Liston's splint, Cline's splint, and MacIntyre's splint, were the best known to surgery, and were often responsible for deplorable results. During this period neither traction nor suspension was generally understood. I think plates and screws have done the same service in the surgery of fractures as Murphy's button has done in the case of intestinal surgery, at a time when the technique of suture of the intestines was in its infancy. The work of Sir Arbuthnot Lane, and others of the same school, has been an immense impetus to those working for better results in the treatment of fractures, and I believe it will go down to history as an important landmark in the march of surgery.

It appears to me that the time has arrived when the routine operative treatment of recent fractures must be regarded as a confession of failure—a confession that the surgeon is unable, by manipulative methods, to reduce deformity and to keep deformity reduced until a first-rate functional result is assured.

Imagination and skill are more often required in the non-operative than in the operative method of treatment. The management of a case for the first three or four weeks requires constant and minute attention, but these disadvantages must be offset against the very real dangers in connexion with operation, especially in the case of fracture of the femur. Even assuming the most perfect surgical technique, delayed union, non-union, delayed infection, perhaps through the blood stream, may take place, and the treatment of fractures so complicated must be commenced de novo under the most unsatisfactory conditions. I speak only of recent fractures. If conservative treatment is not successful in the first instance, a new beginning can usually be made with a bright outlook, provided too long an interval of time is not wasted before the surgeon sees the error of his ways.

The wave of thought in favour of operative treatment of fractures during the decade prior to the War was due to faulty teaching in orthopædic methods. Every student was taught with minute accuracy how to reduce dislocations. No surgeon ever dreamt, unless under very exceptional circumstances, of reducing dislocations by open operation. It was different in the case of fractures. I can remember quite well how minutely I was taught the mechanism of the displacement of the fragments in the case of fractures, and when that aspect of the injury was completed, the teachers and the textbooks went straight on to a detailed description of a multitudinous variety of splints and the methods of their application. There was hardly an intelligent sentence in reference to the all-important subject of reduction.

It is on reduction of displacements and the attainment of a perfect alignment that union and a good functional result depend. I can give no better example of this than fracture to the neck of the femur. It was no wonder that a rising generation of surgeons before the War determined that by some means or another alignment and reduction must be assured, and in an aseptic era the easier method appeared to be open operation.

The War has come and gone and we know that by non-operative methods we should be able in the great majority of cases to attain perfect alignment and a perfect functional result free of risk, immediate and remote. To this day there are cases, few and far between, where a Murphy's button is of use in intestinal surgery, and so occasionally operation will be needed in a surgeon's practice. In the realm of fractures there will remain the patella, the olecranon, and a rapidly decreasing number of the oblique fractures of the lower third of the tibia and fibula, which may defeat all efforts at conservative treatment.

A NOTE ON AMPUTATIONS, WITH SPECIAL REFERENCE TO THE "SLEEVE" AMPUTATION OF THE THIGH IN SEVERE INJURY AND DISEASE*†

NOTWITHSTANDING the experiences of the War, there is often hesitation in departing from time-honoured teaching. This is particularly noticeable in the case of amputations.

To those who were members of the War Office Committee of Surgeons and Limb Makers (afterward attached to the Ministry of Pensions), it became obvious that many of the ideas about amputation, disseminated through the medium of textbooks, were fundamentally at fault. Thus, it was generally agreed that there was no place, or very little place, for amputations about the foot which are associated with the names of Lisfranc, Chopart, Roux, etc.; and that Symes's amputation could be improved upon by dividing the tibia and fibula at a higher level.

It was the opinion of most surgeons and limb makers that amputations through the knee joint were undesirable, for it was impossible properly to fit an artificial limb to a stump constricted below the middle and broad at either end. Furthermore, the projection of the knee joint of the artificial limb in the sitting posture was unsightly, except in females when this deficiency was hidden from view by a skirt.

The operations of Faraboeuf and Teale were condemned by most observers, and the retention of the patella, as in the operations associated with the names of Stokes and Gritti, was shown to be a handicap to the limb makers, unless section of the femur was made at a level unnecessarily high. Amputation at the hip was found to be best when performed by skin flaps and the muscles cut very short, the neck of the femur being divided, and the head left behind to fill up the acetabulum. The best results were obtained when the soft parts were cut so short that they could not push the artificial limb off the tuber ischii. Operations less than 3 inches above and below the level of the knee joint or elbow were avoided. Corner did a service to the

* Read at DesMoines Tri-State District Medical Association, October 1923.
† *Surg., Gyn., and Obstet.*, July 1924.

profession in emphasising these matters, and in pointing out that the amputations remaining in use in the lower limb were: (1) amputation of the toes, (2) Symes's amputation, (3) through leg amputation with skin flaps, (4) amputation of thigh with long anterior and short posterior flap, and (5) amputation through the neck of the femur with skin flaps.

In the upper limb there remain: (1) amputation of the fingers, (2) amputation of the forearm with equal skin flaps, (3) a circular amputation of the upper arm, and (4) Spence's amputation at the shoulder.

The "sleeve" amputation, referred to in the title of this communication, is a method designed to meet certain emergency operations with the least possible surgical risk, and with a view to the conservation of the longest possible stump. The orthodox method of obtaining healthy flaps well above the injury or disease is departed from, and the amputation is carried very much lower than most textbooks would sanction.

Three patients at present under observation will suffice to illustrate the method of amputation which, during the past few years, has been found serviceable in these and many other cases. The actual operation is carried out along the lines suggested by Sampson Handley,* but the general principles involved are not the same.

CASE 1.—In 1916, a strong labouring man was run over by a motor lorry and sustained a fracture about the middle of the shaft of the right femur. Ten days afterward he was seen by the writer.

The leg, from the foot to just below the knee, was gangrenous: the thigh was enormously swollen, red and œdematous; the skin was mottled and vesicated, and large patches of black and purple discoloration extended over a wide area. The thigh had all the appearance of the early stages of moist gangrene which had already destroyed the leg. The œdema, vesication and discoloration extended upward on the abdomen. A tourniquet could not be employed owing to the condition of the soft tissues, and for the same reason digital compression of the vessels was impossible. An incision was made exposing the upper portion of the femoral artery for a length of 2 or 3 inches in order to ascertain its condition. The artery was pulsating in the upper portion of its course, and was held by an assistant between finger and thumb. A circular amputation was quickly performed through the knee joint, just above the line of definite gangrene. The incision was carried above the margin of the patella in front, and the quadriceps extensor tendon divided. The attachments of the soft tissues to the femur were separated with knife and periosteal elevator until the lower segment could be withdrawn by the rotatory movements of a heavy bone forceps, like a cork from a bottle. When the assistant released the femoral artery *there was no bleeding whatever at the end*

* *Brit. M. J.*, 1927, ii, 24.

of the stump. At this level the vessels were thrombosed and obliterated (Figs. 30, 31, 32).

The lower half of the thigh had now the appearance of the sleeve of a coat from which the hand and forearm have been removed. The sleeve was left open and lightly packed with iodoform gauze.

The man made an uninterrupted recovery, except that there was an extensive sloughing of the skin in the upper portion of the thigh. He was seen in August 1923, seven years after operation, and was walking without pain or discomfort with his artificial leg. A scar about the size of the palm of a hand in front indicated where the skin sloughed and was skin-grafted, and the scar through which the femoral artery was exposed was well marked on the inner side (Fig. 32).

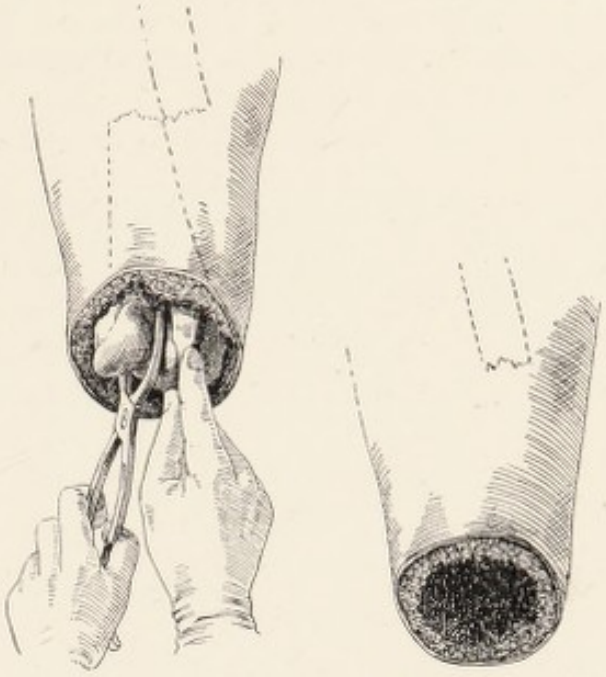

FIG. 30 (left).—Sleeve amputation. The limb is removed by circular amputation and the bone shelled out in the manner shown.

FIG. 31.—Diagram to illustrate the appearance of the stump after amputation.

An X-ray photograph showed irregularities about the end of the femur, and the formation of well-marked osteophytes. Owing to the adequate covering of soft tissues these have given rise to no pain or discomfort whatever.*

It is worthy of note that in this case, and in the other two cases to be mentioned, there was no tendency to abduction or flexion of the stump following the "sleeve" amputation, and that a stump with all the appearance of approaching gangrene, and with thrombosis of the main vessels, recovered with limited sloughing of the superficial tissues.

FIG. 32 (left). Case 1.—The large scar indicates area of superficial sloughing; the inner scar, the site of exposure of the vessels.

FIG. 33. — Illustrating voluntary flexion of stump in Case 1.

I am indebted to Doctor O'Neill and Doctor Coady for their assistance and advice in the management of the case.

* Muirhead Little, *Brit. M. J.*, 1917, states that osteophytes are rarely a cause of disability.

CASE 2 illustrates the good result which can be obtained by amputating by the "sleeve" method well below and not above the area of septic infection.

In 1920, a policeman was shot in the upper portion of the left thigh, and sustained a compound fracture of the femur. He was seen six months later, in consultation with Dr. O'Malley of Galway.

There was no attempt at union of the fractured bone. The soft tissues at the upper portion of the thigh in the region of the fracture were riddled with sinuses. Each discharging sinus led to bare bone at the site of fracture. The patient was very ill, pale, wasted, and anæmic. There was albumin in the urine, and there was no doubt in our minds that as a *dernier résort* an amputation should be expeditiously performed.

FIG. 34. Case 2.—Compound fracture of femur in upper third. Amputation by sleeve method 8 months after injury. The line of section is well below the sinuses in soft tissues.

To obtain healthy flaps and remove the disease, an amputation through the hip joint or through the neck of the femur was indicated. Here, again, the high mortality from such a procedure in such a case was obvious, and the great permanent disability of a through-hip amputation, even if the patient survived, required consideration.

An amputation by the "sleeve" method was decided upon. The incision was made round the knee joint, as before, passing just above the patella in front. With knife and periosteal elevator the lower fragment was freed and extracted by traction and rotatory movements of the leg. Primary amputation through the knee joint, as in the first case, was dispensed with. The stump consisted of a long sleeve, riddled, in this case, with sinuses in the upper portion.

The general condition of the patient rapidly improved, until, after a prolonged convalescence, there was complete recovery. A painless serviceable stump remains, which, I am informed from Blackrock Ministry of Pensions Hospital, lends itself well to the fitting of a modern artificial limb. The illustration shows the position of the multiple healed sinuses in the upper portion of the stump (Fig. 34).

CASE 3.—The third case illustrates the gain of cutting through and not above septic tissues, when adopting the "sleeve" plan of amputation in certain cases of osseous disease.

A lad, about 12 years of age, at present under treatment in Mercer's Hospital, suffered from osteomyelitis of the lower end of his femur

for over a year. Frequent palliative operations had been performed before admission to the hospital—the soft tissues laterally and posteriorly were riddled with many sinuses leading to dead bone. The boy was wasted and very ill from prolonged sepsis. An attempt at a radical operation for the cure of osteomyelitis was followed by a pathological fracture at the junction of the lower with the middle third of the femur.

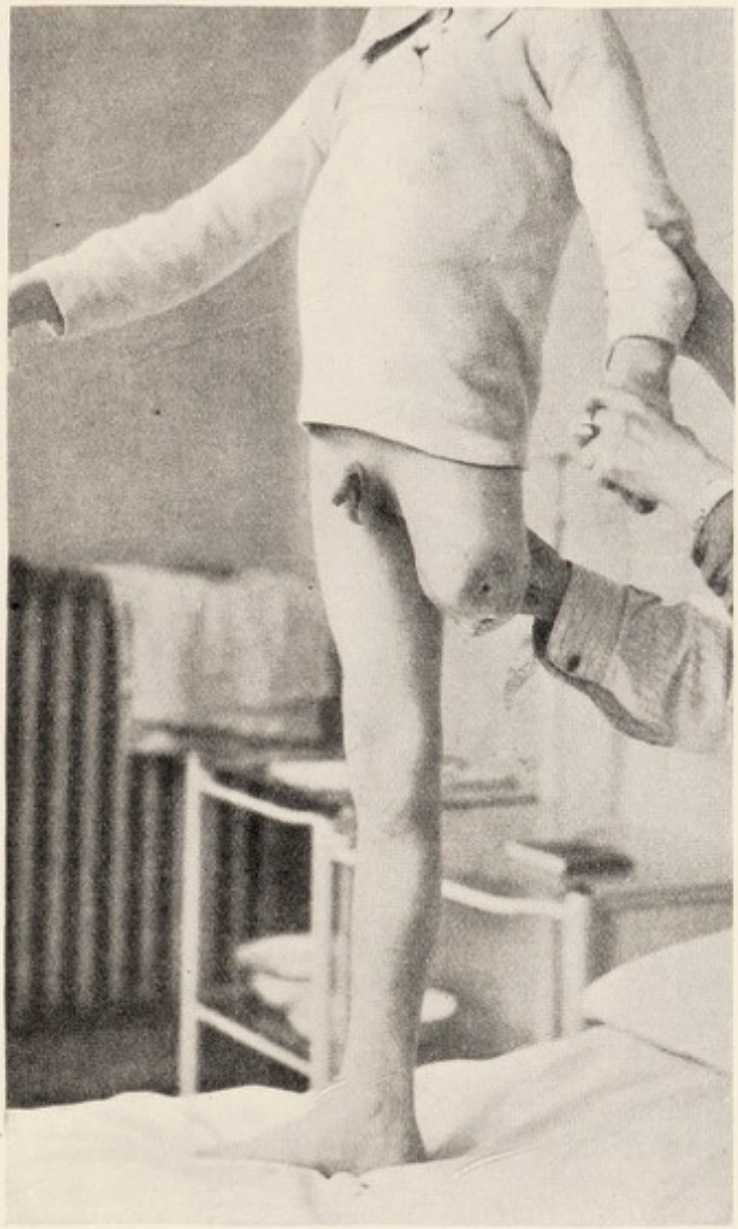

FIG. 35.—Amputation by sleeve method in a case of pathological fracture and osteomyelitis. The soft parts were divided through, not above, the septic area.

The general condition of the patient was very poor, and permission was obtained to amputate the thigh, as a life-saving procedure. To obtain healthy flaps it would have been necessary to commence the operation in the middle of the thigh, and, if the upper fragment of the femur had been filed and trimmed in the orthodox fashion, the final stump would have been within an inch or two of the hip joint an unmanageable position from the limb maker's point of view.

The usual circular incision was made at the knee joint, the knife passing *through* septic tissues and sinuses in the greater part of its course round the limb. In this case it was anticipated that there would be difficulty in securing the vessels in the septic and densely scarred tissues, and, in consequence, the popliteal artery was first exposed, ligatured, and divided near the opening in the adductor magnus. No tourniquet was employed. When the leg was removed, the lower end of the femur was held in a lion forceps, and extracted from the level of the pathological fracture. A few stitches were introduced in this case to bring the edges of the " sleeve " together, and a light gauze pack placed in position to ensure drainage.

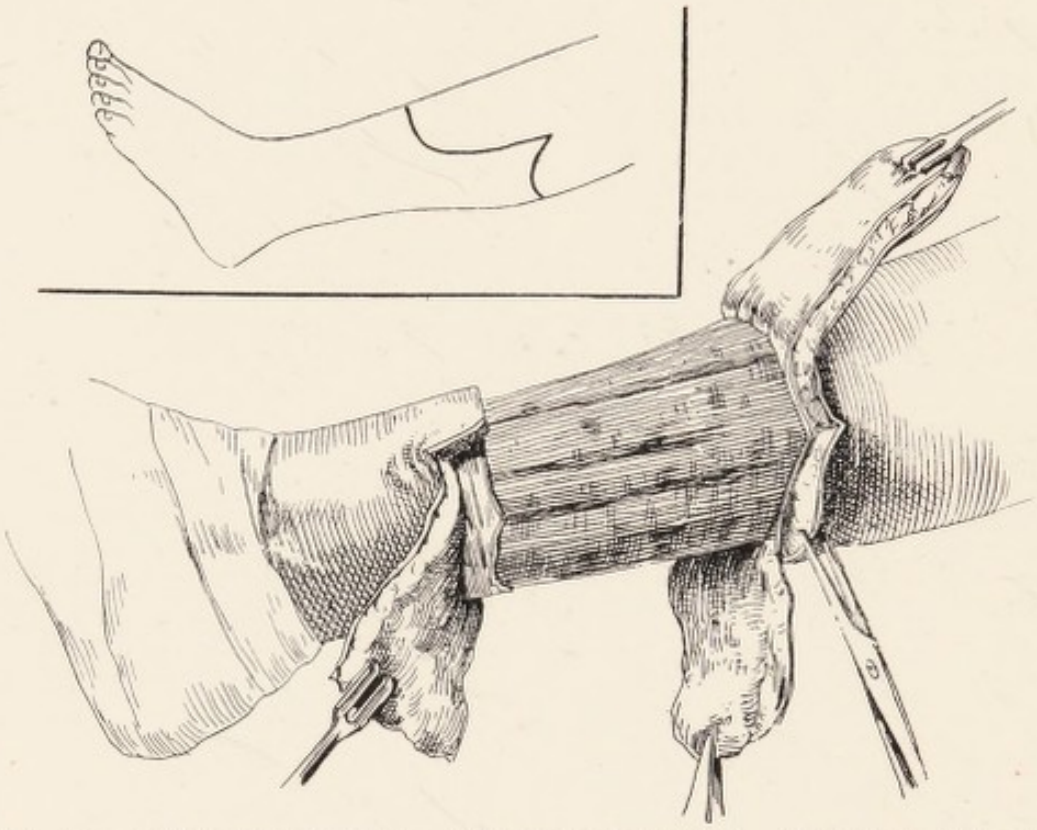

FIG. 36.—Orr's amputation. The line of incision. The skin and fascia flaps are shown.

The illustration (Fig. 35) shows rapid healing of the stump two months after operation.

The " sleeve " operation is suited particularly for cases of complicated fracture of the femur which are bad surgical risks. There is no division of bone with the saw, and there is a proportional diminution of shock. Furthermore, it is usually better to leave the " sleeve " completely open for drainage and contraction, a procedure which saves a considerable amount of time. In all three cases the operation was completed in about 15 minutes.

The operation is applicable to any position in the upper or lower limb, the general principles being the same.

In severe injuries and advanced disease where Symes's opera-

tion cannot be performed, the operation recommended by Orr in *Annals of Surgery*, November 1921, has been performed in several cases in Mercer's Hospital with entire satisfaction.

The site of election for leg amputation is in the middle third. Long anterior and short posterior skin flaps are made. The deep fascia is included in the former. The posterior flap is made quite short, and a flap of fascia is fashioned from behind to turn over the cut end of the stump. The muscles are divided a couple of inches below the point of bone section, and the fibula is cut, as

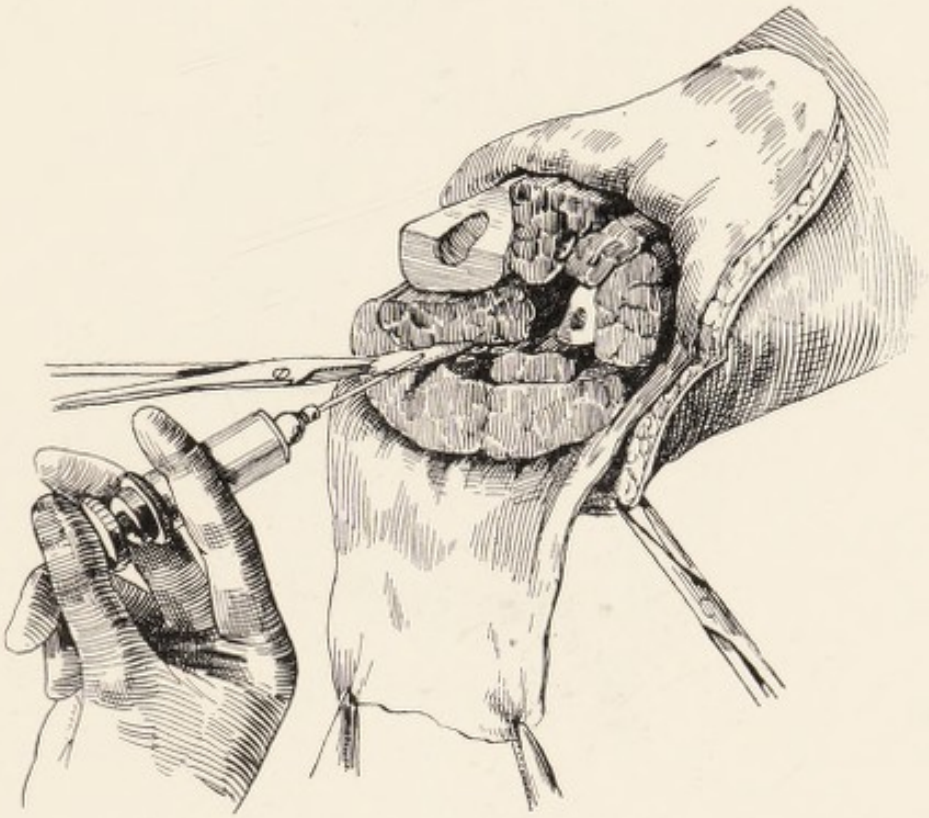

FIG. 37.—Orr's amputation. The leg has been removed. Injection of alcohol into the nerve.

usual, at a higher level than the tibia. The periosteum at the cut end is carefully removed, and the marrow is scooped out with a spoon. The nerves, five in number, are drawn out of the stump as far as possible, and injected with absolute alcohol. The nerve is then divided just below the injected point. This prevents the formation of diffuse neuromata. Sometimes, as an alternative, the nerve is crushed and ligatured by the writer to prevent the growth and lawless distribution of neuromatous tissue.

Muscle flaps are not made, nor is the muscle permitted beyond the end of the bone more than 1 centimetre. Orr thinks that muscle produces an unstable stump which is likely to become chafed or tender. On the other hand, the muscles must not be allowed to retract, and they are fixed round the end of the

tibia with a single purse-string suture of strong catgut. They are also fixed to the fascia, which is sutured over the bone.

The operation gives a firm, rounded stump with skin and fascia freely movable over the bone. The muscles have a new insertion at the end of the stump, which prevents their retraction and the exposure of the bone beneath the skin.

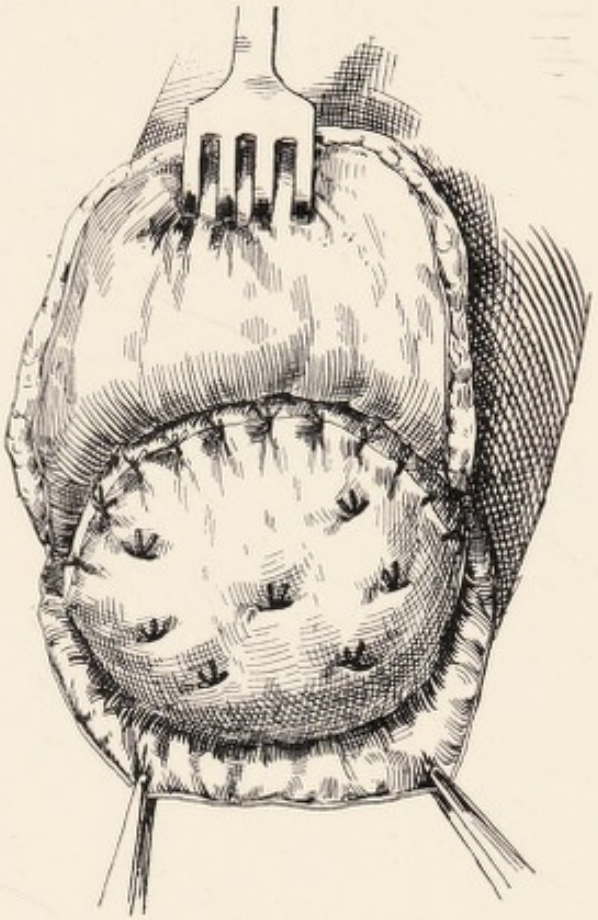

FIG. 38.—Orr's amputation. The posterior fascial flap is sutured into position. The sutures pass deeply into the cut end of the muscle.

If it is necessary to amputate the leg at a higher level, it is a great advantage to remove the fibula *in toto*. Sir Robert Jones points out that, in this way, a piece of bone is removed which stands pressure badly, and, at the same time, the bulk of the stump is diminished so that a flap, which would otherwise be too small, may suffice.

OPERATION AS PART OF THE CONSERVATIVE TREATMENT OF POTT'S CARIES *

OBSERVATIONS FROM A SERIES OF TWENTY-SEVEN CASES

THE position which operative surgery occupies in the treatment of Pott's caries is now somewhat definitely established. For the past eleven years reports have been presented from surgical centres at home and abroad, and numerous statistics concerning the results of treatment are available for comparison and study. It is strange at this period in the history of the treatment, to find so many enthusiasts on the one hand urging the adoption of operative treatment in every case, and so many on the other hand insisting upon the continuance of old-time conservative methods to the exclusion of all others.

In answer to the kind invitation of the Controlling Editor of *The Practitioner*, I propose briefly to state my own beliefs from an experience of a series of 27 cases operated upon during the past eight years.

I have only performed Hibb's operation once, and my remarks will, therefore, be confined to bone grafting as employed to reinforce the conservative treatment of Pott's caries. It must be understood that no attempt is made to remove or deal surgically with the diseased area ; such a procedure, as a rule, is impossible. The operation, which is only designed to produce fixation, may be considered, therefore, as part of the general conservative plan of treatment. Some surgeons fix the diseased spinal segment by means of splints, others by means of plaster, others again by means of a bone-graft, and many, including myself, see the advisability of a combination of methods, designed to reduce the convalescence of the patient by many months.

The idea of introducing a bone-graft to fix a diseased spinal segment has run the gauntlet of healthy criticism, and survived. Whitman sums up the position well when he says : " One may conclude, therefore, that operative treatment, although of the greatest value in selected cases, particularly in the adolescent or adult class, is not to be undertaken as a routine measure in the treatment of Pott's caries, but that it is distinctly supplementary

* From *The Practitioner*, November 1922.

to conservative treatment." And again: "Operations of this character are more likely to be successful in the curative sense in the adolescent or adult class than in early childhood."

Treatment of Children better without Operation

In January 1915 I operated upon a child, aged 5 years, with ever-increasing kyphosis in the mid-dorsal region of the spine (Fig. 39). She had been treated for eight months previously in the country by absolute rest, and later by extension on a Whitman's splint. The disease was exceptionally acute, and the deformity could not be controlled. A rib graft was introduced. The child was apparently well five years afterwards, but subsequently we heard she had died of disseminated tuberculosis.

Shortly afterwards, a child aged 10 years was operated upon.

Fig. 39.—Rib-graft in spinal caries.

A rib was again used for graft. The disease was high up in the dorsal region of the spine, and the operation was prolonged and difficult. The child developed severe acidosis, and died some days after the operation.

In a third case, a child also about 10 years of age (seen by Professor Olgood, of Boston, when visiting Dublin), the lower end of the graft "sprang" from its bed, and protruded through the lower angle of the wound, about three weeks after operation. This occurred without signs of local inflammation. The protruding portion—about 1 in. long—was removed with bone pliers, and the skin at once healed across the gap, leaving the main portion of the graft undisturbed. The child recovered rapidly, and left hospital apparently quite well.

These earlier experiences led me independently to the opinion

that operation was unnecessary, if not actually contra-indicated, in the case of children.

The absence or paucity of suitable institutions for the treatment of crippled children in this country is deplorable, but this want does not justify operation. It is a simple matter to fix a small child on one of the many frames or appliances, to have it nursed single-handed by an intelligent relative, and to permit it—to some extent at all events—to have open-air treatment, even although this is in some open space in the region of a city slum. The child is brought to hospital from time to time, and the state of activity of the disease is tested by repeated X-ray photographs, and at the proper time by tentatively increasing the amount of freedom. Quite often, treatment with fixation is necessary for two years. In this way a surgeon plays for time ; and if it is found necessary, in the end, to help the treatment by the introduction of a bone-graft, the delay in the case of children is a distinct advantage.

Recently a boy, aged 14, was discharged from Mercer's Hospital three months after progressive spinal caries had been treated by the introduction of a bone-graft. In this case it was evident that the patient would never submit to rigid conservative treatment in the country ; and the attendance necessary to enforce quietude could not be obtained. He was sent home, with a letter to his doctor and a strong warning to himself that rest and open air for several months longer was required. I had the satisfaction of knowing that even if further treatment was not carried out, his spine was already firmly fixed posteriorly, and there was a chance of recovery

From the experiences of my series of cases, I do not hesitate to recommend an early operation in every adolescent or adult case with active disease, except those who are in a position to obtain skilled attention and care, nursing, splints, appliances, and orthopædic supervision for two years. If such measures fail and purely orthopædic methods are defeated, the activity of the disease in many cases will be checked with the added fixation obtained by the introduction of a spinal graft. It may be argued that the operation is a severe one, and that the mortality is high. This is not so. The operation has been simplified considerably since its introduction, and the operative mortality in recent years has become quite negligible. It is assumed that judgment is used in the selection of cases. Some patients are such bad surgical risks that no form of treatment will delay the inevitable end. The group of cases under review includes those with kyphosis, with abscess, with paraplegia, with tuberculous lesions elsewhere, and uncomplicated cases—in fact, almost every type of case commonly met with in hospital practice.

Kyphosis

It has been stated that, in all cases with active disease, deformity can be made to disappear completely by conservative treatment. I believe the statement is incorrect, and furthermore that the cause of science is not advanced by the pretension that the impossible has been achieved. I have seen well-marked curvature diminished considerably after postural treatment. At operation, a similar reduction of the kyphotic curve is often possible. I have, for the sake of appearances, removed projecting spinous processes, but I have not seen the uniform and complete successes which are claimed by some.

The first problem in connection with operation on cases with deformity is the shaping of the graft. Twice I have used a rib, but this is not a very satisfactory expedient, for one end of the graft projects considerably further than the other in relation to the focus of disease, and fixation is in consequence not so certain (Fig. 39). Some take the graft from the crest of the ilium with, I believe, satisfactory results. Henderson states that a graft of sufficient curvature can always be taken from the inner surface of the tibia by the electric saw ; but when a long graft is needed, I find the curve is limited and not sufficient to fit some cases of deformity.

In cases of well-marked deformity it is sometimes necessary either to cut the under side of the graft through two-thirds of its thickness at intervals of about half an inch, as recommended by Albee, in order to allow sufficient bend, or to make a green-stick fracture of the graft in the centre. A specimen, obtained from a patient who died of erysipelas (contracted probably from a trophic sore on the leg) six months after operation for spinal caries, showed union of the graft with its bony bed well marked at the site of fracture, and fixation was firmly secured (Fig. 40). As already stated, the deformity can be reduced by pressure at the time of operation when the muscles are relaxed, and this reduction can be maintained by the introduction of the graft and the proper application of a spinal frame. A word of warning is here necessary. Patients with active tuberculous disease of the spine must be gently handled under anæsthesia. Cases have been recorded in which either the anæsthetist, by pushing on the shoulders, or an assistant, by pressing on the feet in order to change the position of the patient on the table, buckled the spine at a time when the guarding support of the erector spinæ muscles is lost.

Abscess

In my experience, one of the most surprising and gratifying features in the treatment of spinal caries is the rapid disappearance

of abscesses after fixation of the diseased segment by a bone-graft.

Recently I operated on a patient with the periosteal type of spinal caries. A lumbar abscess had been aspirated eight times, and was again recurring. A spinal graft was introduced in the usual manner on the opposite side to the abscess, and the latter rapidly disappeared. There is no trace of abscess now—four months after operation.

In about half the cases an abscess can be detected either in the lumbar region, in the psoas sheath, or, as shown by X-rays, extending on one or both sides of the diseased vertebræ. The abscess is treated by aspiration, if easily accessible. In the case of a large lumbar or psoas abscess which has resisted this treatment, evacuation of the contents is accomplished by what

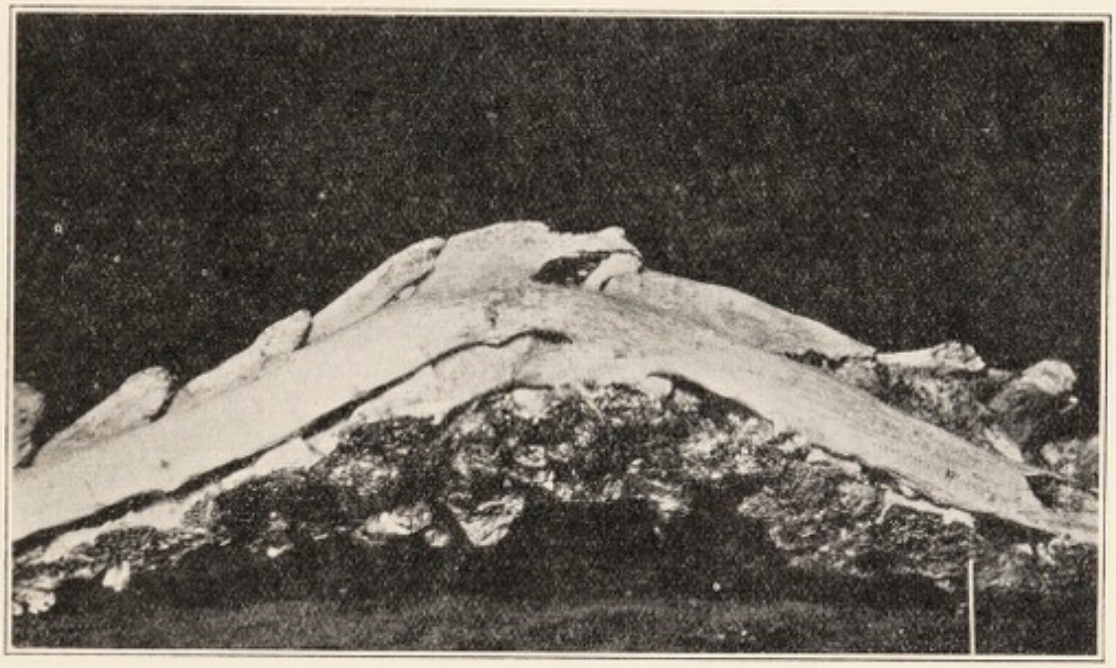

FIG. 40.—Specimen from patient who died six months after operation. The graft was fractured to take the curve. There is strong bony union between the graft and the spinal segment. Firm fixation resulted.

might be called a plan of temporary internal drainage. An incision is made two or three inches long, and the contents of the abscess cavity mopped out with gauze until, by pressure and patience, it is practically dry. The cavity is then filled with a quantity of iodoform gauze, buttered over with bismuth and iodoform paste. The wound is accurately and completely closed over the gauze, but at one angle one or two interrupted sutures are tied with only one knot and left long. By loosening these waiting sutures the gauze can be withdrawn in 48 hours. With its removal a quantity of fluid exudes, containing blood, sterile pus, iodoform paste and debris. The stitches are now carefully

tied and the wound closed once more. As a rule, no further treatment is necessary. The stitches should not be removed for at least a fortnight. Sometimes after a couple of weeks the wound may weep from one or other angle, but this soon ceases and gives no further trouble. Deep abscesses, discovered only by X-rays, are ignored, and as a rule give no trouble.* On one occasion pus welled up as the graft was being laid in position. This neither complicated the after-treatment nor prolonged convalescence.

Calvé reported a method which might be useful in the type of case (rare in our experience) in which an abscess, escaping from the bodies of the vertebræ, presses the cord backwards. A properly curved small metal catheter or canula is pushed through one of the intervertebral foramina, the abscess cavity is entered by this route, and the contents evacuated.

Paraplegia

Paralysis will gradually disappear in some cases treated by conservative methods unaided by operation, but rapid recovery often follows the bone-grafting operation.

A pensioner in Blackrock Special Hospital (Ministry of Pensions) was treated for Pott's caries in the mid-dorsal region by conservative methods under skilled care for almost one year. He had kyphosis and complete paralysis. A stout bone-graft was introduced in May 1919, and within three months movements in the lower limbs had returned. In May 1921, he reported himself; he had developed tuberculous glands in his neck, which were removed. He walked into hospital—the muscular power in his legs had returned to practically normal. In August 1922, he wrote to me to say he was quite well.

A second paraplegic patient treated in Mercer's Hospital made a similar recovery, operation was not performed until prolonged postural conservative methods had failed to produce an encouraging response from the paralysed limbs.

A third patient, a girl aged 17, developed very acute spinal disease with rapid development of kyphosis and motor paralysis. She had had obvious involvement of the antero-lateral columns of her cord. Three weeks after the operation movement began to return in the legs. Three months after operation she could flex and extend her knees, and raise her feet unaided from the bed. The legs were then swung in abduction and extension on a Balkan frame to prevent spastic adduction of the thighs and flexion of the knees, with which she was threatened. Five months after operation the patient was rapidly recovering. Six months after operation, when her final recovery seemed assured, she developed an attack of acute erysipelas in both

* Kanavel, on the other hand, thinks that drainage of the posterior mediastinum in tuberculous abscesses is of great importance. He quotes Jacobs as saying that intra-spinal abscess is the most frequent cause of paralysis in adults.

legs. The infection spread rapidly upwards to the trunk, ending fatally in about ten days. The cause of the erysipelas could not be ascertained. Post-mortem examination showed the graft along its entire length firmly incorporated by osseous union with the spinous processes and the laminæ on which it had been placed. The graft was fractured at operation in order to take the kyphotic curve, and at the point of fracture union between spine and graft was particularly strong. On the superficial aspect the line of fracture could be distinctly seen (Figs. 40 and 41). Fixation of the diseased segment was complete.

Recent writers on the subject of bone-grafting for Pott's disease only go so far as to say that paralysis is not a contra-

FIG. 41.—X-ray photograph of the same specimen showing firm incorporation of the graft with the vertebræ six months after operation.

indication. I believe it is a strong indication for operation, unless there is early response to purely conservative treatment. Bone-grafting is infinitely to be preferred to laminectomy or to such palliative procedures as costo-transversectomy for the evacuation of an abscess cavity. It must be borne in mind that paralysis in these cases is seldom brought about by pressure attributable to the angular deformity, and that it is not due to tuberculous myelitis. Rarely, an abscess spreads back from the body of the vertebræ and presses on the cord ; the trouble appears to arise from pachymeningitis, with the development of œdema and granulation tissue. From a study of the pathology and on the analogy of the treatment of other tuberculous joints, it is easy to understand that the chances of success from laminectomy are more remote than the chances from fixation of the diseased segment.

Fixation, giving absolute and undisturbed rest, is the great curative factor in the treatment of osseous tuberculosis. Complete removal of the disease is never necessary if ankylosis is assured. Fibrosis, ossification and cure follow as a routine. In Pott's caries the same principles of treatment are applied.

Infection

Bone-grafts inherently resist infection. Sepsis, unless severe, will not cause death of the graft. I have had two cases of infection after operation; the first, in a child, has been already referred to.

Fig. 42.—Sequestrum from an infected graft twelve months after operation.

The second patient, a woman about 30 years of age, developed a sinus at the lower end of the wound, which remained discharging for a year. The graft could be felt with a probe fixed firmly in position, but quite bare in the lower portion. At the end of a year a large sequestrum was extruded, and the wound healed rapidly (Fig. 42). A subsequent X-ray photograph showed the graft apparently unchanged and undisturbed. The patient was seen two years later, and had made a good recovery.

Infection has not occurred in any of our recent cases. The greatest care is needed in applying and changing the dressings for the first three weeks after operation. Padding must be applied generously and in many layers to prevent pressure of the splint if kyphosis is present, but it is not necessary to change the dressings more than three times during the first six weeks.

Tuberculous Lesions Elsewhere

Tuberculosis of the spine is a manifestation of tuberculosis elsewhere, but the discovery of a distant lesion is not, in itself, a contra-indication to operation. The following case had a pulmonary focus.

During the war, April 1917, a young officer was invalided home from France suffering from pain in his back and a nightly temperature of 99°. He was labelled as some form of trench pyrexia. During the course of examination X-ray photographs showed a distinct blurring in the dorso-lumbar region, and as pain was reflected in the course of the twelfth dorsal nerve, our suspicions were aroused. A smart hæmoptysis followed and, after recumbent treatment for about six weeks, a bone transplant was put in place. This officer returned to active service (against advice) within six months of the operation, and has since remained quite well. He played football for his regiment in 1919. A photograph taken September 1922 showed the graft *in situ* and the spinal segment firmly fixed.

Behaviour of the Graft.—There is no doubt that, if the operation is performed in the manner originally recommended by Albee, *i.e.* splitting of the spinous processes so that the graft will be supported by a series of forks thus made, bony incorporation between the graft and the bed rapidly takes place. When the graft is placed under the erector spinæ muscle in the groove made by the spinous processes, laminæ and transverse processes, adequate fixation is obtained; but I had some doubts, until obtaining the specimen illustrated, about the solidity of union bone to bone. That this bony union does take place beyond doubt strengthens the case very considerably for performing the operation in the manner described later.

The operation of bone-grafting for spinal caries is followed by more uniform success than similar operations performed upon the bones of the limbs. In the one case, the graft is introduced into a bed of healthy bone far removed from the tuberculous disease situated in the front of the vertebral bodies. In the case of grafting the long bones, on the other hand (the operation is usually indicated in ununited fractures, or to replace defects produced by gunshot or other injuries), old scars must be traversed, sclerosed bone removed, and the operation is often beset with much difficulty. Numerous cases of this kind required attention in the special orthopædic hospitals established by the Ministry of Pensions, and in my experience reasonable success followed operation in about 30 per cent. of cases. In those that failed, the grafts either became absorbed and disappeared, or there was failure of union with the host at one or other end; or, again,

severe infection would arise from old latent sepsis and destroy the graft. (See p. 113.)

In the modified Albee operation, the graft is neither comparable to an inlay graft nor to an intramedullary graft—the former so highly recommended by Albee, the latter by the late J. B. Murphy. The graft employed is more in the nature of the massive lateral graft used with such success, in ununited fractures, by Henderson, of the Mayo Clinic.

I have heard it stated by authorities for whom I have great respect that spinal grafts often disappear and absorb. In a percentage of cases, such absorption may actually take place; but it must be remembered, on the other hand, that bone-grafts sometimes behave in a fashion which is apt to mislead the most experienced surgeon. When an X-ray photograph is taken about three months after operation, the density of the graft may be found considerably diminished, almost to the point of disappearance; but, if another photograph is taken about six months later, the graft in many instances has reappeared to view, more dense and strong in appearance than ever before. When watching the behaviour of bone-grafts after operations at the Ministry of Pensions Hospital, Blackrock, the time when this loss of density was best seen, *i.e.* about three months after operation, was referred to as "the period of anxiety." We never were quite sure whether the graft would entirely disappear and become absorbed, or reappear in a more robust form (Figs. 59, 60).

J. B. Murphy used to write in a picturesque fashion about the removal of a bony brick by the osteoclasts and the simultaneous insertion of another brick by the osteoblasts in the life-history of a graft. It is possible that the destructive activity of the osteoclasts is recognised by increasing loss of shadow, as shown in early X-ray photographs, long before the osteoblastic bricks lose their transparency and cast a shadow on the plate. The failure of new callus to throw more than a faint shadow on an X-ray plate is well known. Thus we see the destructive action earlier than the constructive action in X-ray photographs, although both activities are simultaneous. I have laboured this point because, in my experience, grafts introduced into the spine do not absorb and disappear in the manner seen frequently in cases of old gunshot wounds of the extremities and ununited fractures. There may be apparent absorption, but real absorption in spinal cases in adults is not common.

Operation

The procedure is the same in every case. I am indebted, I think, to Sir Robert Jones, as I am indebted to him for countless lessons in connection with the surgery of bones, for the suggestion

some years ago that a bone-graft can be effectively introduced underneath the erector spinæ muscle instead of into a bed prepared by the splitting of the spinous processes. I have adopted this simple method in every case. It is the method I have seen employed by Sir Henry Gray, of Aberdeen, and commended by him, in a most instructive and illuminating paper.

If there is no kyphosis, the skin is carefully marked before operation to indicate the site of disease. The patient lies prone on the table ; the entire back, including buttock and leg (nearest the operator) to the foot is prepared with methylated spirit and iodine ; the leg is then acutely flexed on the thigh, and the front portion below the knee is similarly treated. The foot is wrapped in a sterilised towel, and sheets are arranged in the usual manner, but in such a way that flexion of the knee can be made during operation without much disturbance. Before commencing the operation, the tissues are infiltrated with 1 per cent. novocain and adrenalin solution ; the infiltration is made both superficially and deeply. Shock is thus diminished, and bleeding very considerably reduced. There is free bleeding, under ordinary circumstances, during the separation of the muscles from the spinal column. Without infiltration the field becomes considerably obscured.

An incision is made about six to seven inches long, the centre of which corresponds to the mark on the skin, or to the most prominent diseased vertebra, when kyphosis is present. The aponeurotic sheath covering the erector spinæ muscle is divided. The muscle is freely separated from the sides of the spinous processes and the laminæ by the use of a sharp knife and periosteal elevator. The bony bed, extending well above and below the diseased area, is laid bare and stripped as far as possible of periosteum. This is accomplished by "scooping" the bone with Jones's gouge, and by a free use of the instrument illustrated. It consists of a rat-tail file or raspatory bent to a suitable angle on a convenient handle. I am indebted to Messrs. Fannin, Dublin, and Thackeray, of Leeds, for accurately carrying out instructions in its manufacture (Fig. 43). The wound is now plugged with gauze to stop oozing, and covered completely over by a sheet or towel.

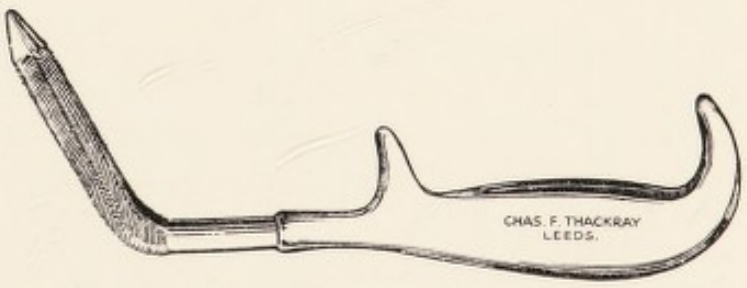

FIG. 43.—Author's instrument for freshening the bony bed under the erector spinæ muscle before introduction of the graft.

The graft is obtained from the tibia, as follows: the knee is flexed on the thigh and held steadily by an assistant. If strongly flexed, little or no bleeding will take place when the incision is made. The length of the graft and the required shape are

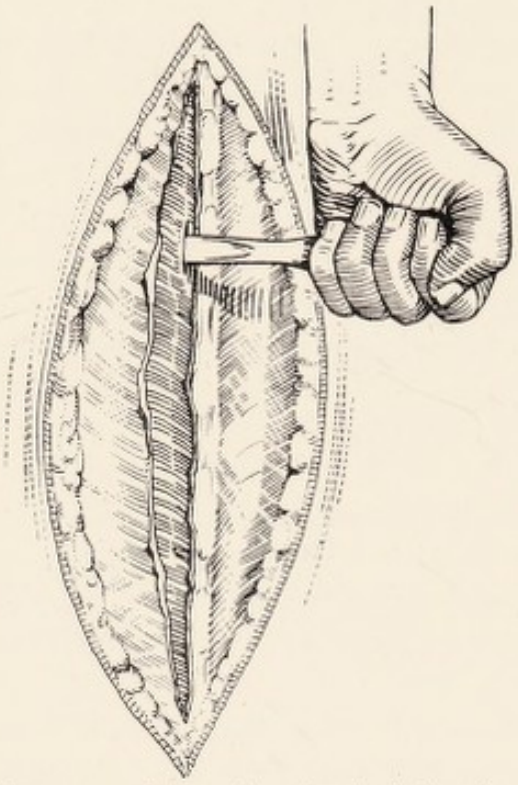

FIG. 44.—Preparing the bed for the graft; raising the erector spinæ muscle.

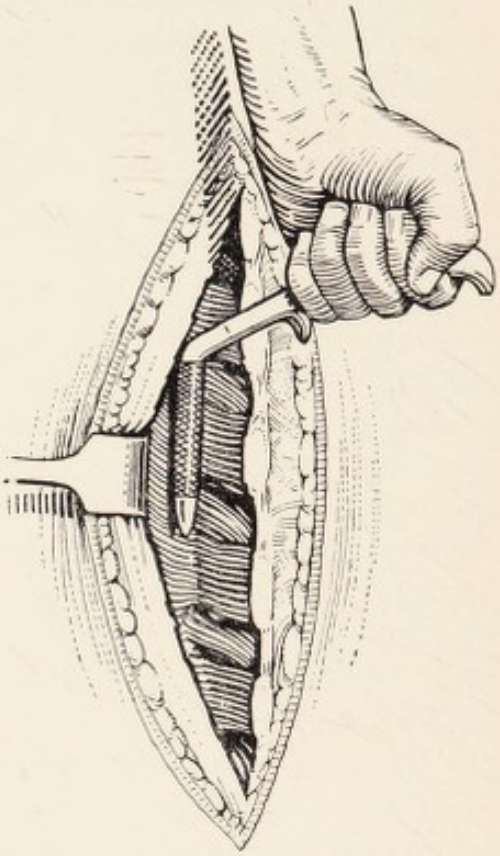

FIG. 45.—Preparing the bed for the graft; freshening the bone.

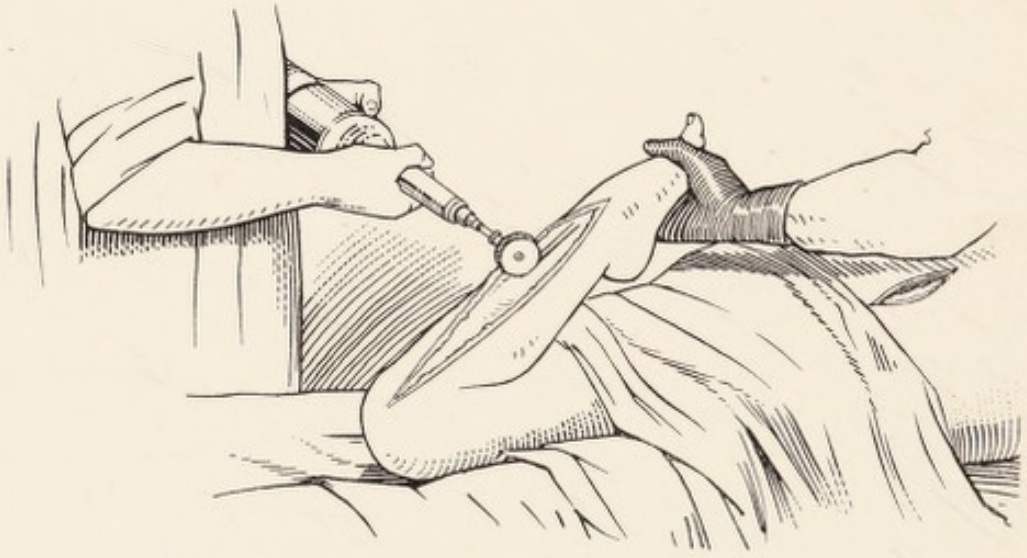

FIG. 46.—Taking the graft from the tibia.

estimated by a flexible probe laid along the tibia after the skin incision has been made; the incision extends from just below the knee to the ankle, and exposes the subcutaneous surface of the tibia. The twin-saw is so arranged that a graft of about half an

inch in thickness, consisting of periosteum, compact bone and marrow, will be secured. The extremities of the graft are cut with a small motor saw, and finally a few touches of a broad chisel render it quite free. It is lifted with two pairs of forceps from the tibia and placed snugly in the bed already prepared underneath the erector spinæ muscle (Figs. 44, 45, 46). An assistant stitches the wound in the leg while the surgeon closes in layers the tissues covering the graft. Copious wool dressings are applied in layers, so that there will be an elastic pressure evenly distributed when the patient is placed on the spinal frame. It is better to adjust the frame (Thomas's or Jones's) while the patient still lies prone, and then gently turn him, simultaneously with the frame, into the dorsal position.

There has been some controversy about the relative merits of the electrically-driven saw and the chisel and mallet. I have used both, and I cannot help feeling that the saw is infinitely preferable. The only argument against its use which seems to me reasonable is that excessive heat is developed during the cutting of the graft. Albee denies that the graft is either overheated or injured if the saw is properly used ; but, at all events, the most important portions of the graft, viz. the periosteal and endosteal surfaces, cannot be injured in this way. I imagine the personal equation comes into this question as into so many questions in surgery, and it is likely that some will do better with the saw than with the chisel and *vice versâ*. I have taken large numbers of bone-grafts from the tibia with the electrical saw. The operation is quicker, the shock less, and the workmanship better than if the cutting is otherwise performed. It requires practice to use the saw to advantage, and it must not be judged until it has been tried a number of times. I have heard it condemned by those who, obviously, never understood its use.

After-Treatment

When dealing with bone-grafts in connection with injuries to the long bones, I came to the conclusion that, on an average, three months' absolute fixation of the grafted bone was essential to success, and that subsequent movements and slight strains were beneficial in accordance with Wolff's law. For this reason, in grafting for spinal caries, the patient is kept on a frame or supported by sandbags in bed for three months, after which he is tentatively allowed to move quietly about with a spinal support. He is given more freedom after six months, but always recommended to behave as an invalid until 12 months have elapsed. In some cases, the rapidity with which the patients lose all symptoms and desire to get back to work, is surprising.

Any return of pain, increasing deformity, reappearance of abscess, etc., are taken as signs that further strict conservative treatment, with all the rest and sunshine obtainable, is absolutely necessary.

In conclusion, I wish to acknowledge my indebtedness to Dr. Garrett Hardman for the trouble he took in producing numerous X-ray photographs while at Blackrock Hospital, for similar work at Mercer's Hospital, and also in connection with my private patients. My thanks are due to Prof. A. F. Dixon and Dr. E. C. Smith for help in connection with this communication. Dr. Milne Henry assisted me at all operations, outside Blackrock Hospital, and to her, too, I am very much indebted.

Since this paper was written, an additional report has been received from the country. Dr. Flanagan, of Sligo, writes :—

"The patient has done very well and is completely cured. He is back at his work as a blacksmith and has suffered no inconvenience whatever. He was operated upon in 1917."

This refers to a case of spinal caries without kyphosis, and with a large psoas abscess.

Conclusions

1. The conservative treatment of children is best without operation.
2. All adults, in the absence of special contra-indications and who either cannot obtain or will not endure prolonged conservative treatment by orthodox methods, should be given the benefit of operation.
3. The additional fixation obtained by a bone-graft often determines cure in a patient who has not responded to the recognised non-operative treatment.
4. Whether the graft is introduced as originally recommended by Albee or laterally under the erector spinæ muscles, firm union takes place bone to bone.
5. Abscesses, as a rule, disappear after operative fixation of the diseased spinal segment.
6. More rapid recovery frequently follows operation in cases of paraplegia.
7. An active primary tuberculous lesion elsewhere is not *per se* a contra-indication to operation.
8. Bone-grafts absorb less frequently in spinal cases than elsewhere, probably owing to the fact that the bed for the graft always consists of healthy bone.
9. The early recognition by X-ray photographs of destructive osteoclastic action should not be mistaken for commencing absorption. The simultaneous constructive activities of the osteoblasts do not become visible until a later date.
10. The electric saw does not cause injury to the graft, and requires practice for its proper use.
11. Prudence dictates three months' post-operative treatment in bed and rest with a spinal support should be advised until twelve months have elapsed.

A further series of 20 cases have been operated upon since this paper was written. The patients are now kept three months on a frame in bed, three months in bed without a frame, three months moving quietly about with a Jones's posterior spinal support, and for three months very quietly trying the effects of the treatment without support. Thus twelve months is given as the average time to complete the cure, but many cases require longer.

Under the old methods of conservative treatment, the outlook for a patient suffering from Pott's caries was deplorable.

Seeman (quoted by Whitman) traced 182 cases, and of the older cases 50 per cent. were dead, and the disease still active in 25 per cent. over a twelve years' period. The cause of death in most cases is disseminated tuberculosis. Jones and Lovett put the mortality from 20 to 25 per cent.

The writer has traced 29 consecutive cases in which he applied a bone-graft as part of the conservative treatment in adults. The age ranged from 16 years to 50. About half the cases had abscesses; one had hæmoptysis at the time of operation. Of these 18 were cured, or apparently cured—(three are too recent to be certain). One of the early cases died immediately after operation (1917); four died of disseminated tuberculosis after they had left hospital and were reaching convalescence. In five, the disease again became active after apparent cure, and the cause of death in one case was not connected with spinal disease.

COMPRESSION NEURITIS DUE TO THE NORMAL FIRST DORSAL RIB

Two cases of compression neuritis, under the care of Sir Harold Stiles, one of which I saw in Edinburgh six years ago, stimulated my interest in a condition which, until recently, has escaped general observation. At first sight the cases appeared to be some form of ulnar nerve neuritis, occurring in adults without trauma, or other obvious reason. On consideration it would have occurred to a surgeon that these patients were suffering from the presence of a cervical rib, but X-ray examination gave a negative result.

During the last few years I saw two cases which I believed to be in every respect similar, but my suggestion that the condition might be relieved by operation was at variance with the opinion of those who had been previously consulted, and I was left with a polite indication from the patients that the activities of surgeons should be placed under some form of legal restraint.

About twelve months ago an athletic clergyman, 35 years of age, presented himself with the following history. He had met with no injury, other than the commonplace falls at football, etc. He had no illnesses worthy of note, except influenza, but he had noticed for the past four years a gradually increasing loss of grasping power in his right hand. The loss of power began with painful cramps, which he attributed to too much writing. Improvement sometimes followed treatment, then a relapse would occur, and he was worse than before. On waking in the morning the arm would " fall asleep," writing became impossible, and he noticed a gradual wasting of the muscles of the hand. He thought that the first finger and thumb were the worst at first, but subsequently the last three fingers were the most affected. Various doctors were consulted, and he was treated, *inter alia*, for writer's cramp, neuritis, and syringomyelia. He always carried a specially warm glove to protect the affected hand from cold.

On examination it was found that the interossei muscles were practically non-existent, and that there was weakness in the median distribution, as shown by the poor attempts to flex the first finger. An inability to extend the wrist fully without flexing the fingers, pointed to involvement of the musculo-spiral nerve. Generally

* From *The Practitioner*, June 1920.

speaking, the appearance of the hand suggested a mild variety of *main en griffe*. Loss of power was most pronounced in the area supplied by the ulnar nerve. Sensation appeared normal, except in the ring and little finger, and here it was only slightly altered.

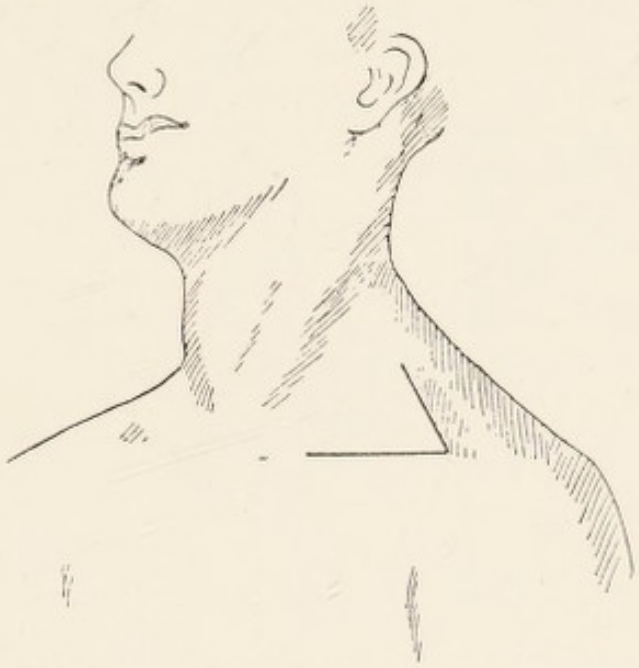

FIG. 47.—Incision for removal of the first rib working from behind.

He could not tell degrees of hot and cold with the same facility as when the test was applied to the normal hand, and he could appreciate light touches better than pinpricks. Pain, but for the initial cramps some years previously, had been conspicuous by its

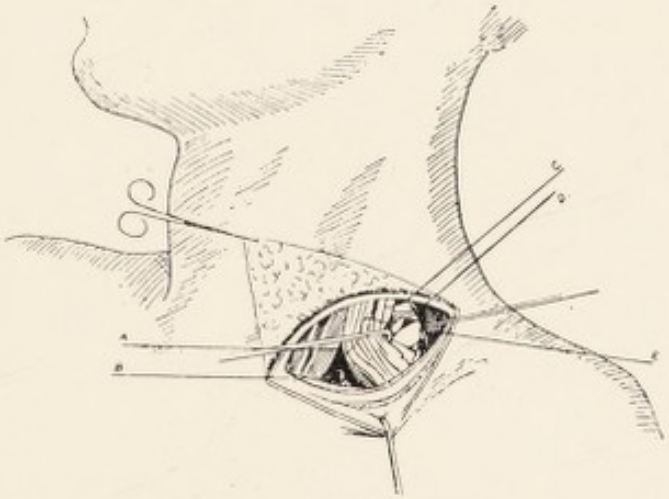

FIG. 48.—Retraction of plexus forwards towards scalenus ansicus (A); Artery (B); Trapezius and Levator anguli scapulæ (E).

absence, and in this respect his case differed from others recorded. X-ray photographs demonstrated the absence of cervical rib, and showed a normal thoracic inlet.

During the examination the patient made a statement of great interest, with direct bearing on his condition. He said that the

gripping power of his fingers depended greatly on the position of the arm. Above his head his power was increased, and he could write on a blackboard steadily, and with ease. Grasping a tea-cup, on the other hand, was almost impossible. On giving him a pen and paper he wrote his name like a man suffering from paralysis agitans; but when the paper was put on the wall above his head the writing was clear and steady.

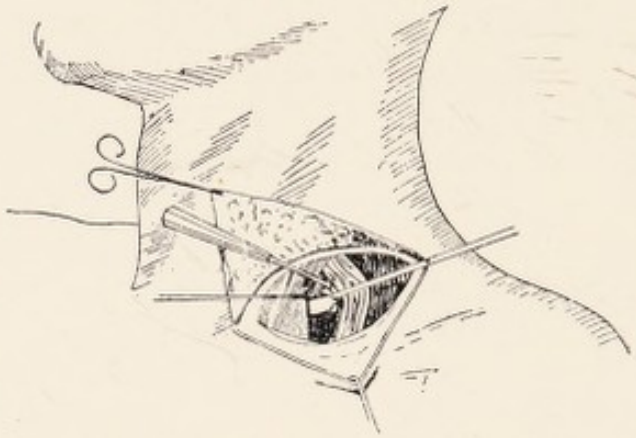

FIG. 49.—Exposure of the rib nearer the compression point, the plexus is now retracted backwards.

Treatment by massage, ionisation, hot-air baths, etc., was tried for several months. Special attention was given to the upper fibres of the trapezius, in the hope of increasing the support of the pectoral girdle upwards. There was no lasting improvement in his condition, and a paper published in the *British Journal of Surgery*, by Stopford and Telford, in October 1919, describing ten consecutive cases of

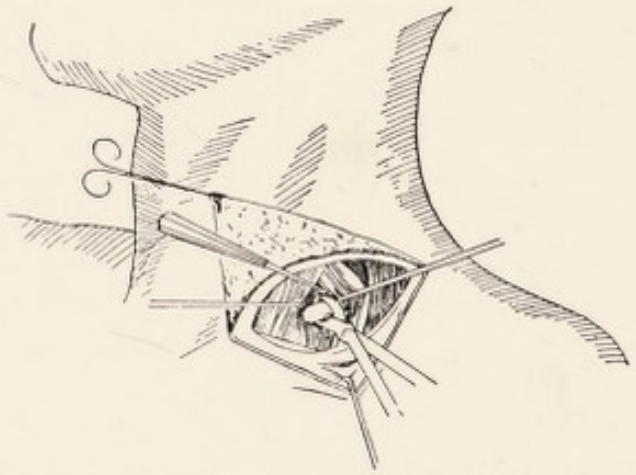

FIG. 50.—Division of rib between the retracted artery in front and the plexus behind.

the condition, removed any remaining doubts as to the best line of treatment to adopt.

The operation of removal of the first rib is out of the beaten track of most surgeons, and a lively recollection of the anatomy called for pause. The experience of this case, however, and subsequent operations on the cadaver leads me to think that the

operation is not difficult, and may be accomplished with practically no risk.

On January 1, an incision was made above the clavicle, as if for ligature of the subclavian artery, a second limb was added, running parallel to the fibres of the trapezius muscle. A little dissection brought the external jugular vein, the posterior belly of the omo-hyoid, and the nerves of the brachial plexus, crossed by the transversalis coli vein into view. A finger in the wound found the back part of the first rib much higher in the neck than was mentally assumed. The brachial nerves were drawn forwards and downwards, and the interval between the scalenus medius and levator anguli scapulæ muscles defined. The roots of the nerve of Bell in this position were not seen, but their hidden presence was respected. The attachment of the scalenus medius muscle to the first rib was divided sub-periosteally, and the inner border of the bone cleared of periosteum and Sibson's fascia. Doyen's rib elevator and cleft-palate raspatories were used to bare the underside of the rib, and to separate it from the underlying pleura. The rib was then divided with shears behind the scalenus medius. I felt I could not get far enough forward by dissection from behind, and when the rib was defined I retracted the nerves and other structures back, and cleared the bone between the artery and the lower brachial trunk. The rib was now cut in front of the groove, which is supposed to carry the subclavian artery. It was noted that the artery did not lie in direct contact with the rib, but the nerve was tightly stretched like a band across the inner border. At the completion of the operation, when cutting away an irregular point of bone, either the external jugular or subclavian vein was injured. The bleeding was controlled in a moment, and we had the satisfaction of feeling that the bone had been divided well in front of the compression point. The segment of rib removed extended from the posterior edge of the insertion of the scalenus medius to the scalene tubercle, so as to include the groove for the subclavian artery, and the trunk formed by the eighth cervical and first dorsal nerves. Subperiosteal resection of the first rib may possibly be followed by regeneration of bone, but there are two reasons why a recurrence of compression of the nerve is unlikely :—(1) After removal of the segment at fault the divided ends of the rib fall towards the thorax, and new bone would take a curved direction away from the plexus. (2) The periosteum is of necessity stripped from the rib like rolling up a sleeve, and not by two flaps in the manner usually adopted lower down.

Some months must elapse before the result of this procedure can be judged. Following operation, as might be expected, there was more pronounced sensory and motor disturbance over a wide area, due to the retraction and handling of the plexus. In Thorburn's cases of cervical rib, pain was relieved by operaton in 80 per cent. ; paralysis was cured in 50 per cent. ; impairment of sensation was improved in all, but cured in none ; wasting usually persisted.

In addition to the cases operated upon by Stiles (unpublished),

Thorburn, Murphy, Morley, Stopford, and Telford have drawn attention to brachial compression neuritis produced by a normal first rib.

The symptoms in a general way are those of cervical rib. Pain along the ulnar border of the arm and forearm was present in all the cases described by Stopford. The pain was always increased by anything producing depression of the shoulder girdle. He states that atrophy and paresis affect for the most part the intrinsic muscles of the hand, but the flexors and extensors of the wrist not infrequently are involved. Loss of protopathic sensibility is greater than the epicritic loss ; a dissociation which denotes nerve compression.

Ætiology.—Any condition which lowers the shoulder girdle, such as fractured clavicle, will pre-dispose to compression by bringing the lower trunk in more close relationship with the first rib. The majority of cases, however, occur in young adults without apparent cause. There is some evidence to show that when an unusually large contribution from the first or second dorsal nerves goes to the formation of the lower trunk of the brachial plexus, any condition which lowers the shoulder girdle may cause compression against the first rib. At puberty a descent of the shoulder normally takes place, especially in women. If there is muscular weakness, and this normal descent is exaggerated, and, at the same time the lower brachial nerve trunk contains a larger contribution than usual, compression is likely to occur.

Diagnosis.—The history of the case ; pain along the internal cutaneous nerves ; atrophy of the intrinsic muscles of the hand ; the perception of touches with cotton wool, with the absence of distinct feeling of pin-pricks to the inner fingers ; and very constantly a loss of accurate differentiation between degrees of hot and cold are guides in excluding rheumatism, or simple neuritis. Inflammatory conditions of the nerve roots (radiculitis) are often associated with inequality of the pupils, due to sympathetic involvement in a position above the point where compression of the lower trunk takes place at the first rib. Syringomyelia must be excluded ; and it is interesting to note that Murphy has drawn attention to an association between this disease and the presence of cervical rib. J. B. Murphy states that occasionally elongation of the transverse process of the seventh cervical vertebra, or acute angulation of the first rib at its juncture with the transverse process, produces the same symptoms as a true seventh cervical rib. Great care must be taken to ascertain, before removal of a cervical rib, that it is the real cause of the trouble. At least one case is described in which a cervical rib was present, but the compression of the

nerve was due to a normal first rib, and the symptoms disappeared after removal of the latter.

I have to thank Professor A. K. Henry for his assistance in connection with the literature on the subject, and for valuable suggestions made when working on the cadaver. Dr. McAuley kindly assisted me at the operation, and Sir Harold Stiles wrote me a full description of the operation as performed by him.

SURGERY OF THE SACRO-ILIAC JOINT

THE difficulty I experienced in obtaining from current literature precise information in the study of three recent cases of sacro-iliac disease is my excuse for offering a short contribution to the surgery of the joint. To deal with this subject and to estimate at the proper value the present position regarding the diagnosis, prognosis, and treatment of sacro-iliac disease it is necessary to recognise certain gross anatomical and pathological facts.

The sacro-iliac is a diarthrodial or amphiarthrodial joint composed of two great masses of very vascular cancellous bone enclosing a negligible synovial cavity.

There is no *post-mortem* or operative evidence to show that disease ever originates in the synovial cavity, and the possibility may be dismissed from the field of practical surgery.

On the other hand, the cancellous bone of the ilium or sacrum is a suitable nidus for the development of a tuberculous or septic focus such as is so commonly found in the metaphysis of long bones (Fig. 51). To the surgeon contemplating operation the great posterior sacro-iliac ligaments and the excessive thickness of the iliac bone in the region of the posterior spine offer a powerful barrier. The posterior ligaments are of primary importance, supporting as they do the weight of the superimposed trunk on the pelvis.

In contrast to the great thickness of bone in the posterior region of the joint there is but a shell of iliac bone occupied by the gluteus medius muscle covering the articulation on the outside (Fig. 52).

The lumbo-sacral cord bears a direct anterior relation to the joint, hence the frequent presence of sciatica at the onset of sacro-iliac disease.

Diagnosis.—It is necessary to go back a number of years before finding in the literature anything but a passing mention of the symptoms. Erichsen gave us the classical description which detailed five cardinal symptoms—pain, lameness, changes in the attitude of the limb, swelling and abscess.

But do these symptoms bear investigation? The pain is far from being characteristic if it exists; lameness conveys nothing to a surgeon with an open mind; changes in the attitude of the limb occur in almost every pathological lesion of the lower extremity; swelling and abscess herald a vast destruction of the joint, which often cannot be checked by surgical means. If these symptoms are to be definitely established before the

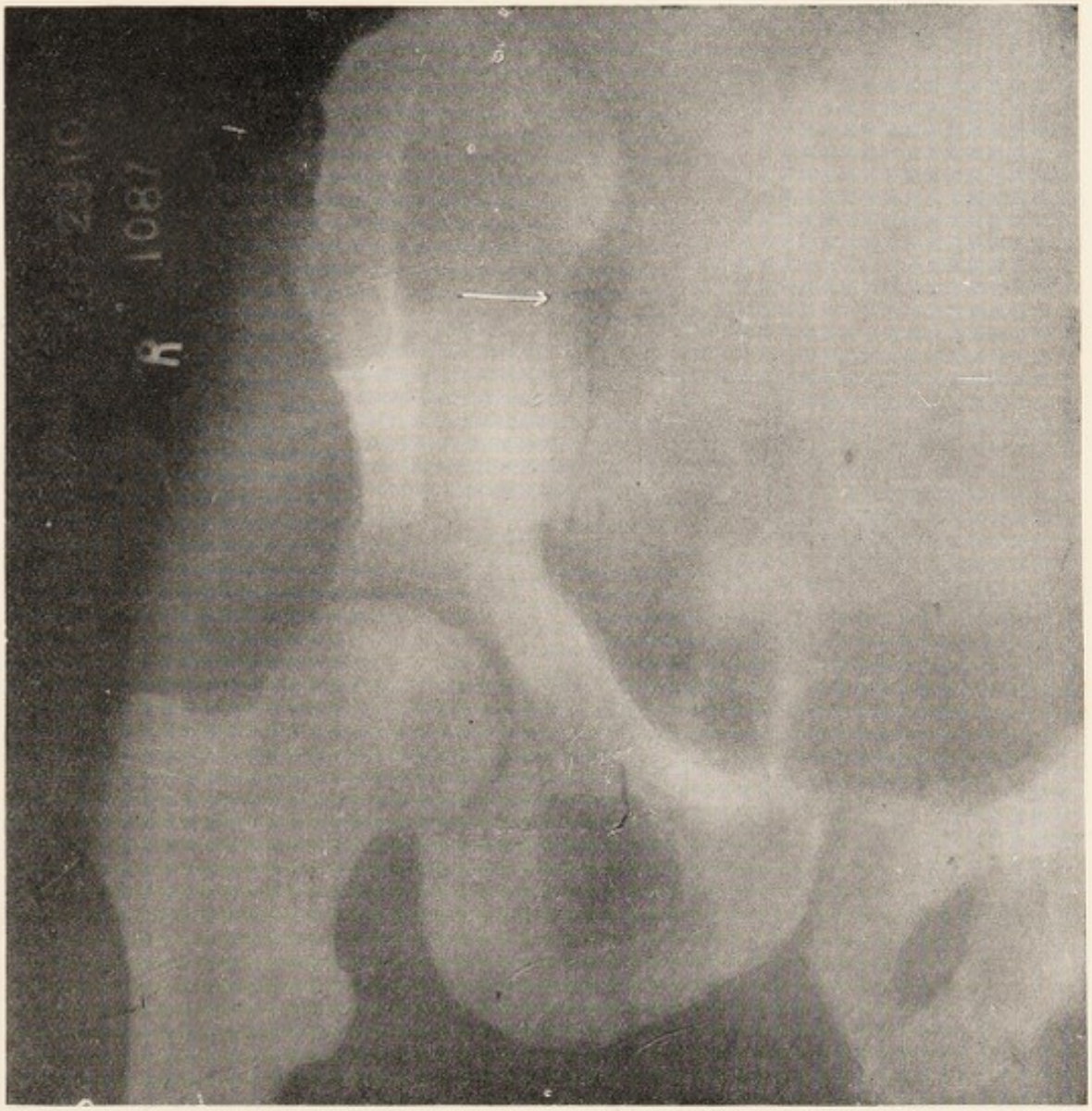

FIG. 51.—X-ray showing a focus in the upper portion of the sacro-iliac joint in a patient, aged 45, with "sciatica."

recognition and treatment of sacro-iliac disease it is courting disaster, and the reason why the prognosis is so exceptionally bad at once becomes obvious.

One is reminded of the words of Murphy when describing another disease—that a case with these symptoms already present is one for an undertaker and not for a surgeon.

Signs, such as pain on crowding together the iliac bones, tenderness in the front of the joint as examined per rectum, scoliosis with drooping of the pelvis, wasting of the muscles, and pain on heavy percussion behind, may be taken as occurring late, after advanced disintegration of the joint. Such symptoms cannot be elicited at the onset of a focus in the sacrum or ilium, or in primary synovial disease, if such ever occurs.

Too much emphasis cannot be laid on the fact that the text-book signs and symptoms are only present when there is extensive

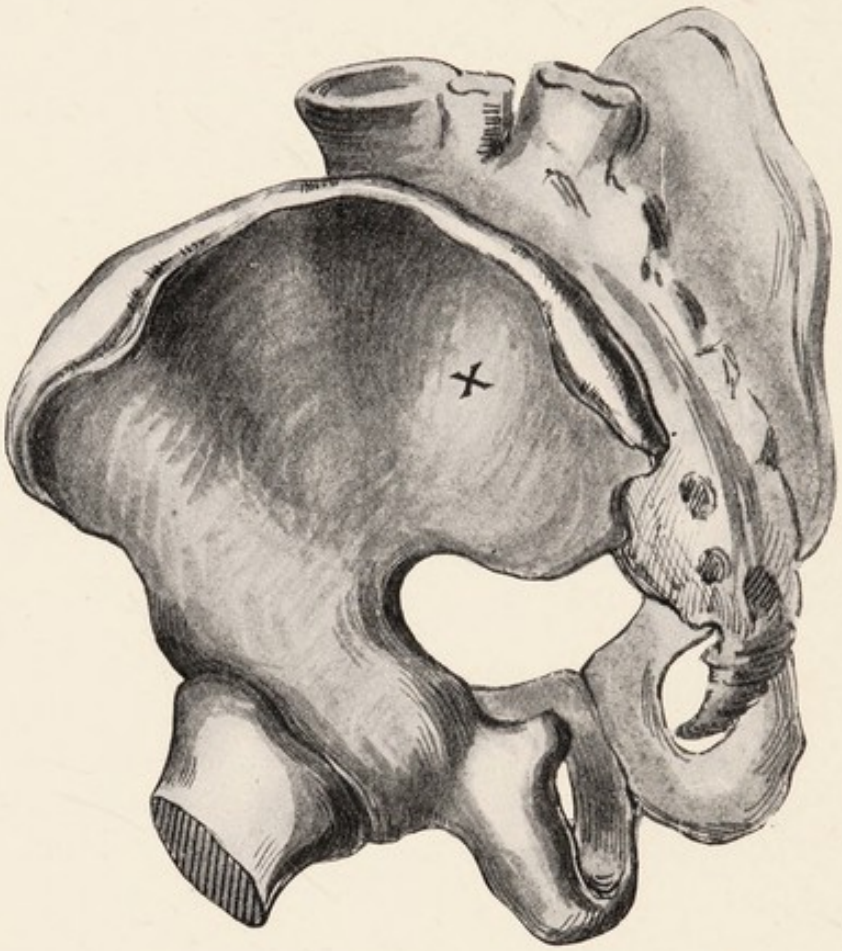

FIG. 52.—X marks the position on the bony pelvis for the application of the trephine or drill to expose the sacro-iliac joint.

destruction, and although the picture is then unmistakable the time is past for successful surgical interference. In the great majority of cases the disease can be recognised at the onset with the same precision as in other joints. For example, all cases of persistent sciatica should be considered as suspect, no matter at what age. The disease has been described in patients of 5 years and in patients over 60, but the most active years of life, from 15 to 35, should be watched with most suspicion. The sciatic pain in sacro-iliac disease often stops at the knee, and, in addition, radiates upwards into the sacro-lumbar region over a wide are a

In more advanced cases the pain may be accompanied by tenderness over the course of the superior gluteal nerve.

The general movements of the patient, notwithstanding the free and unimpaired action of the hip-joint, are restricted, and there is obvious difficulty in turning or assuming a comfortable position in bed.

An acute onset with considerable rise of temperature was found in the first case I have to record in this paper.

If under ordinary treatment there is not a rapid subsidence of the pain and discomfort alluded to, no time should be lost in obtaining a good radiograph of the pelvis. The line of the sacro-iliac joint is admirably seen and the absence or presence of disease recognised by comparison with the opposite side.

The prognosis of sacro-iliac disease with suppuration is admitted by all to be bad. Of the older writers Erichsen never saw a patient recover after full development of the disease and after suppuration had set in. Makins, on the other hand, describes several cases on which he operated with success after the formation of abscess, and urges the necessity of treatment of the joint along exactly the same lines as for diseases of joints in general. Stiles describes operation on late cases through the posterior route, but reminds us of the very unsatisfactory results. Tubby found in 38 cases of the suppurating form of the disease that without operation there were only three cures, death usually occurring from septicæmia or secondary tuberculosis. Tubby, however, points out that the prognosis is favourably influenced by the thorough removal of diseased bone and the proper treatment of the abscess cavity. He adds that if the cases are seen early and placed under treatment the prognosis is on the whole favourable.

The treatment of sacro-iliac disease, if the diagnosis can be established at a reasonably early period, is in no way different in principle from the treatment of other joints. The indications for operation will be the same, and the cases which will recover by conservative management can be selected.

It is with the operative treatment of sacro-iliac disease that I propose to deal in this short communication. If there is a tuberculous or septic focus present in the sacrum or ilium, as shown by a skiagraph, it should be exposed and removed here, as elsewhere, in as complete a manner as possible. The joint is not inaccessible, and its anatomical relations are such as to make accurate landmarks for the surgeon. The joint must be laid open by precise surgical methods, and on no account is the bone to be reached by following up existing sinuses. Mr. Golding-Bird and Mr. Makins have laid stress on this point.

It is apparent, notwithstanding earlier attempts to treat sacro-iliac disease in a rational manner, that X-ray photography

and aseptic technique have not been utilised to develop the surgery of the joint.

Textbooks on surgical anatomy are as silent on the subject as are the surgical works ; the points which might be of use to the operating surgeon are omitted.

For obvious reasons, attempts to expose the articulation

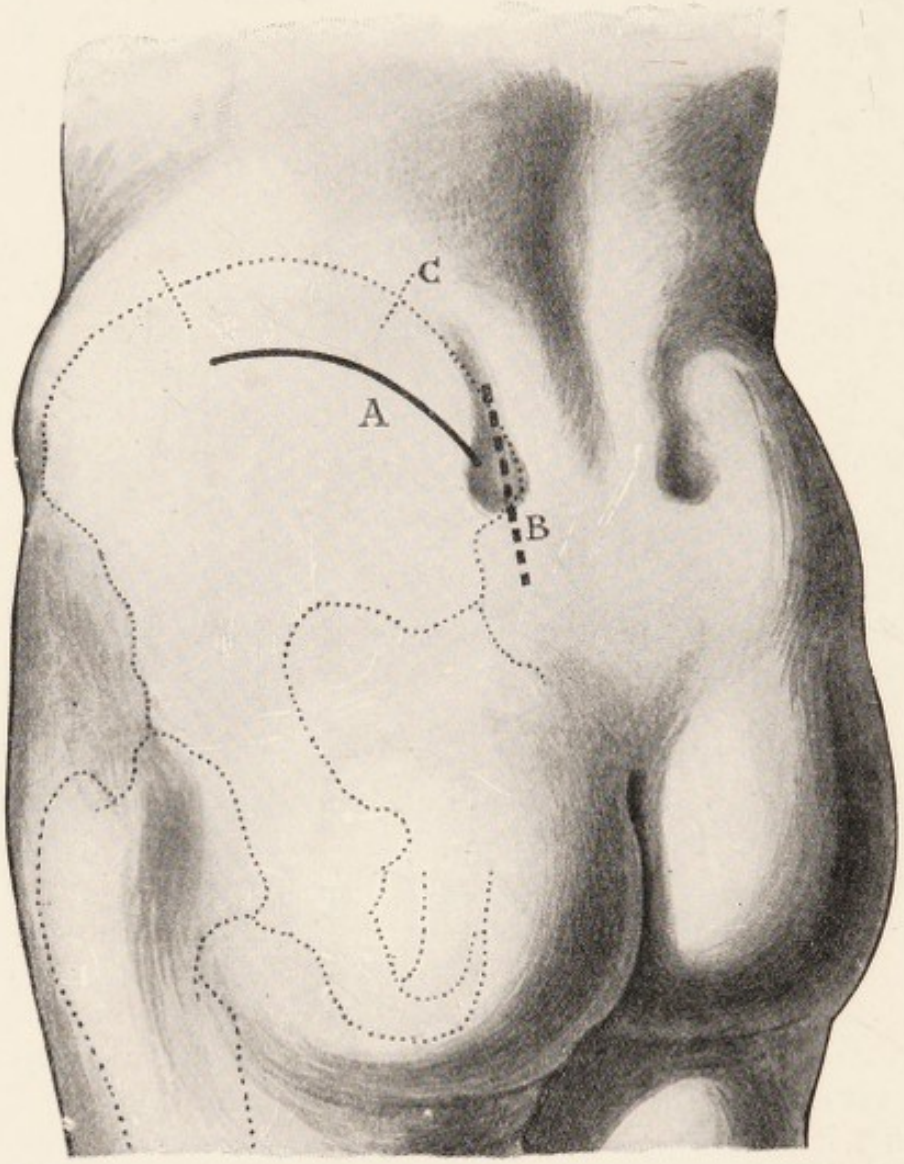

FIG. 53.—A shows the best line of incision, the mid-point of which corresponds to the junction of the posterior third with the anterior two-thirds of the iliac crest. B shows faulty approach to the joint.

from behind are faulty (Fig. 53). By this route the powerful posterior sacro-iliac ligaments offer a barrier which, if broken down, interferes immeasurably with the suspension of the sacrum and superimposed trunk on the iliac bones. Injury to these structures can only be repaired by bony ankylosis after very prolonged rest. Similarly, an exposure of the joint immediately in front of the posterior iliac spine is rendered difficult by the

great thickness of the strong attachment of the gluteus maximus, and by the bone in this region.

On the other hand, in the centre of the fossa occupied by the gluteus medius muscle, about $2\frac{1}{4}$ in. in front of the posterior spine, the bone is thin, and through this a drill or trephine will enter the front of the joint at its highest point.

The exact position can be ascertained on the bony pelvis by joining a point marking the junction of the posterior and middle thirds of the crest of the ilium with the anterior extremity of the sciatic notch. The central point of this line marks the upper and front portion of the sacro-iliac joint.

The first impression on viewing this point on the bony pelvis, and still more so when the soft parts are *in situ*, is that it is considerably in front of the joint, and in this situation the drill or trephine would enter the pelvis. That such is not the case is easily verified.

Assuming that an X-ray photograph demonstrates an osseous focus in an early case of sacro-iliac disease, the operation is carried out as follows : The anterior and posterior iliac spines are marked while the patient is standing. (It is easier to accurately find the posterior spine lying at the bottom of a distinct dimple with the patient in the erect position.)

The patient is placed in the position familiar in kidney operations, and the point marking the junction of the posterior and middle thirds of the crest of the ilium ascertained. A curved incision 4 in. long is made 1 in. below the crest of the ilium, the centre of which corresponds to the point thus indicated (Fig. 53).

The superficial fatty tissue here is strong and well-marked, and lying deep to it is the strong aponeurosis covering the gluteus medius muscle.

These fasciæ are divided in the length of the incision together with the underlying muscle fibres, and the bone is exposed (Fig. 54).

The bone is cleared with a periosteal elevator and the tissues retracted downwards. A finger now feels for the sciatic notch, and the drilling of the bone is commenced midway between this and the crest of the ilium. The best instrument is Doyen's burr with bit and brace (Fig. 55). It should be inclined slightly backwards until the joint is reached. If the bone is removed later with gouge or chisel in a slightly forward direction the pelvic fascia underlying the iliacus muscle can be felt in front of the joint, and an abscess in this position evacuated at the very earliest moment.

If further exposure of the joint becomes necessary, the bone is gouged away in a downward direction towards the front of the sciatic notch and backwards towards the posterior inferior spine if the disease is more located in the posterior portion.

Throughout the operation it is not necessary to ligature any important vessel or to injure the superficial nerves which lie to the front. The position of the incision is an admirable one, for this area lies developmentally between two sets of blood vessels, the segmental above and those for the limb below.

Before illustrating the remarks just made by a very brief

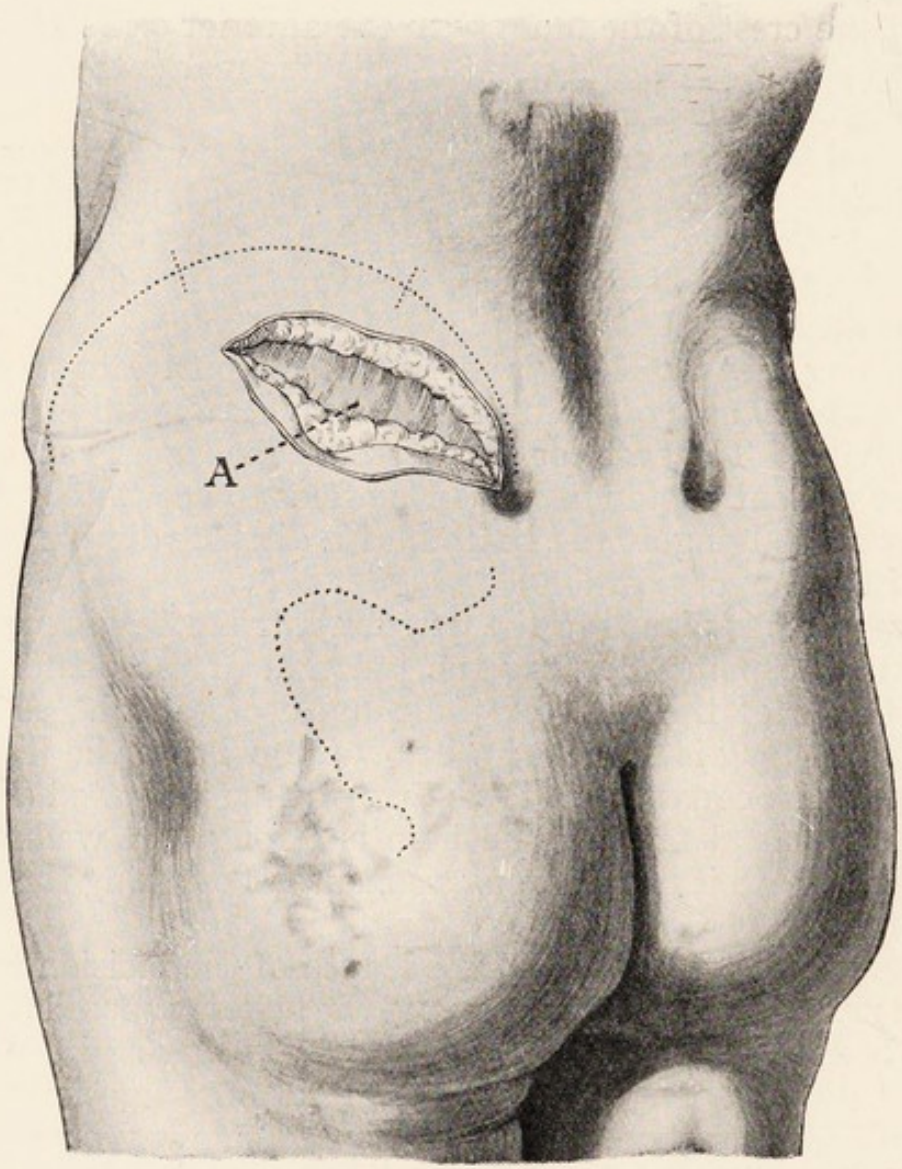

FIG. 54.—The skin and superficial fascia divided, exposing the strong aponeurosis covering the gluteus medius muscle.

mention of three cases, I would like to emphasise the following points :

1. The disease once well established is a very fatal one.

2. Radical treatment in the early stages is frequently indicated and offers a good chance of recovery.

3. The signs and symptoms usually described do not exist in those stages of the disease in which treatment promises most.

4. Vague and persistent pains in the sacro-gluteal and lumbar regions, especially referred down the sciatic nerve, when there is no history of previous similar attacks which got well, should arouse suspicion of sacro-iliac disease, no matter what the age of the patient.

5. An X-ray photograph gives valuable information.

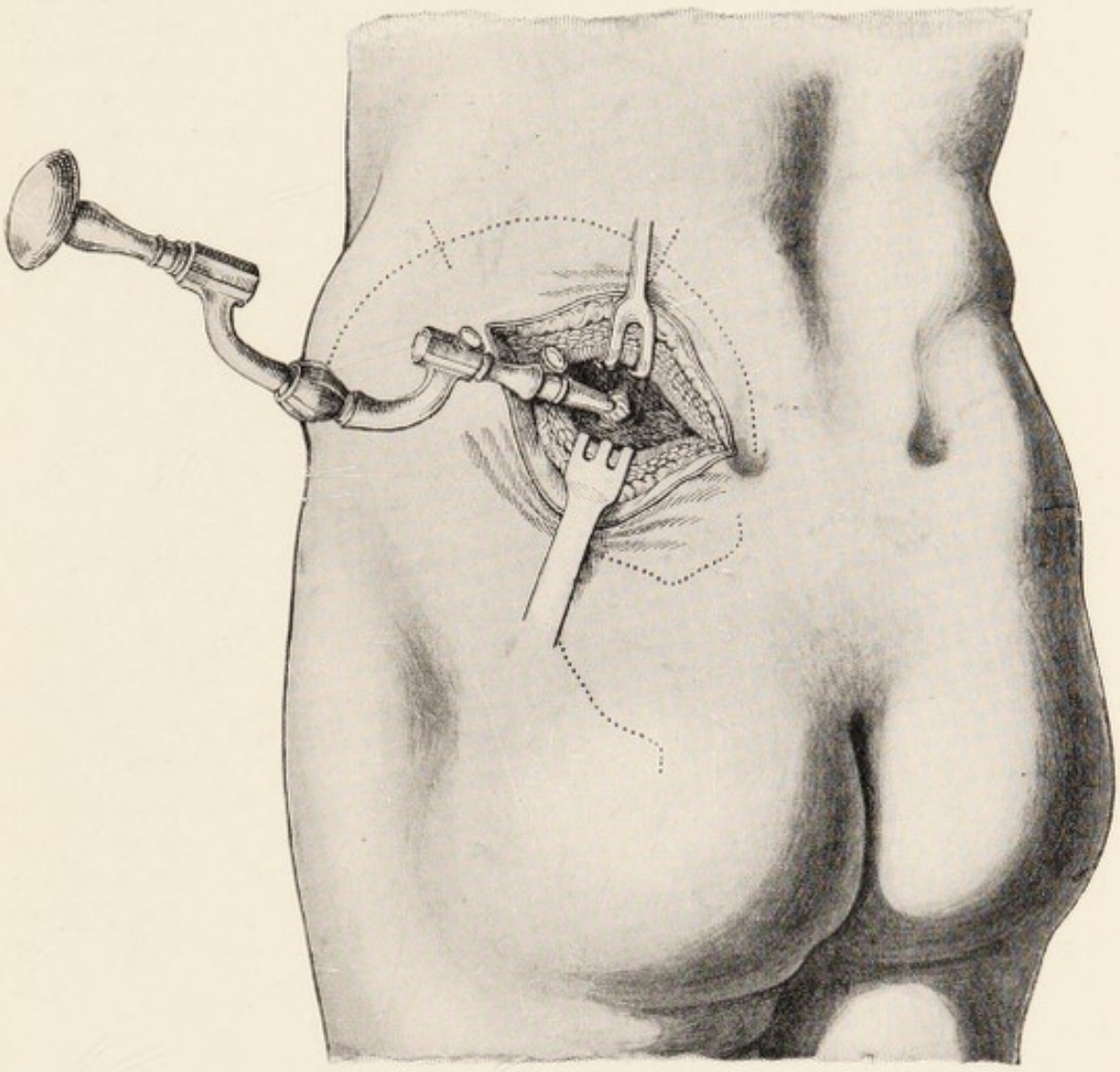

FIG. 55.—Drill (directed slightly backwards) applied to the bone midway between the sciatic notch and the iliac crest.

6. Early operation to expose and remove the focus of acute disease is indicated in this joint as in others.

7. The joint is not inaccessible, and is easily reached through the iliac bone in the centre of the fossa occupied by the gluteus medius muscle.

A very brief description of three cases will suffice to illustrate the remarks just made.

CASE 1.—Mr. R., between 40 and 50 years of age. Symptoms came on acutely. He was apparently in perfect health, until coming in one evening after exercise he developed acute pain in the course of his sciatic nerve, which did not extend below the knee. His temperature for several days reached 102°. For a week he was treated for sciatica and influenza. The temperature fell, and the pain became less, but the general discomfort about the sacro-gluteal region was increased. Thus he could not with any comfort turn in the bed or change his position. It gave him great pain and trouble to get out of bed. Yet on examination all the movements of the hip-joint were perfectly free ; no pain was caused by forcibly crowding together the iliac bones. There was no tenderness on rectal examination. Sacro-iliac disease was carefully searched for. For a month nothing but palliative treatment was adopted, there being no evidence of bony disease. The patient in the meantime was improving, though his temperature was never settled, reaching 99° and 100° after intervals of no fever.

He was allowed up and out for drives, but the discomfort in the sacro-gluteal region was never absent, and leaning on his sound leg produced more pain on the opposite side. An X-ray photograph demonstrated an early focus in the bone on the iliac side of the joint. I proceeded to operate in the manner already indicated. The opening in the bone struck the front of the joint, and after a little gouging in an anterior direction about half a drachm of pus was evacuated. The finger could feel the pelvic fascia deep to the iliacus muscle, and was carried into the small abscess cavity leading underneath the bone towards the sciatic notch. The overhanging bone was gouged away, and the little cavity filled with sublimated iodoform and bismuth paste. After the operation the pain and discomfort disappeared, and the wound healed without drainage. A weak spot developed in the scar a fortnight afterwards, and on introducing a probe a little serum and bismuth were extruded. Each day there was a little bismuth on the pad covering this point. In eight weeks the patient was sent home. Six months after operation, Dr. Rensen, a distinguished Continental surgeon whom he consulted, wrote to me as follows : "Mr. R. is now quite well. The little fistula has closed after one injection of bismuth and vaseline. He has augmented his weight, and walks upright without any support." A year later this gentleman was in perfect health.

CASE 2.—This was a girl who, in December 1910, complained of "sciatic" pain from the hip to the ankle. She was treated with liniments, but finding no improvement, was admitted into a Dublin hospital and was detained for six weeks. After another interval, as her pain increased, she sought admission to another hospital, where, after treatment for sciatica, an abscess formed which opened on the outer aspect and below the left gluteal fold.

For four months the sinus discharged ; she became more and more incapacitated, and appeared in a crippled condition at the extern department of Mercer's Hospital.

An X-ray photograph readily showed active disease of the sacro-iliac joint.

The articulation was laid open in the manner described and cleared of tuberculous granulation tissue and diseased bone.

FIG. 56.—Fixation of the sacro-iliac joint by a tibial graft in old-standing tuberculosis of the joint. All pain disappeared after operation. The X marks the position of the graft.

Shortly after the operation she developed diphtheria, and the wound, already infected from the pre-existing sinus, suppurated freely. A sequestrum was extruded through the sinus some weeks later. Her convalescence was prolonged, but six months afterwards the operation wound was soundly healed and the sinus closed.

She was seen recently and is a strong, healthy girl, without any discomfort save some stiffness in her sacro-iliac region.

CASE 3.—Male, aged 49, admitted to Mercer's Hospital, September 1910, with symptoms of sciatica and lumbago; urine loaded with urates. No signs of sacro-iliac disease, for which he was carefully examined. X-ray photograph defective; the patient refused to remain in hospital until a second picture was obtained.

"Sciatica" and "lumbago" increased in severity, and the patient sought readmission. One month after his first examination an iliac abscess could be detected. An X-ray photograph now showed extensive destruction of the left sacro-iliac joint, in addition to a focus in the lumbo-sacral articulation. The case was treated along conservative lines, the abscess was evacuated, and sublimated bismuth and iodoform paste introduced into the cavity. The patient made a good recovery.

CASE 4.—In this case a bone-graft was introduced to fix the joint, and was followed by a very satisfactory result (Fig. 56).

The bone was drilled in the manner shown in Fig. 55. A channel was made through the joint deep into the sacrum and a bone-graft taken from the tibia was hammered into position.

RECONSTRUCTION OF THE SHOULDER*

As time goes on the possibilities of giving operative aid in cases passing through hospitals for disabled pensioners are becoming less and less. The majority of the patients have been operated on once or many times, and a halt has been called in most cases to all but purely non-operative orthopædic methods of treatment. There are cases still which are admitted for conditions of non-union, malunion, and cross-union of bones capable of repair, but they are rare.

The same applies to joints, nerves, and muscles, although here, too, some cases appear to have drifted from one place to another without the obvious rational operative treatment having been tried.

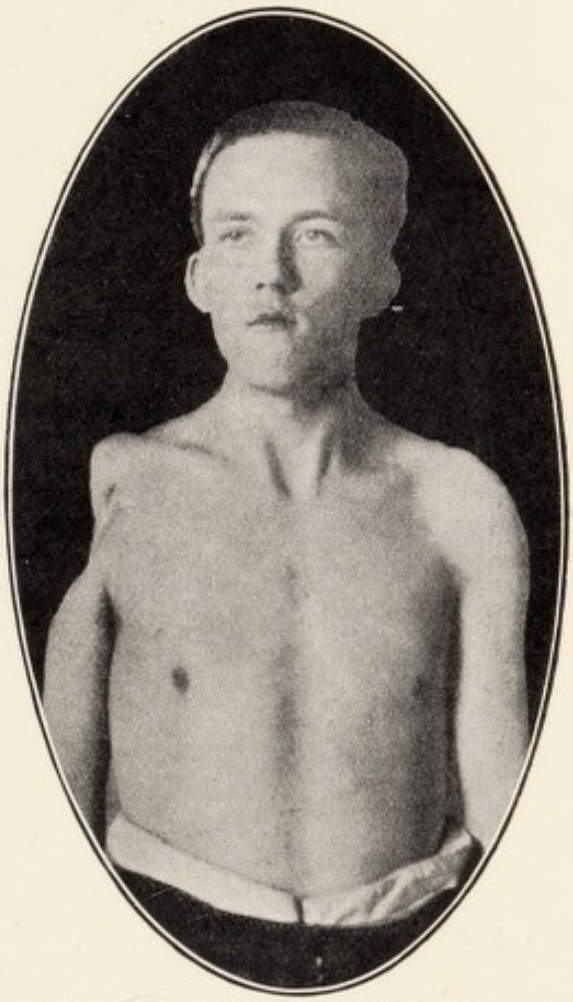

FIG. 57.—Pensioner K. Wounded 1918. The right arm is seen hanging from the trunk by a pedicle containing the vessels and nerves. The skin, deltoid muscle, and upper end of the humerus were blown away.

A pensioner, aged about 25, was wounded in November 1918 by a high-explosive shell. The right shoulder below the acromion process was carried away *en masse*, skin, muscles, and bone, leaving only a pedicle on the inner side carrying the main vessels and nerves by which the arm hung helplessly to his side. The wound was septic and unhealed for eighteen months.

On admission, a dense cicatrix occupied the right deltoid region. The area of the scar extended backwards over the lower scapular region, and forwards over the insertion of the pectoralis major muscle (Fig. 57). The movements in the hand were strong and free. All the muscles of the upper arm were out of action; nevertheless he could flex and extend the

* From *British Journal of Surgery*, No. 34, 1921.

elbow with considerable strength. This trick was accomplished by fixing the extensors and flexors of the forearm below and contracting them on their attachment to the condyles of the humerus, thus producing flexion and extension of the elbow and an excellent mimicry of the normal action of the biceps and brachialis anticus muscles. Fig. 58 shows a skiagram taken at this time.

The patient had been told so often that nothing could be done to restore the shoulder and upper arm, that consent to operation was only obtained on condition that it was completed in one stage.

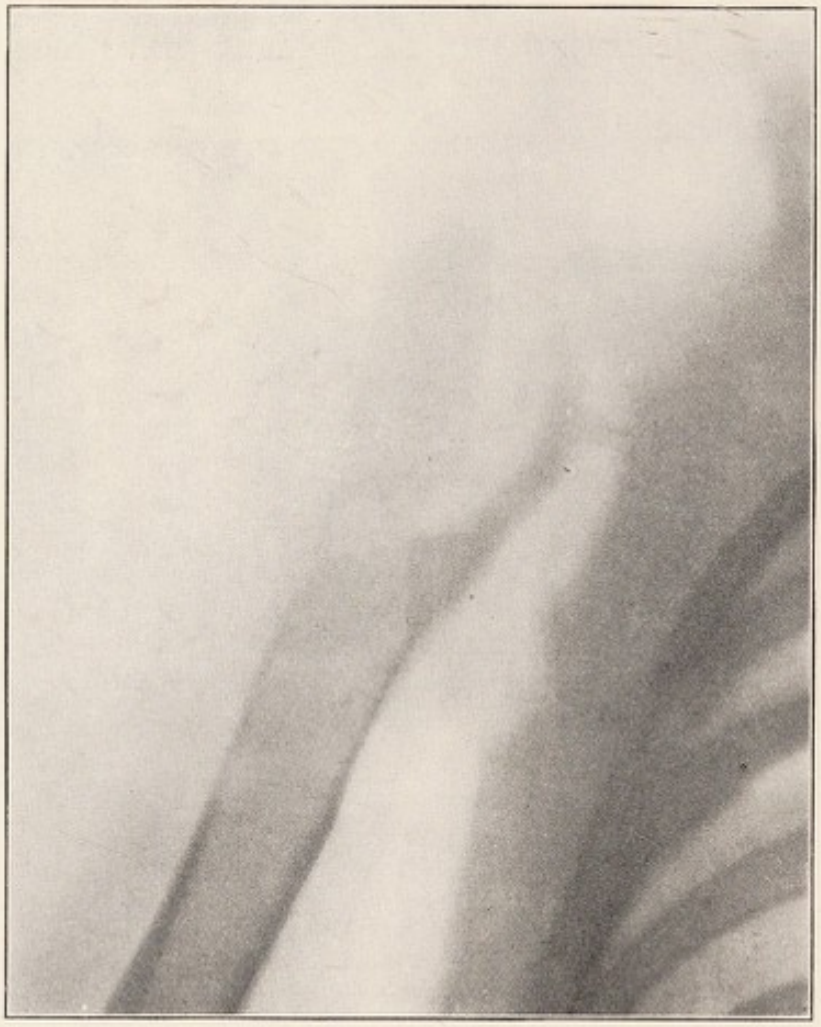

FIG. 58.—Skiagram of patient on admission, showing absence of upper end of the humerus.

The scar was subjected to massage, radiant heat, etc., as a test for the presence of any latent sepsis, if such existed, before a major operation was attempted.

OPERATION, April 1920 :—

1st Stage.—Two incisions were made, one just below the acromion process, extending forwards under the clavicle and backwards beneath the spine of the scapula, above the cicatrix. The second skirted the cicatrix below at the level of the middle of the shaft of the humerus. The incisions met in front and behind so as completely to encircle all the scar tissue. The dissection was slow and tedious, as the scar (the result of old sepsis) had penetrated deeply in a position

corresponding to the shoulder-joint. After removal of the scar, a deep hiatus was left between the acromion process and the upper end of the fractured humerus; the arm hung flaccidly, like the sleeve of a coat, from the inner flap containing the vessels and nerves.

2nd Stage.—The upper end of the humerus was cleared and divided until healthy bone appeared, and all irregularities were removed. The glenoid cavity was exposed and an effort was made to freshen the surface.

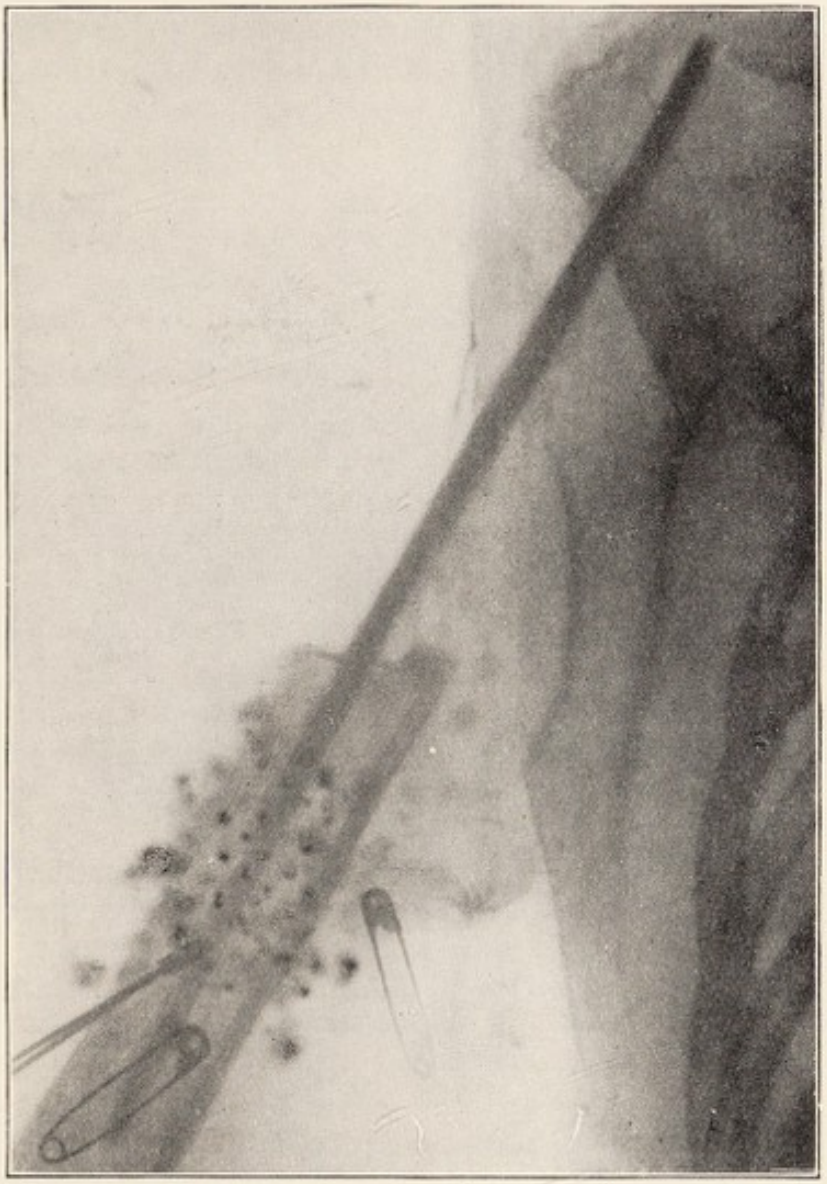

FIG. 59.—Skiagram taken immediately after operation; 4 in. of the graft is intramedullary, the upper portion is in contact with the glenoid cavity, the coracoid, and the acromion.

3rd Stage.—A bone-graft 9 in. long was removed from the inner surface of the right tibia with the Albee twin saw, regulated so as to cut a graft of tight fit for the medullary cavity of the humerus. The graft was driven tightly into the humerus for 4 in. The arm was abducted and held in position so that the graft lay along the glenoid cavity, the upper extremity touching the acromion and coracoid processes (Fig. 59). The intention was to obtain a broad union between graft and scapula with the arm in slight abduction.

4th Stage.—Five inches of the graft lay bare, with no skin, muscle, or other soft tissues for a covering. To remedy this a plastic operation of some magnitude was necessary. A large pedicled skin-flap was fashioned from the front of the chest, and the skin above and below the original incisions freshly undermined. A skin covering was obtained, but it was obvious that this was insufficient for the graft, although ample so far as the wound area was concerned. It was decided to replace the destroyed deltoid muscle by transplantation of the clavicular portion of the pectoralis major outwards as described by Elmslie. The attachment of the muscle to the clavicle was separated subperiosteally, and the clavicular isolated from the sternal portion. The tendon attachment was severed, so that now the muscle lay quite free but for a pedicle which contained the vascular and nerve

FIG. 60.—Skiagram three months after operation—"the period of anxiety." The loss of density in the graft due to the destructive powers of osteoclasts is more apparent than the regenerative osteoblastic process at this date.

supply. The detached muscle was swung outwards over the bone-graft, and attached to the acromion process and clavicle above by a few points of suture. Below it was sutured to the periosteum and soft tissues round the humerus in about the position where the normal deltoid is inserted.

The clavicular portion of the pectoralis major has been used successfully to replace a deltoid destroyed by injury, good abduction of the arm resulting; but in the present case, ankylosis of the bone-graft with the scapula was aimed at, and the muscle-graft was used merely to give ample covering to the bone.

The skin-flap was now sutured in position and the undermined margins were brought into line. The operation occupied two hours.

The arm was carefully immobilised on an abduction splint. The

stitches were removed in a fortnight, and the splint was replaced by an extensive plaster casing.

For three months rigid immobilisation was insisted upon, as is the custom, and afterwards slight stresses and strains were permitted in conjunction with massage and active movements to stimulate growth in the graft.

The behaviour of the bone-graft in this case illustrates many interesting points. The growth is seen in the photographs taking place at the side of the graft remote from the periosteum. The skiagram taken three months after operation (Fig. 60) demonstrates a condition which gives rise to anxiety in many grafting operations about this period. There is a mottled irregular appearance in the portion not directly contacted with bone, and an alarming loss of density. It is difficult to foretell at this stage whether the graft is about to crumble and become absorbed, or whether appearances are deceptive and the loss of density is due to the fact that at first the demolishing powers of the osteoclasts are more apparent in the photographs than is the reproducing capacity of the osteoblasts. It must be assumed that the activity of both classes of cells goes on simultaneously in successful cases, the osteoblasts inserting a new brick in the structure as the old ones are removed *pari passu* by the osteoclasts. Sometimes, however, in the grafts that fail, osteoblastic action is absent. This cannot be told by X-rays, for bone in the embryonic stage is translucent and does not cast a shadow.

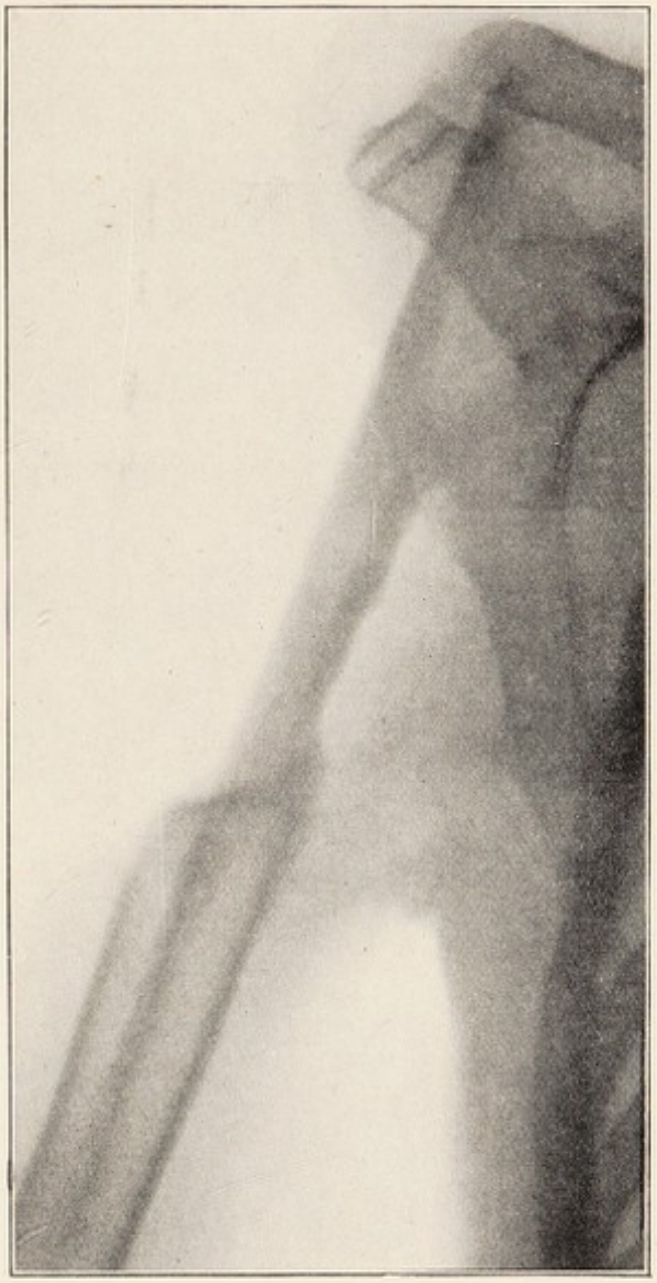

FIG. 61.—Skiagram six months after operation. There is firm union at the upper end of the humerus and at and above the glenoid cavity. Between these points the graft, in accordance with Wolff's law, has increased considerably in girth and density. The intramedullary portion is becoming absorbed.

The photograph taken six months after operation dispelled anxiety, for now a buttress of dense new bone could be seen on the medullary

side of the graft and the density of the whole had considerably increased (Fig. 61). The increase of density and thickness was confined to the portion of the graft bearing stresses and strains, namely, between the upper end of the humerus and the glenoid cavity. There was firm ankylosis at these two points.

Thickening of the portion of graft inserted into the humerus, and also of that portion above the glenoid cavity, is seen in the second photograph, where stresses and strains, if any, were distributed over the whole graft. After ankylosis had occurred at the glenoid and

FIG. 62.—Skiagram nine months after operation. The graft has replaced the upper end of the humerus. The intramedullary portion, to which no strains or stresses are now transmitted, has almost disappeared. There is firm union with the scapula.

the upper end of the humerus, the lower intramedullary portion and the portion above the glenoid became inert, and absorption took place, especially below. More active movements and a more general use of the arm were allowed later, and with the movements of the scapula some strain was evidently transmitted to the portion above the glenoid, which became more solid and dense. The graft below united firmly to the upper end of the humerus, and there was no further use for the intramedullary portion, which is seen attenuated and about to disappear (Fig. 62).

The condition of the patient before operation is well shown in Fig. 57, and fourteen months after operation the patient is shown (Fig. 63) holding a vessel weighing 5½ lb. at arm's length during a time exposure. He can use his arm freely, and almost place his hand to the back of his head. The scapular movements are increasing in range, and the muscles of the upper arm have recovered.

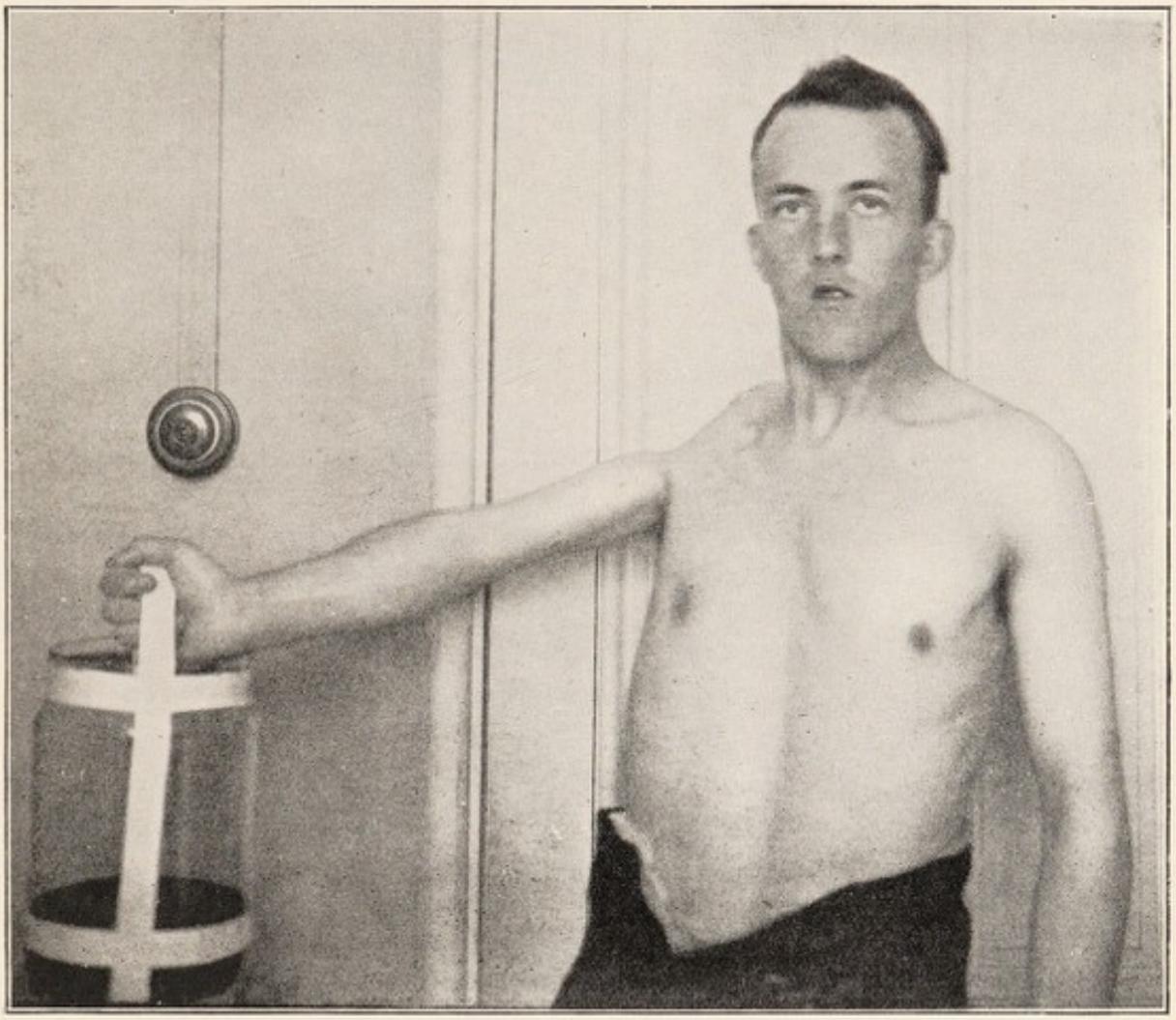

FIG. 63.—Patient fourteen months after operation holding a vessel 5½ lb. in weight at arm's length for a time-exposure photograph.

FOURTEEN POINTS ABOUT BONE-GRAFTS

1. A loss of density apparent in a graft as shown by X-ray photographs a few weeks after operation is deceptive, and does not necessarily indicate absorption and failure. In the early stages the demolishing activity of the osteoclasts may be more apparent than the bone-producing power of the osteoblasts.

2. The final success of bone-grafting depends upon the operation of Wolff's law, that is, the graft, stimulated by strains and stresses, changes its internal architecture and external conformation until the required strength is attained. In other words,

"the amount of growth in a bone depends on the need for it" (Murphy).

3. To provide the necessary strains and stresses, it is advisable to allow the graft to functionate after preliminary fixation for about three months.

4. The periosteum should be left on the graft, because, although not essential, it is the medium through which new blood-vessels enter the graft and the surrounding structures. Furthermore, in removing the periosteum, superficial layers of osteoblasts may be sacrificed even in an adult. A periosteum-covered graft is therefore less likely to become absorbed.

5. In old ununited fractures with false joints the bone in the "critical area" (near the site of fracture) is sclerosed and non-vascular, and makes unsuitable soil for that portion of the graft in contact with this area.

6. In such cases a graft, instead of exhibiting osteogenetic powers and responding to Wolff's law, may become attenuated and absorbed, or break in the critical area five or six months after operation.

7. In the same class of case very prolonged fixation is particularly unfavourable to osteogenesis, to the establishment of blood-supply, and bony union. Early movements and the bearing of mechanical stress and strain, on the other hand, may lead to yielding of the graft and failure. The problem is a difficult one in the case of the humerus or femur, where strength is essential. Wide resection of the sclerosed bone, with resignation on the part of the patient to a short limb, is the only remedy when non-operative methods fail.

8. A graft must not be used to span a gap in the humerus or femur—it breaks or absorbs. The freshened ends of the fractured bone must be in apposition, and the graft used as a support. This does not apply to grafting of the radius and ulna, nor when a graft is used to replace entirely the lost extremity of a bone.

9. But for slightly slower osteogenetic powers the intra-medullary peg is effective. This method of bone-grafting is satisfactory and simple in practice, although faulty in theory.

10. The bone-graft has inherent bacteria-resisting properties: sepsis does not necessarily mean loss of the graft.

11. Absolute fixation of the graft in its bed for about three months, secured either as part of the operation, or afterwards by splints or plaster, is essential to success.

12. Bone-grafting for spinal caries is followed by more uniformly successful results in adults than is seen elsewhere. This is to be expected, since both the graft and the recipient bed (in the region of the spinous processes) consist of healthy bone.

13. As in the operation of tendon transplantation and nerve suture, the operation of bone-grafting should be preceded by correction of any existing deformity and by the freeing of adhesions in neighbouring tendons and joints.

14. Identical grafts behave differently in apparently similar cases, and no emphatic prognosis can be given for many months.

CONTRIBUTION TO A DISCUSSION ON ARTHROPLASTY

At the International Congress of Surgeons, 1923

THE relative merits of arthroplasty, excision, and arthrodesis depend so much upon the individual case and the joint involved that, to make a profitable comparison would be very difficult, especially when we consider the large number of border-line cases in connection with which the most expert surgical opinion is divided. We can, however, be guided here, as elsewhere, by general principles.

The problem is entirely different in the military orthopædic hospitals, in which ankylosis was seen after severe sepsis and complicated by massive scars, to that present in civil practice with ankylosis following metastatic infections or simple direct injury.

In theory, an arthroplasty of such joints as the shoulder and the hip should give favourable results, for in these cases, unlike the hinged joints, the fear of excessive lateral mobility does not arise. In the case of the shoulder, arthroplasty gives variable results, but I doubt—when all things are considered—if the patient has a more useful arm than after the old-time excision carefully performed, or after fixation in the position of election. The operation of arthroplasty is definitely preferable to fixation when the movements of the scapula are limited, and when a good deltoid is present, but as a general rule for working men, ankylosis of the shoulder in good position gives the best functional result.

I have never seen a really good result follow arthroplasty or excision of the interphalangeal finger-joints. If this is the general experience of surgeons it is a reflection on the science of surgery, for the importance of mobile finger-joints cannot be over-estimated. In one case I endeavoured to produce mobility of the fingers by covering the divided ends of the phalanages with small discs of cartilage, as suggested by Murphy, but the result was disappointing. Dr. MacAusland points out that the phalangeal joints lend themselves poorly to plastic work, owing to concomitant damage to the tendon sheaths and the tendons; but, apart from this,

it seems almost impossible to steer a course between a flail post-operative digit and recurrent stiffness.

I cannot agree with the statement that excision of the elbow is, of necessity, followed by a flail joint. In the Dublin School, in my student days, I can recollect admirable results after operations performed by the last generation of surgeons on strictly anatomical lines. Nevertheless fixation in a good position satisfies many patients, and in many post-war cases there is no alternative. An arthroplasty in the elbow, performed

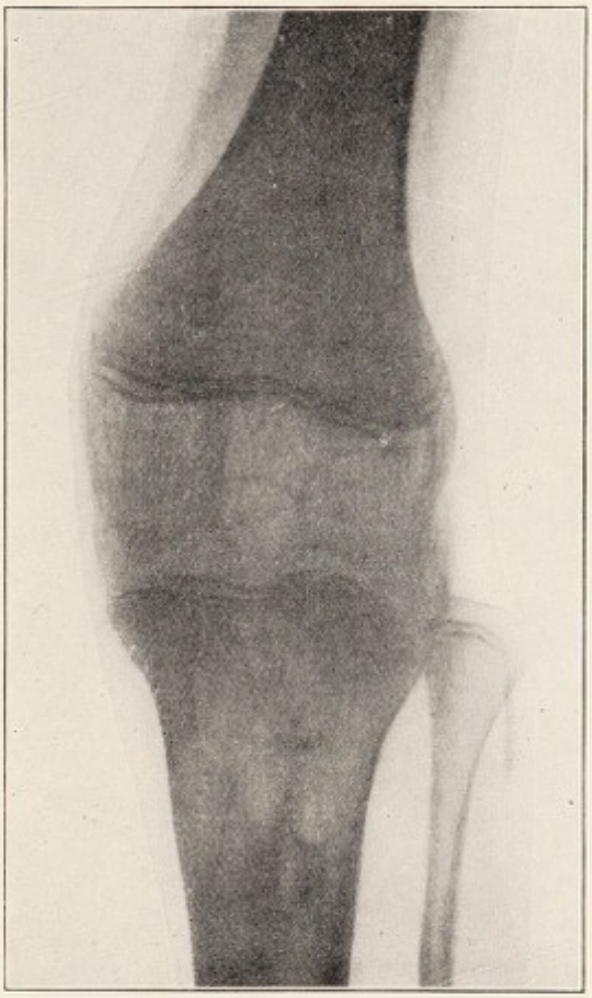

FIG. 64.—Right knee-joint before operation.

with the highest possible grade of surgical technique and judgment, provides a stronger joint than follows excision, but the gamble is greater.

There is difference of opinion as to whether arthroplasty in the case of an ankylosed knee-joint is justifiable. We have all seen Putti's admirable results. Murphy advocated the operation ; Jones is inclined to condemn it ; MacAusland says it must be cautiously advised. It appears to me that the operation is seldom indicated, but that the general condemnation may have been too emphatic.

In August 1919, a child, aged 11, gave me a history of acute osteomyelitis of both tibiæ, a prolonged illness and frequent operations. Both knee-joints were firmly ankylosed, the left in flexion, the right in extension. X-ray photographs showed firm, bony ankylosis with destruction of the epiphysis of the femur and tibia on both sides (Figs. 64 and 65).

A month later, in September 1919, Murphy's operation of arthroplasty was performed on the left flexed knee. The operation was fashioned so as to leave as large an amount of bone as possible in a lateral diameter, in order to diminish the tendency to lateral instability. A mortice in the form of a substantial groove was made from front to back on the surface of the femur, and a corresponding tenon cut in the tibia with a view to limiting

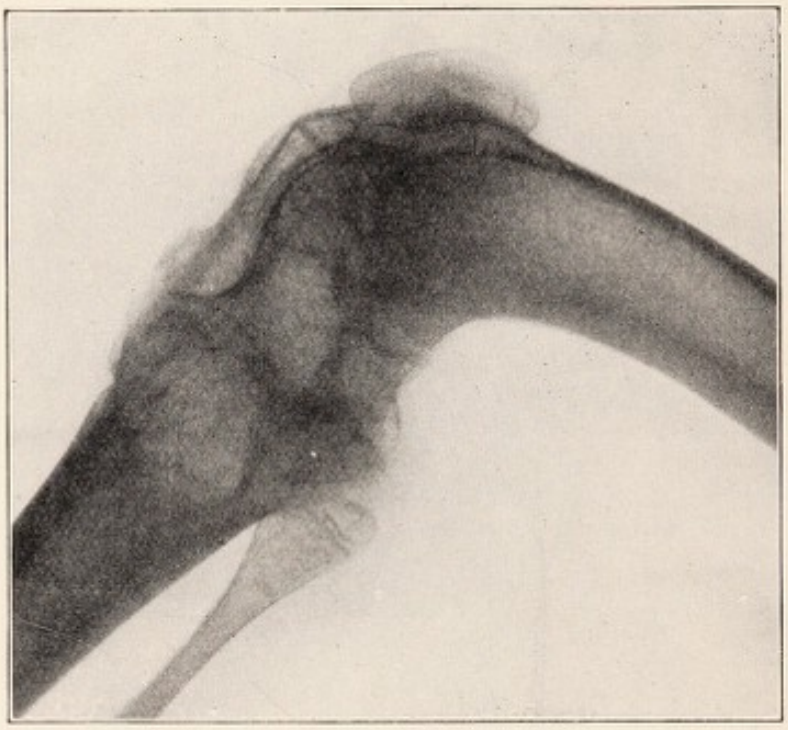

FIG. 65.—Left knee-joint before operation.

lateral gliding. Slightly more bone was taken from behind to counteract any tendency towards hyper-extension (Fig. 66).

The child was encouraged to move the joint from the first, great care begin taken to prevent movements in the lateral direction. Two months after operation she could walk with the support of a jointed calliper splint, with easy voluntary flexion to about half a right angle, and without pain. Six months later an arthroplasty was performed on the right extended knee and the after-treatment carried out in the same manner (Fig. 67).

Two years after the first operation and eighteen months after the second, she was walking freely without splints or crutches, and but for a slight forward bend of the body—a habit contracted

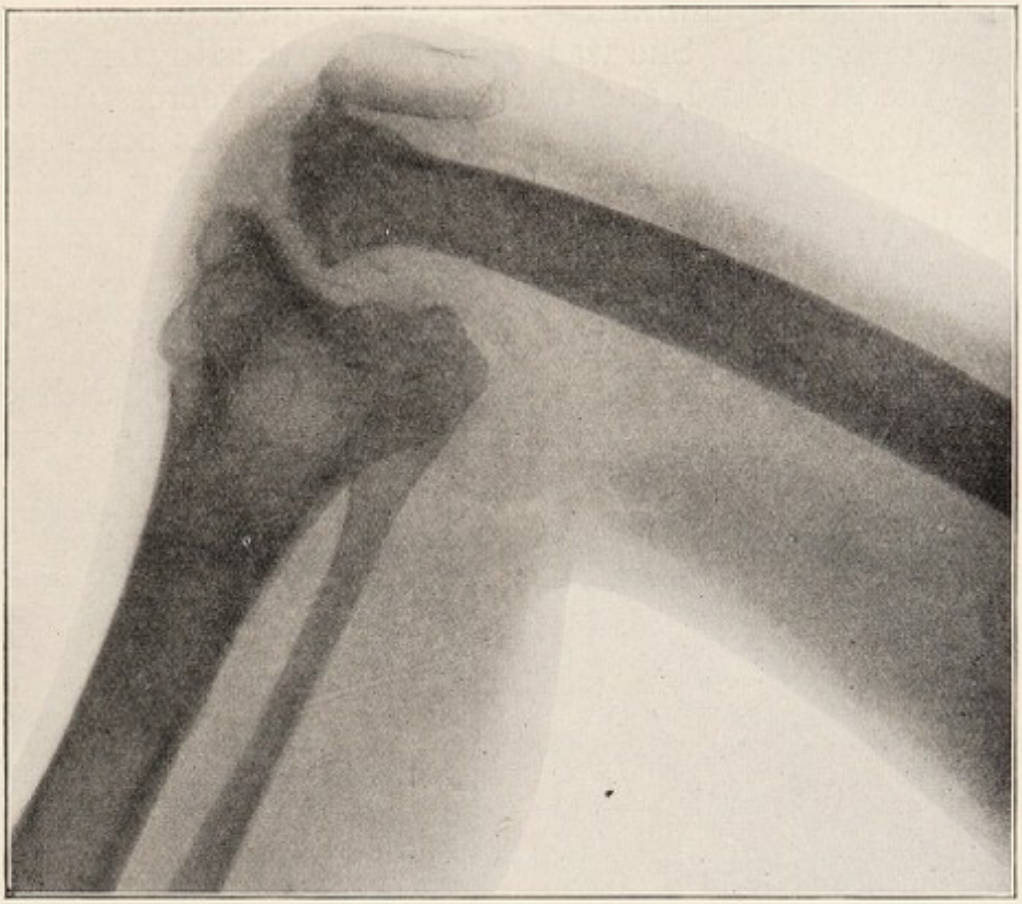

FIG. 66.—Left knee after operation. The patella was "turned turtle" to prevent union.

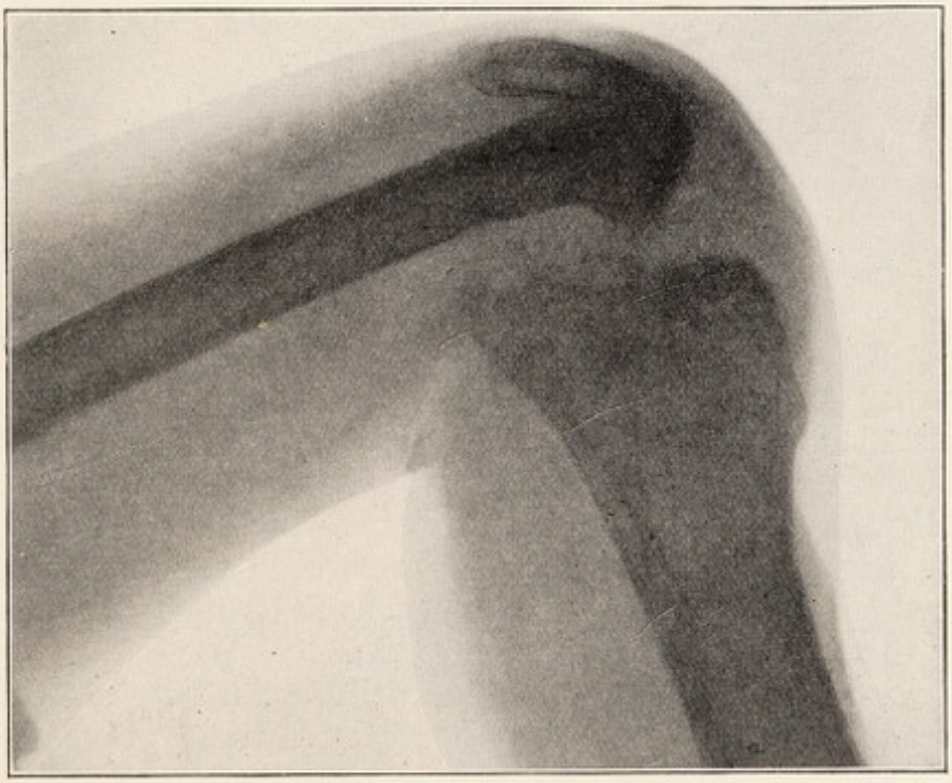

FIG. 67.—Right knee after operation.

to obtain better equilibrium—her gait to the ordinary observer was almost normal. She was exhibited at the Royal Academy of Medicine in Ireland, and when asked to hop across the room did so with agility (Figs. 68 and 69). There was some lateral mobility, but not more than is often seen following stretching of the ligaments after a prolonged effusion or after extension in the treatment of injuries.

I attribute the success of the operation, in this case, (1) to the complete absence of pain after the operation, and the consequent ease with which the after-treatment was carried out; and (2) to the care that was taken from the time of the operation

FIGS. 68 and 69.—Snapshots of child walking, showing amount of voluntary flexion on both knees.

and during the first six months of after-treatment to prevent any lateral movement whatever. To ensure this absence of pain after operation it is necessary to remove any remains of old lateral ligaments and capsule of the joint which carry the sensory nerves. Ligaments receive nerve fibres, both sensory and vasomotor, which come from the same nerves that supply the muscles moving the joint and the overlying skin.

I cannot think of anything more important in obtaining a good result after arthroplasty operations than prevention of pain. The early after-treatment is simplified a hundredfold. This absence of pain can be assured in cases where the ligaments

and capsule have been totally destroyed by the pre-existing disease or injury, or have been removed during the operative procedure.

In this connection Murphy states :—" In the early days of our arthroplasty work we felt that something serious would happen if we totally removed the articular ligaments. As time went on, however, I learned that large ligaments developed about the site of a pseudarthrosis." This statement is probably correct. If no movement is allowed in the lateral direction during repair there will be a corresponding condensation of the connective tissues on each side. On the other hand, movements are secured in desired directions from the earliest moment. Connective tissues trained in this way eventually take on the form and function of ligaments.

The object of mentioning this one particular case is not to advocate the operation of arthroplasty of the knee-joint, but to show that, under favourable circumstances, when there are real indications for the operation, there is a reasonable prospect of success.

In the case of the hip-joint, if a mobilising operation is indicated—which is seldom—arthroplasty, after the Murphy method, is indicated, rather than excision, in view of the extreme importance of weight-bearing stability. It is true that, after excision of tuberculous hip-joints in young people, if the limb is fully abducted and the trochanter placed in the acetabulum after the method of Stiles, good results follow, but in other cases where there is a choice of operation, weight-bearing stability is far better assured by the operation of arthroplasty. I have been disappointed in the mobility following this operation, and I have been impressed with its magnitude and danger, but I have seen the records of many encouraging and brilliant results.

In some cases I have found the operation of cheilectomy a simple and admirable substitute for arthroplasty. The more conservative operation is followed by good results, as is illustrated by the following case :—

A girl, aged 21, presented herself for treatment for polyarticular metastatic arthritis. The left knee-joint, the right hip, and the two wrists were disorganised. The left knee could not be completely extended without intense pain, and the right hip could bear no weight whatever, the slightest pressure on the heel causing pain in the joint. Locomotion was only possible with the aid of crutches, and even then was attended with much suffering. She had been dependent on the use of crutches for seven years. X-ray photographs showed lipping of the left tibia, and a ring of osteo-arthritic bone surrounded the right femur at the junction of the head and neck (Figs. 70, 71). The lipping

of the tibia was removed with a gouge and chisel through a well-marked line of cleavage; the flexion deformity was corrected easily by a weight-and-pulley extension applied for about ten days. Full flexion and extension were obtained without pain. A month later the right hip-joint was exposed through Kocher's posterior excision. There was a well-marked "cornice" of newly-formed bone at the junction of the head and neck of the femur, presenting the familiar mushroom appearance. The capsule was opened and the new bone was chiselled away from about two-thirds of the circumference. The result was dramatic.

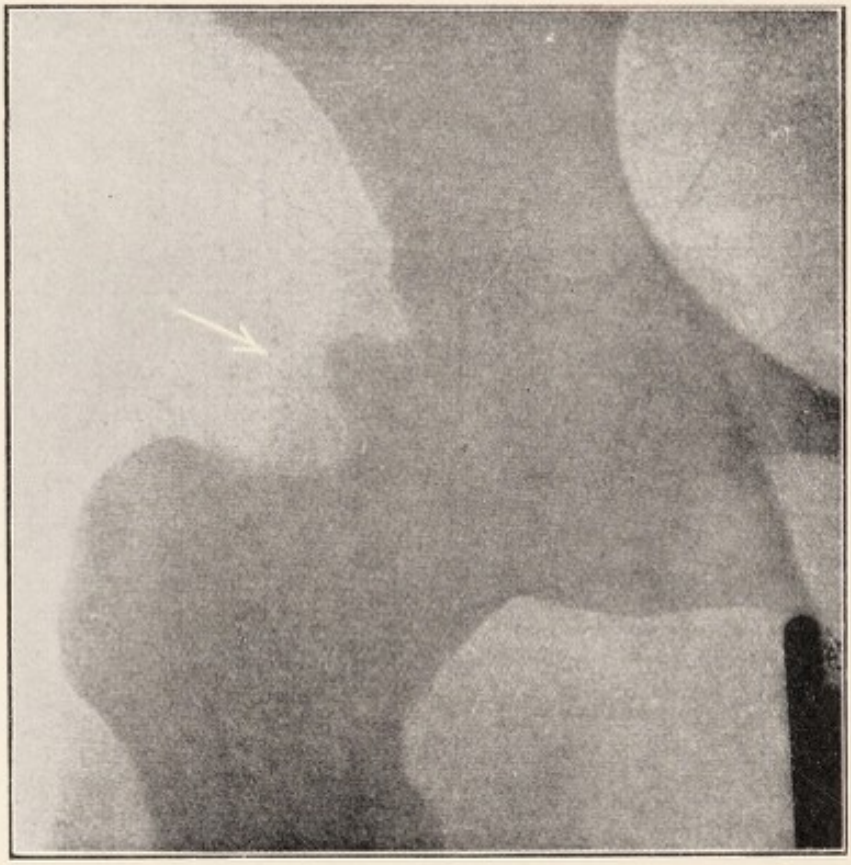

FIG. 70.—Patient, age 21, October 1912, before operation. A ring of new bone surrounded the junction of the head and neck of the femur. Great pain accompanied any movement of the joint. Crutches were used for seven years.

All pain disappeared on the following day, and in ten days the entire weight of the body could be borne on the right limb. The movements of the joint were free and painless, following the removal of the osteophytes, and the subsequent progress was uneventful. The condition of the wrist-joints underwent a marked improvement when crutches were abandoned and she resumed duty. For some years she has been employed in establishments as a skilled worker in fine needlework and embroidery. This was the first recorded case.*

* Sampson Handley independently performed the same operation and described the procedure under the title Cheilectomy.

Whatever the underlying cause of the formation of osteophytes —trauma, infection, or friction, or all three combined—there is a difference between those formed in the young and those formed in elderly people. In the latter the fibrous layer of the capsule undergoes ossification; *i.e.* the layer of white fibrous tissue which is continuous with the embryonic periosteum before the joint is formed. The osteophytes are quite continuous with the old bone, and it is seldom that the rim of the acetabulum escapes. There is no line of cleavage, and removal from the rim is difficult. The operation is often followed by recurrence or ankylosis. In the young the new lips of bone take more the form of the

FIG. 71.—Patient, age 21, three years after operation. Patient fourteen days after operation was walking with no pain and without crutches. Free movements were restored to the joint. There is no sign of recurrence.

excrescence seen in the case of bunion; removal through a line of cleavage is complete and easily accomplished; recurrence is unlikely, and the results of this simple operation appear, on the whole, quite satisfactory.

NOTE.—Mr. Milne kindly saw the patient referred to in London in April 1926, thirteen and a half years after operation. He reports as follows as to her present condition :—" The patient is doing general clerical work in an office, and travels up and down from Chatham to London each day. In the right hip there is very slight stiffness, but no pain or other symptoms. Weather makes no difference to it, and it is no stiffer in the morning when she wakes up. On examination : the hip will flex to 80°, and 10° of abduction. There is no grating in the joint and no pain on movement. The new X-ray photographs showed more irregularity than is seen in Fig. 71.

SOME POINTS ABOUT BONE-GRAFTS

FOUR years of war provided such a plethora of material for the study of bone-grafting operations that it is possible for surgeons to survey the field from the standpoint of considerable experience. Discussions about bone-grafting in the past have centred mainly around theoretical and academic questions, such as the rôle of the periosteum in the osteogenetic process, and the ultimate fate of the graft in its new position, the all-important clinical standpoint receiving but scant recognition.

So far as the osteogenetic power of periosteum is concerned, the controversy largely appears to hang round the point, what is meant by the periosteum? If merely the fibrous sheath which surrounds bone, then the periosteum is but a limiting and vascularising membrane. If, on the other hand, the cambium or epiosteum layer lying between periosteum and bone, and rich in osteoblasts, is included as part of the periosteum, then most certainly the periosteum plays an important part in the production of bone. This bone-producing layer, lying between the periosteum and the surface of the bone, clings in children to the periosteum, whereas in adults it appears to belong more properly to the bone, and, in the absence of trauma or inflammation, to be inseparable from it.

If the periosteum is preserved, with its clinging osteoblasts, as in the case of subperiosteal resection of bone in a child, new bone will be formed with mathematical accuracy. In adults subperiosteal resection may or may not be followed by new bone-formation, the result apparently depending to a large extent on whether or not the osteoblasts are detached from the bone in the process of separating the periosteum.

From a practical point of view absence of the periosteum from an implanted bone-graft probably means slower vascularisation and a more prolonged convalescence for the patient. The retention of periosteum with the graft is not essential for success, but appears to play a decided part in the formation of an involucrum of new bone, which is seen with comparative regularity round a graft a few weeks old. Periosteal covered grafts are more permanent, and less likely to be absorbed.*

* Haas in his experimental studies showed that the maximum of reparative power is maintained if both periosteum and endosteum are preserved.

Murphy and others held that the graft was nothing more or less than a scaffold, which is replaced by new bone. When the graft was contacted with living bone, the Haversian vessels permeated the Haversian canals of the graft, and carried with them osteoblasts and osteoclasts. The osteoblasts made good the defects in the graft produced by the activity of the osteoclasts. That the graft is not a mere scaffolding removed by the action of the osteoclasts and replaced by the activity of the osteoblasts, but is really viable and inherently carries its own osteogenetic powers, becomes more likely under certain pathological conditions.

FIG. 72.—Gunshot wound of lower end of humerus before operation. Temporary musculo-spiral paralysis disappeared *pari passu* with the healing of the wound three months after the injury.

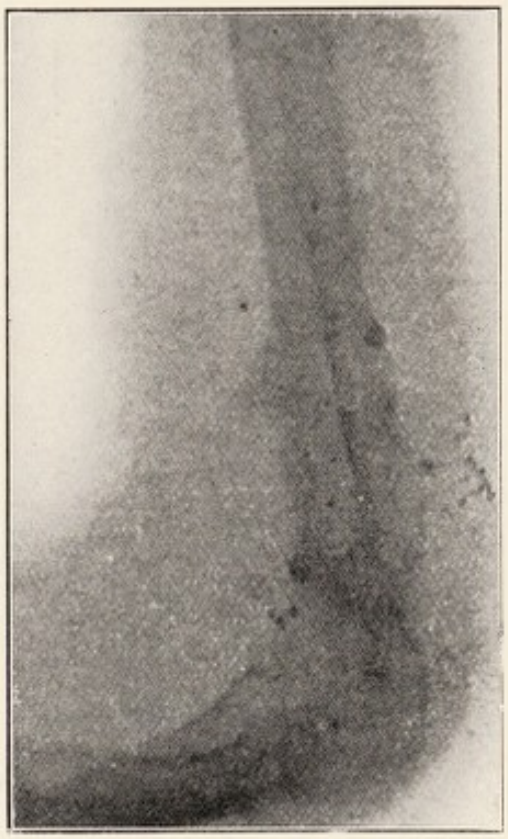

FIG. 73.—After operation. The introduction of a peg-graft four months after healing was followed by lighting up of latent sepsis in the old wound. The graft survived, firm union followed, with full movements at the elbow-joint.

If a fracture occurs, the result of accident, the graft unites by the formation of callus, by a process simulating the repair of normal bone, and if a graft becomes infected, and the infection is not sufficiently severe to kill it outright, then an involucrum and sequestrum may be formed (Fig. 42). In other words, almost from the time of insertion, a graft behaves in a manner identical with ordinary bone.

Sir Robert Jones illustrates a case of bone-graft introduced to replace a tibia lost from disease. The graft broke near the

centre, but subsequent X-ray photographs demonstrated a very definite formation of callus at the site of fracture. To ensure union in a fractured graft both endosteum and periosteum must be preserved.

Experience teaches many interesting points in connection

FIG. 74.—Old ununited fracture of humerus.

with the surgery of bone-grafting. Ruin is not inevitable if accidental infection follows the operation, either through error of technique or the result of latent sepsis. A graft will often survive all but the streptococcal and other severe infections, and a bacteriological investigation should be made of the pus, in order to gauge the prognosis. Technique should approach

perfection in every surgical operation, but should infection occur, or from the nature of things be inevitable, a bone-graft will withstand the assault in a surprising manner, and the end results may be admirable (Figs. 72 and 73). In proof of this we have only to watch the completely separated fragments of bone in a compound " ploughed " fracture the result of gunshot

FIG. 75.—Repair by peg bone-graft 15 months after accident.

wound, and see the fragments not only remaining viable, but rapidly consolidating with the fractured ends during repair. It is not true to suppose that bare bone is of necessity devitalised and will end in sequestration in a septic case, and the same observation applies to a bone-graft. Hence the golden rule not to remove loose fragments in the early treatment of septic

fractures, nor disturb a bone-graft because unexpected infection follows the operation.

The first thought of the surgeon must be how to fix the graft in its new bed and by what method the limb is to be immobilised immediately after operation. A small amount of movement does not delay union in a simple fracture, as evidenced by the rapid repair of a broken rib or jaw, but the slightest mobility in a bone-graft may make all the difference between success and failure.

In planning the line of the incision there will be no difficulty

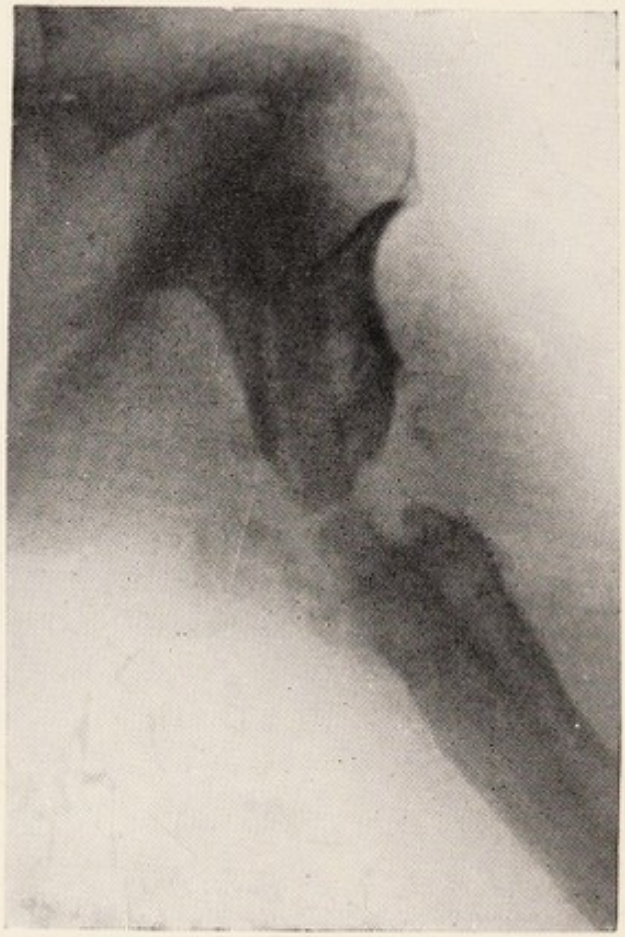

FIG. 76.—Illustrating fracture of peg-graft in old fracture of humerus.

[Later experiences proved that if a gap was left in the humerus or femur failure invariably followed.]

in dealing with easily accessible bones, such as the ulna and tibia, but in the case of the humerus and radius real respect must be paid to anatomical structures. Cases operated on previously, and exhibiting many scars, require ingenuity in planning the operation, so as to avoid, *inter alia*, the musculo-spiral and posterior interosseous nerves. The best plan is to expose the bone in its most easily accessible portion and then to extend the dissection by keeping under the periosteum, or as close to the bone as possible. The less the muscular attachments are

interfered with the more rapidly will the osteogenetic process be established. Ruthless stripping of the bone must be avoided.

In old ununited fractures the difficulty at once arises of how

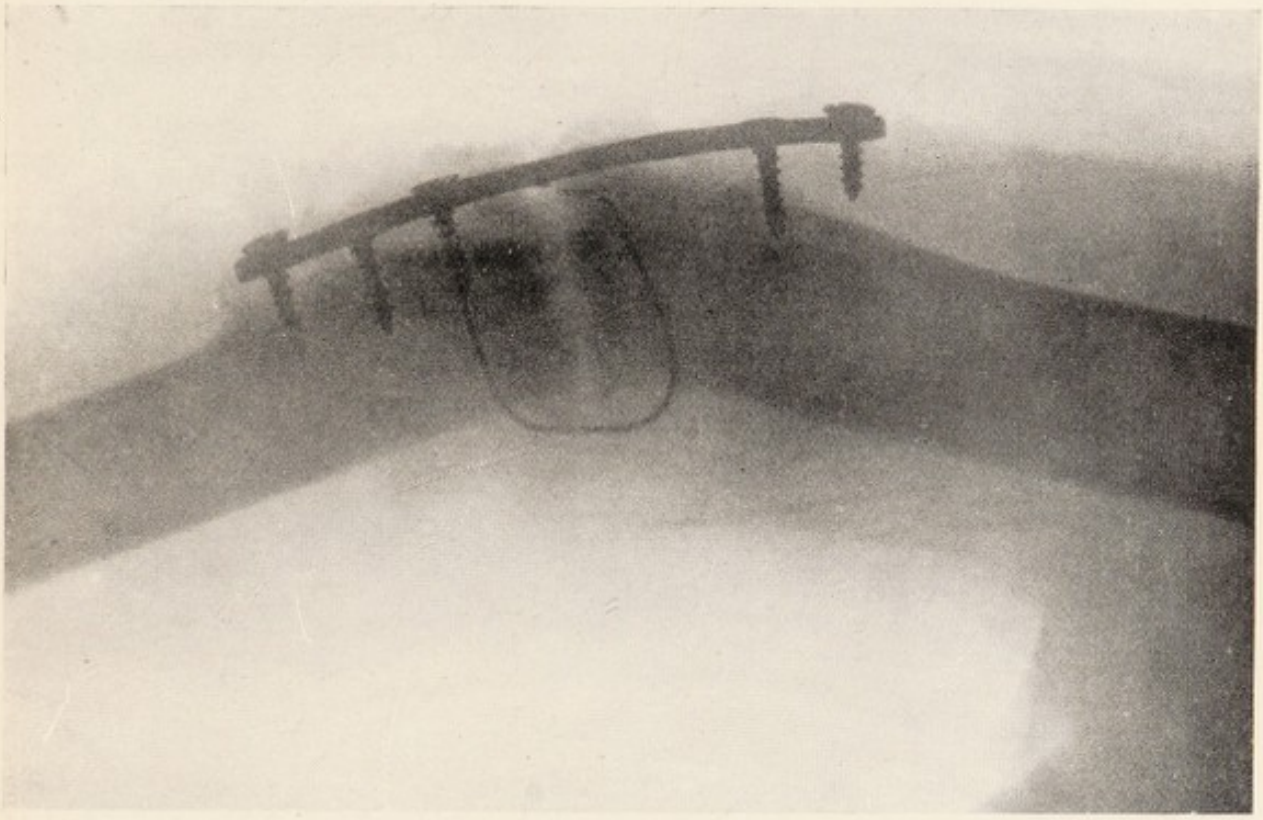

FIG. 77.—Fracture of humerus of eight years' standing.

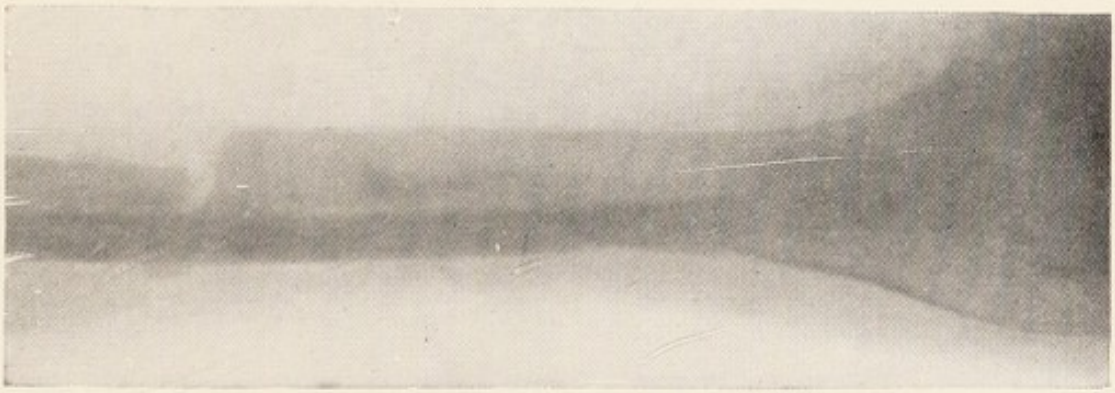

FIG. 78.—Long inlay graft in ununited fracture of the humerus of eight years' standing. Plate, screws, and wire removed. Six months after operation there was absorption of the graft in the "critical area" and failure of union.

to prepare a bed for the graft in the presence of, perhaps, two or three inches of sclerosed non-vascular bone. Complete resection often cannot be done without undue sacrifice of the length of the limb. In such cases reliance may be placed on a long stout graft extending for a considerable distance above and below the

sclerosed area, and an attempt made to create vascular channels by drilling holes and reaming out a new medullary cavity before placing the graft in position.

A long stout inlay graft is most likely to succeed, but it should be remembered that the recipient bone in the *critical area*—that is, the region of the fracture—is unsuitable soil; osteogenesis and thickening of the graft may fail, and the solution of continuity reappear on absorption of the graft many months after operation. Radical shortening of the bone is the only remedy if grafting fails, and in the case of the humerus gives a good functional but poor æsthetic result. The operation should for

FIG. 79.—Section of bone removed six months after a peg-graft operation. Note the firm incorporation of the peg with surrounding bone.

choice take the form of "the step" coaptation recommended by Hey Groves.

In old cases a sliding graft, taken from above or below the site of fracture, must not be used; the lower or upper end of a graft so taken would consist of sclerosed bone, non-vascular and devitalised by prolonged inflammatory changes. Sliding grafts should be reserved to bridge a fracture in recent simple cases, and even then should be sparingly employed; they are frequently too short and insecure.

The intramedullary peg is condemned by many, but it provides the simplest form of bone-graft, and in the late J. B.

Murphy's hands it gave excellent results, the peg becoming firmly incorporated with the bone into which it was inserted (Fig. 79). In one case, an ununited fracture of the humerus of eight years' standing, the upper portion of the peg failed to unite, and gradually formed a species of ball-and-socket joint within the medullary cavity, but there was firm incorporation of the lower end of the graft with the recipient bone. At a second operation, three months afterwards, it was found impossible to remove this portion of the graft without the free use of the chisel.

There is one obvious difficulty in the introduction of a peg-graft, for if half be driven into the medullary cavity of one fragment it is impossible to complete the introduction of the other without undue traction of the limb. To overcome this difficulty, the end of the graft which protrudes from the medullary

FIG. 80.—Bones of forearm on admission. Great angular deformity and shortening.

cavity of one fragment should be laid in a groove cut in the other during traction of the limb. When the traction is relaxed the end of the peg glides past the groove into position. The alignment is of necessity perfect.

It must be remembered that overstrenuous traction of the arm in a case of ununited fracture of the humerus will produce transient musculo-spiral paralysis, and give rise to anxiety for two or three months. The peg-graft is admirable if it were not for the real danger of fracture during convalescence (Fig. 76). This accident has occurred over and over again notwithstanding the greatest care in applying splints and plaster dressings. Owing to this liability to fracture, the use of a peg-graft may with advantage be confined to cases of fracture or defect in the bones of the forearm (Figs. 80, 81 and 84), and more stable lateral inlay grafts be reserved for the repair of the femur and humerus.

Injury to the radius or ulna is followed often by pronation deformity, the correction of which is an important part of the preliminary treatment. An intramedullary peg in the radius will not be disturbed by the coaxing of the lower fragments into a supinated position, although, whenever possible, every deformity should be corrected before operation is undertaken. When an inlay-graft is employed it is a simple matter to lay the upper end in a groove of the proper dimensions and then push it for a short distance into the medullary cavity above; but in this case the lower end may tend to spring away from the lower fragment, and some means must be adopted for its fixation. Surrounding the bone by two or three heavy catgut ligatures tightly tied round the graft suffices in most cases, provided the rigid fixation of the limb is afterwards ensured.

By some, reliance is placed on the rigid fixation of the graft

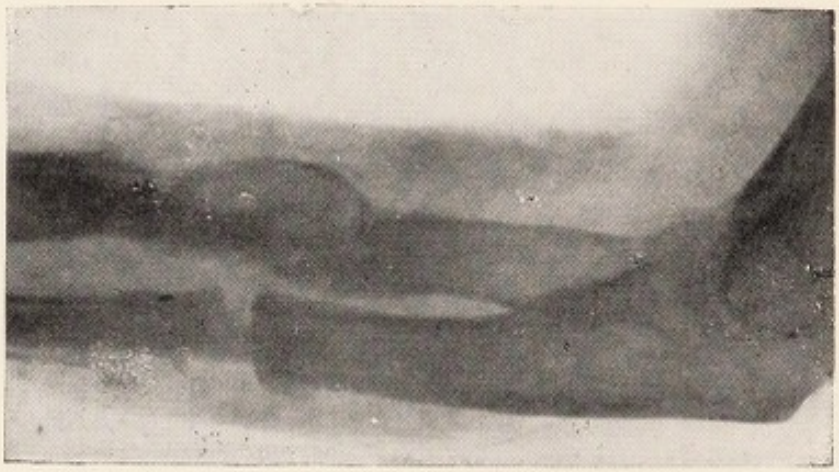

FIG. 81.—Reconstruction of the forearm shown in previous fig. by resection of bone, plate, and wires *en bloc*, and bridging of gaps with intramedullary pegs. The radial peg increased in diameter to size of normal radius after six months.

in situ by mechanical aids, and early movements of the limb are encouraged to stimulate the activities of the bone (so well seen in children) according to Wolff's law. By others the graft is so arranged that success entirely depends on the fixity supplied by the splint or plaster cast, and no movement is allowed for at least three months. All are agreed that unless the graft lies in its bed incapable of movement the operation is certain to fail.

In the hands of Lane, Hey Groves, and others, as might be expected, excellent results follow the use of plates, bolts, and screws in combination with grafts. This procedure, however, prolongs and complicates the operation, and frankly I am afraid of disappointments the result of attempting too much. Bone nails can be readily made with the lathe and appliances provided with the Albee electro-motor saw, and the graft can be thus secured in position. It is fascinating but tedious work. I have

twice fixed the graft with a series of bone nails, but the operation appeared to me to be unduly prolonged. By making the graft a tight fit for the groove and hammering it into position reasonable fixation can also be secured.

In all my cases (except two) the graft, consisting of periosteum,

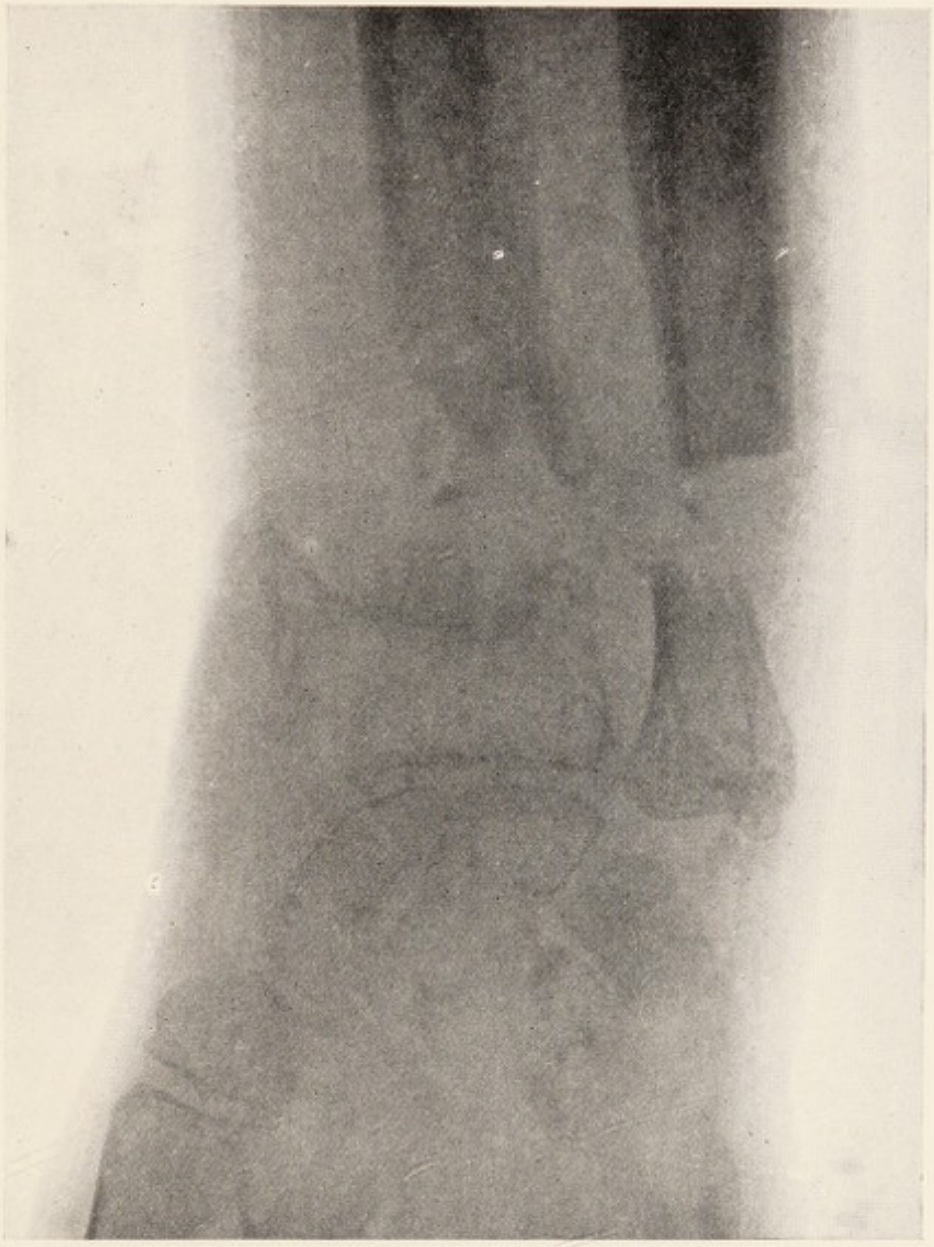

FIG. 82.—One of a series of cases of old fracture of the radius with marked radial displacement of the hand and prominence of the head of the ulna. A portion of the ulna has been removed to correct alignment.

compact bone, endosteum, and marrow, was taken in the orthodox manner from the subcutaneous surface of the tibia by means of Albee's twin electro-motor saw. In the two cases—one a congenital dislocation of the hip (Fig. 90), and the other caries of the spine with much deformity—a rib-transplant was found most suitable in size and shape.

A note of warning is necessary regarding fracture of the tibia from which a graft has been taken This may occur some months after operation. As a precautionary measure a light plaster casing should be employed, and the use of crutches encouraged until strength of the leg is assured. There is little risk of this

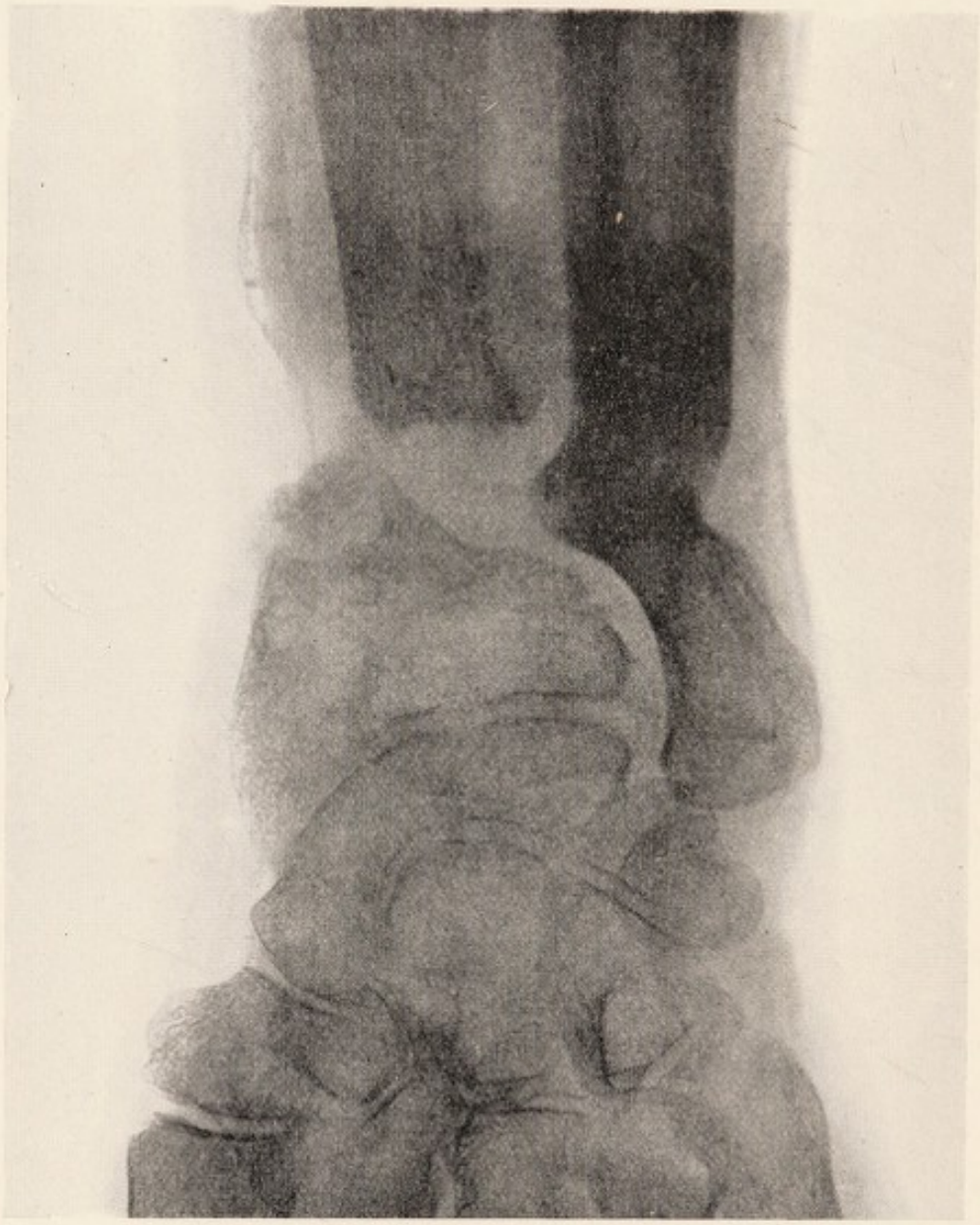

FIG. 83.—Same case showing regeneration of the ulna with desired deviation.

accident if the strong crest of the tibia is avoided in taking the graft.

Hey Groves expresses the thought of most workers in this branch of surgery when he states that his " feelings are those of disappointment and hope—disappointment that the proportion of successes has been so small, and hope that by the experience gained one may be able to avoid causes of failure, which are seen to be so obvious, and therefore so possible of evasion."

FIG. 84.—Final result. The radius has been grafted. The wrist is in dorsiflexio with slight movement.

The illustrations which follow are chosen from a large number to illustrate various types of cases and are self-explanatory.

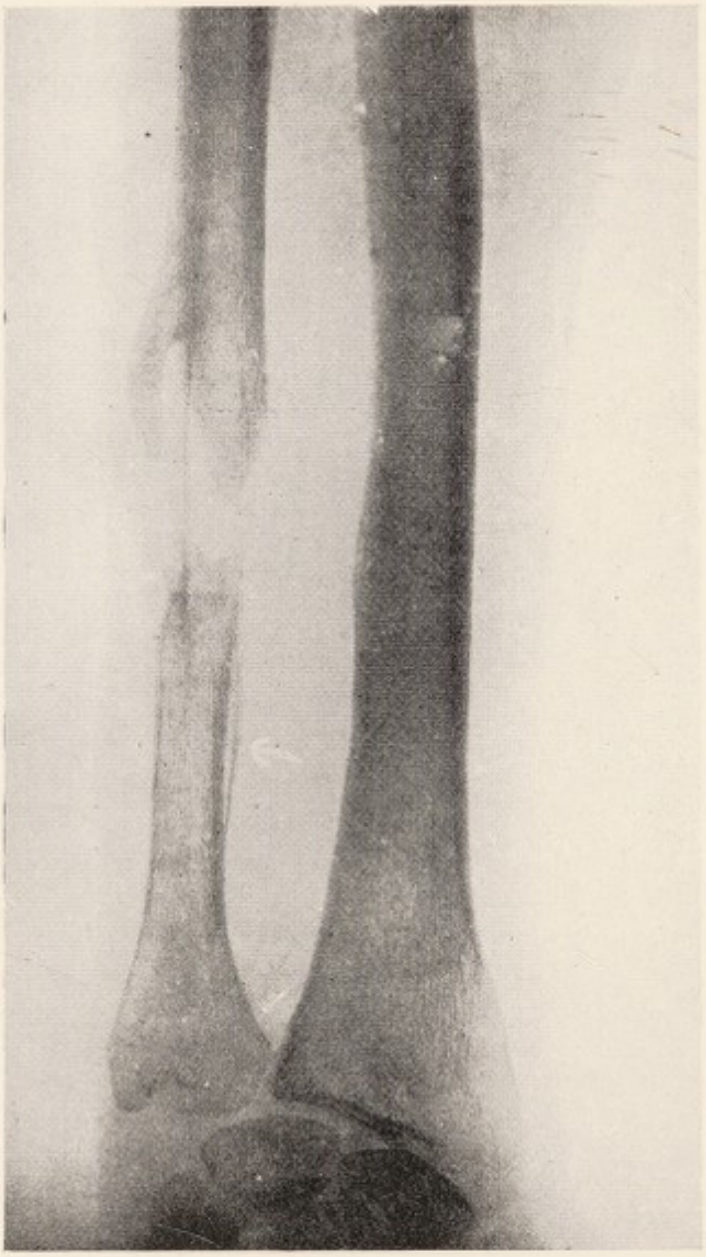

FIG. 85.—One of a series of old fracture of the ulna. The accessibility of the bone renders operation easy.

FIG. 86.—Graft in position. The peg is not long enough above. Result good.

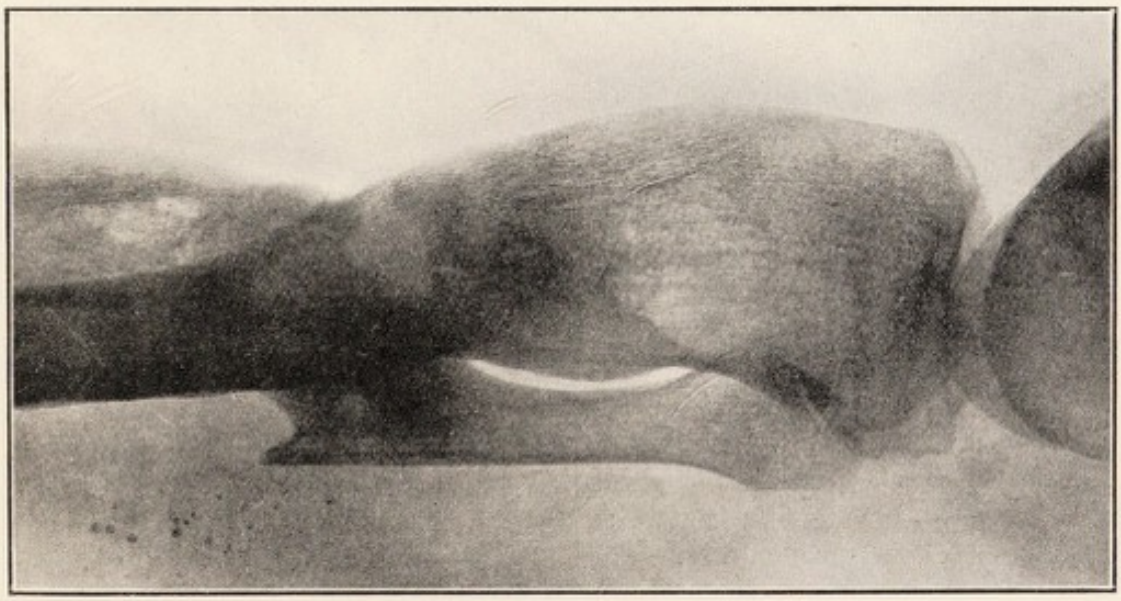

FIG. 87.—Union of fibula and tibia. Note thickening of fibula, the result of weight-bearing. Good functional result.

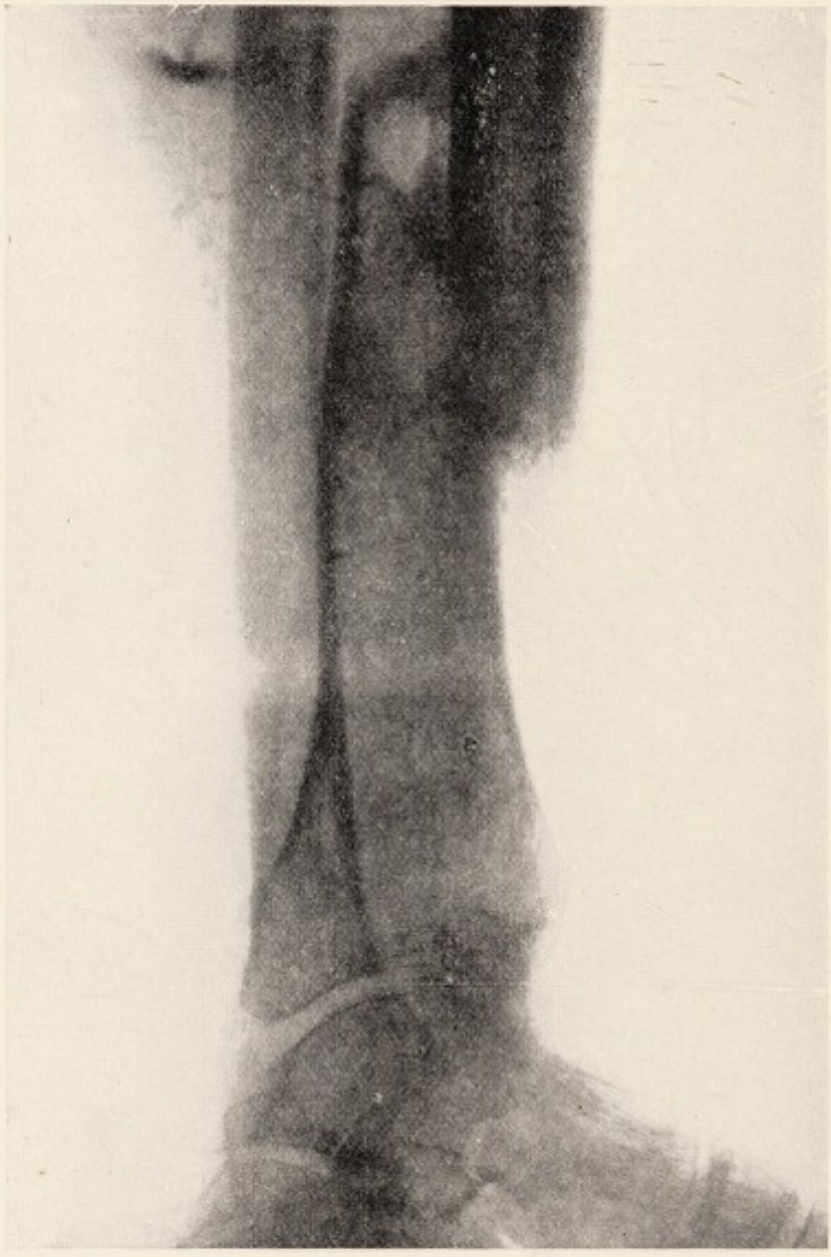

FIG. 88.—Old fracture of the tibia and fibula, with marked deformity.

FIG. 89.—Same case, with deformity corrected and held in position by a sliding graft from the bone above.

FIG. 90.—To illustrate the deepening of the acetabulum by a rib-graft in the open operation for congenital dislocation of the hip.

FRACTURE OF THE BASE OF THE SKULL

TRAUMATIC INTRACRANIAL AEROCELE *

A FATAL case of head injury, admitted into Mercer's Hospital, exhibited some unusual features worthy of interest.

The patient, aged 45 years, fell from a bicycle on the right frontal region. There was a small wound above the outer side of the right eyebrow, and some ecchymosis and bruising over the entire frontal region; the right pupil was dilated; there was retention of urine; blood-stained cerebro-spinal fluid trickled from the nose. The diagnosis of fracture of the anterior fossa of the base of the skull could be predicted with certainty. He was mentally confused, but he was able to swallow and to answer questions with fair intelligence.

Operation.—An hour after admission his condition was less satisfactory. The skull was opened over the right frontal lobe by means of Hudson's drill and bone forceps. On incision of the dura air bubbled out in small quantities, followed by blood-stained cerebro-spinal fluid. The general blood pressure was low and the brain correspondingly retracted. The frontal lobe of the brain appeared in no way injured, but on free exposure an unusual phenomenon was observed. The patient was breathing heavily; on expiration the frontal lobe moved upwards from the base of the skull and fell back again on inspiration. This movement of the brain synchronous with respiration was well marked, and rendered obscure the natural pulsation. It was obvious that air under some pressure was passing from the nose through a rent in the dura, in the neighbourhood of the cribriform plate of the ethmoid and roof of the orbit. It was difficult, however, to understand, with the dura widely opened by the operation, by what mechanism the brain moved; yet the movement was very distinct and obvious to all present.†

The wound was closed without drainage in order to lessen the paramount danger of infection. The absorption of the cerebro-spinal fluid flowing into the aerolar scalp tissues provided, in our view, a sufficient outlet for the extravasation of blood and cerebro-spinal fluid. The nose was cleaned out with alcohol and loosely plugged with sterilised wool.

Course of Case.—The patient's condition improved considerably after operation. Hexamine was administered freely by the mouth, and small doses of hyoscine assisted in controlling restlessness and

* *Lancet*, 1923, I, 529.

† Professors Henry and Heathcote of Cairo are carrying out research work in connection with this and similar cases.

irritability which at times increased to a state of violence. Six days after operation the temperature rose to 102° F.; the patient became unconscious; the breathing was stertorous, and the pupils were dilated. The right pupil was still slightly larger than the left; both reacted to light, and there was a faint conjunctival reflex. 30 c.cm. of turbid fluid, containing a pure culture of pneumococci, was withdrawn by lumbar puncture by Dr. Milne Henry. During the withdrawal of the fluid the blood pressure fell from 130 to about 110, and rose again about 15 minutes afterwards. The temperature continued to rise until it reached 105°, and the patient died of meningitis on the eighth day after operation.

Remarks.—Since this communication was written, a paper has appeared by Grant, of Philadelphia,* on Intracranial Aerocele following fracture of the skull. He states that reliable authorities have spoken of the condition as "pneumocranium," but objection is taken to this term as having no definite meaning. "Pneumocele" or "aerocele" connotes a swelling or tumour containing air; "intracranial" localises the position of this air, and, as it always follows injury, the word "traumatic" may be added with advantage. He states that trauma of the frontal region of the skull involving the sinuses, a compound comminuted fracture resulting in a tear of the dura which permits the ingress of the air, is the commonest cause of the condition; but any compound fracture with a dural tear, whether the sinuses are involved or not, may be followed by the formation of an aerocele. The air is always intradural.

Grant points out that the presence of intracranial air may not be suspected until shown by X-ray. He finds ten recorded cases of the condition in recent years, and in six the aerocele developed insidiously, and was found by X-rays at intervals varying from a few days to several months after injury. In some cases the injury was comparatively trivial. In our case the patient was admitted at night and operated upon within an hour of admission, so that no X-ray examination was made. In Grant's case the injury appears to have been almost identical, but on the left side. In both cases the pupil was dilated on the side of injury, possibly owing to some involvement of the third cranial nerve, but more likely—in the absence of other ocular signs—to stimulation of the sympathetic, and at operation air escaped in small quantities when the dura was incised. In Grant's case subsequent X-ray examinations showed no increased density due to the presence of air, and it was concluded that the rent in the dura closed spontaneously. The literature on the subject suggests that, owing to the danger of infection in these

* *Surgery, Gynæcology, and Obstetrics*, February 1923.

cases, the presence of aerocele immediately following injury is an indication for operation, and Grant thinks that an attempt should be made to close the dural tear. If five or six days have elapsed, and the aerocele is discovered in a photograph by accident, the sinus may have spontaneously closed and the policy of watching and waiting for absorption should be instituted. Air, *per se*, once the possibility of infection can be excluded, is relatively innocuous and will be ultimately absorbed. In nine of the ten cases collected by Grant injuries to the scalp were noted in the region of the eyebrow. In four no operation was performed ; two of these recovered and two died—one six months after injury. Of the remaining six, four died ; in one a cyst

FIG. 91.—From a photograph showing obliteration of the sulci by the exudate. This is well marked in the neighbourhood of the Sylvian fissure. Some of the thrombosed vessels are also visible. (See post-mortem report.)

containing air the size of a hen's egg was found, and three succumbed to meningitis.

In making the diagnosis of fractured base of the skull, it is convenient to consider the signs in three classes—certain, probable and uncertain. If cerebro-spinal fluid escapes from the nose, ear, or mouth, a fractured base is certain ; in rarer cases brain matter may be extruded, which also renders the diagnosis certain, and a third certain sign may now be added—*i.e.* the demonstration of an aerocele by a skiagram. Of the " probable " signs, first importance should be attached to injury to the cranial nerves. The " uncertain " signs are numerous ; those most obvious being ecchymosis, appearing late, and often preceded by bleeding from the ear and nose or mouth. The mental condition of a patient varies to such an extent in all head injuries that it is only of diagnostic importance when considered in conjunction with the other factors.

The points of interest in the present case are : (1) The intradural presence of air ; (2) the rise and fall of the frontal lobe with respiration, which was well marked, but difficult to explain ;

and (3) early dilatation of the pupil on the side of injury without other ocular signs, in the absence of compression and before the onset of meningitis.

In view of the high mortality from infection to the meninges in fractures of the base of the skull communicating with the external air, and notwithstanding the general trend of opinion in favour of operation, it seems questionable whether treatment along conservative lines would not be followed by better results. Prophylaxis in the form of careful attention to the orifice through which blood and cerebro-spinal fluid are escaping, and the administration of urotropine and its derivatives, will tend to prevent infection better than drainage. To search for and close the rent in the dura at the site of a basal fracture, as suggested by Grant, in many cases would be a procedure of great mechanical difficulty and danger; furthermore, intradural air, *per se*, as already stated, is innocuous and rapidly absorbed. The great difficulty is to be certain beforehand that no compression, laceration, or controllable hæmorrhage exists, in addition to the fracture and the subdural air.

Post-mortem Report, by Dr. E. C. Smith

On January 21 about 10 c.cm. of cerebro-spinal fluid were received for examination from the above case. The fluid was cloudy and contained a copious white sediment. Cultures were made on blood-agar. Smears of the sediment, when stained by Gram, showed numerous polymorphs. Large numbers of Gram-positive cocci in pairs were also present. On the following day (22nd) the plates showed a pure growth of pneumococci. The colonies were greenish, and some hæmolysis was visible. The cocci were bile-soluble. The brain was exposed by extending the operation wound and removing the calvarium.

The quantity of cerebro-spinal fluid was much greater than normal. It was distinctly turbid. The surface of the brain was covered with a purulent exudate which obliterated the sulci. The exudate was most marked anteriorly (see Fig. 91). Many of the meningeal vessels stood out prominently and felt very firm, apparently thrombosed. Direct smears were made of the exudate and stained by Gram. Numerous pus-cells and Gram-positive diplococci were present, some of the latter had well-marked capsules. When the brain was removed, a fracture, extending through the right side of the ethmoid bone and involving the sphenoid, was apparent. When a probe was passed down from the fracture it appeared at the anterior nares.

SIMPLE OPERATION FOR HAMMER-TOE*

HAMMER-TOE, like many other conditions of minor surgical importance, causes such discomfort and pain to patients that surgical advice is eagerly sought for its relief. Patients, however, are often not prepared to undergo an operation which will necessitate the administration of a general anæsthetic and total disablement for about a fortnight. It is seldom that the condition, however uncomfortable, prevents people from carrying on their business, and they will not submit to treatment which will cause any considerable inconvenience. The procedure

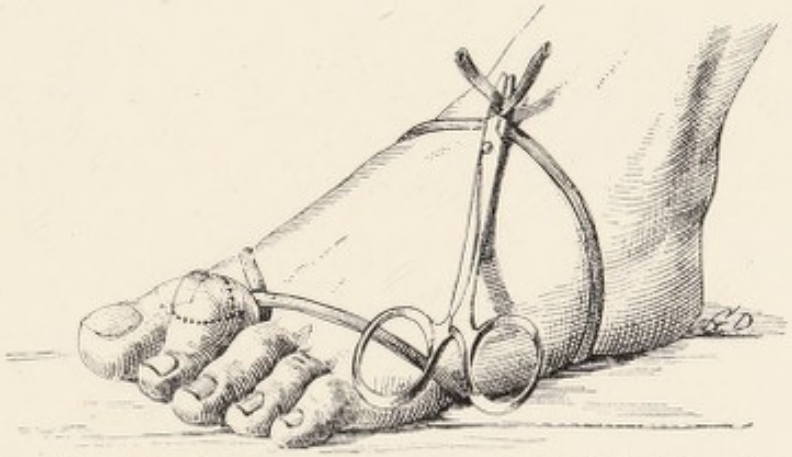

FIG. 92.—Operation for hammer-toe. An elliptical incision is made which freely exposes the joint when the skin bearing the corn is removed. The tubing prevents diffusion of the local anæsthetic.

described below appears more simple than the methods usually described in textbooks.

Fig. 92 represents a hammer-toe encircled by rubber tubing held in position by an artery forceps on the dorsum of the foot. This tubing is applied prior to the injection of a local anæsthetic, preferably a 1 per cent. solution of novocain with the addition of a few drops of suprarenal extract. The rubber tube localises the solution and prevents its diffusion, while at the same time the anæsthesia is rendered more effective in the presence of venous congestion. The tube should not render the toe bloodless, and should be removed immediately before the commencement of the operation.

* *Med. Press and Circular*, 1910.

The first illustration also shows an elliptical incision mapped out for the removal of the portion of the skin bearing the corn.

This incision is better than the lateral incision usually

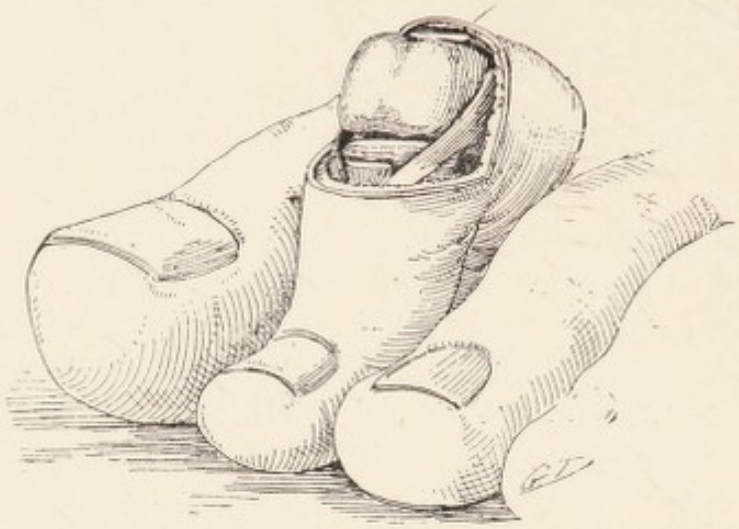

FIG. 93.—Operation for hammer-toe. The central strip of the extensor tendon is divided and the head of the first phalanx protruded through the lateral portions.

recommended. While at once removing the corn, it gives free access to the affected joint, and at the completion of the operation the suturing of the margins of the wound brings the toe into

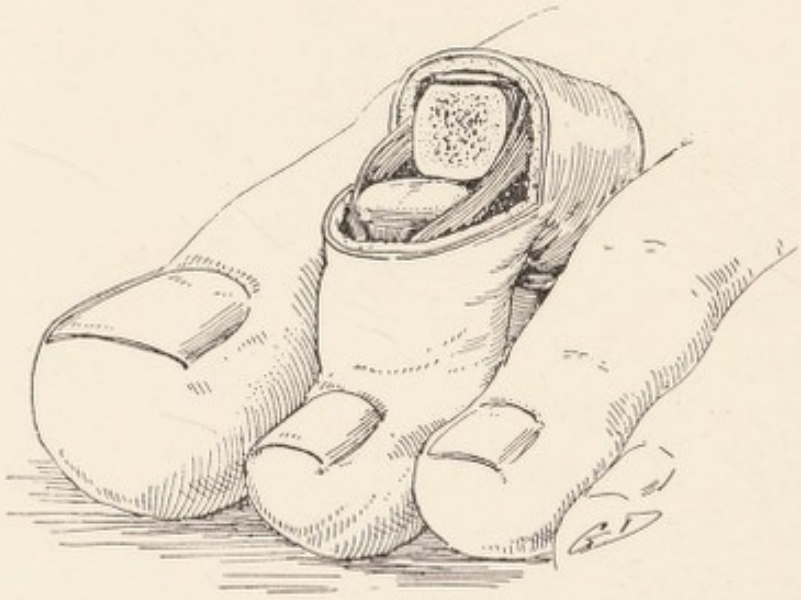

FIG. 94.—Operation for hammer-toe. The head of the phalanx has been removed with bone forceps.

a straight position without the aid of any splint. The disadvantages of a scar across the dorsum of the toe are negligible. The hypodermic needle is inserted on the lateral aspect immediately in front of the coil of tube which encircles the toe. The

needle is pushed almost to the bone in a sloping direction towards the distal extremity. A drachm or less of the solution is injected, the needle withdrawn, and the same repeated on the opposite side. The toe swells in proportion to the amount of fluid injected and becomes anæsthetic in less than five minutes. The skin and corn are removed, and the joint with the three slips of the extensor tendon is well exposed.

Fig. 93 shows the exposure of the head of the first phalanx, which can be accomplished with very little dissection by the use of a periosteal elevator or some such instrument. The central slip of the tendon is divided and the head protrudes through the two lateral slips. The head is now removed freely with a bone forceps or fine saw, as shown in Fig. 94, and the toe brought into

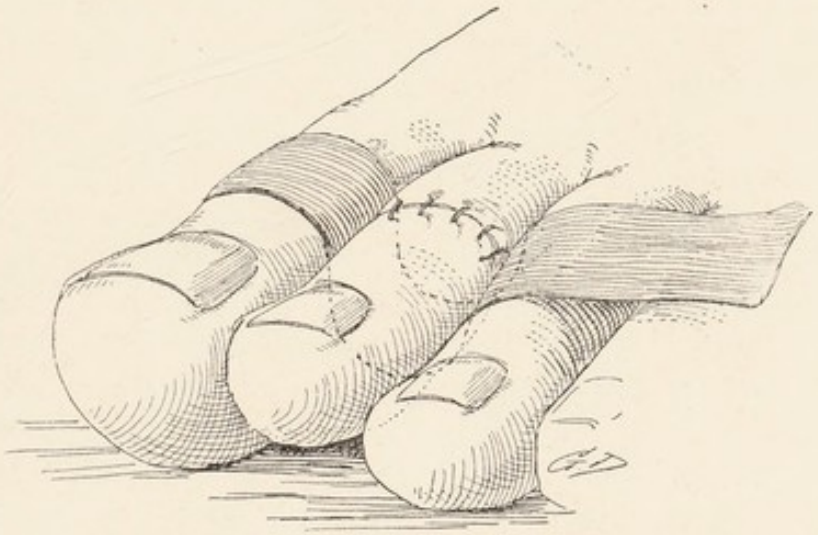

FIG. 95.—Operation for hammer-toe. Final stage. The approximation of the skin edges with sutures brings the toe into position. The strapping is usually applied over the toe, in the reverse manner to that illustrated.

position by the approximation of the widely-separated skin edges. At this stage of the operation the advantages of the elliptical incision become again apparent. The operation takes from five to ten minutes, and but for the two insertions of the hypodermic needle, is quite painless.

Fig. 95 represents the completion of the operation. A gauze collodion dressing is applied, and over it a strip of adhesive strapping in the reverse manner to that shown in the illustration. It is laid over the wound and proximal phalanx with the adhesive surface uppermost ; the ends are then passed under the adjoining toes, to which they become fixed. This counteracts any tendency to hyperextension of the affected digit. The patient from the first is allowed to walk about in an easy shoe, and after a fortnight all dressings are discarded.

Subcutaneous operations are useless ; amputation of the toe

is seldom required, but if performed, does not so frequently predispose to the development of hallux valgus as is often suggested. Excision of the joint, partial or complete, is the best remedy, and when performed by a dorsal elliptical incision, with local anæsthesia, is simplicity itself.

Sir Robert Jones recommends complete excision to promote ankylosis and to prevent the possibility of recurrence.

THREE CASES OF TUBERCULAR DISEASE OF THE LOWER END OF THE FEMUR

ILLUSTRATING SOME POINTS IN PATHOLOGY AND TREATMENT

PUBLICATIONS on the subject of tubercular disease of the bones and joints in children, more particularly in relation to the work of Stiles, have thrown light on a subject which heretofore has been somewhat confused.

In this communication I propose to concentrate attention on three recent cases of tubercular disease of the juxta-epiphyseal (metaphysis) portion of the lower end of the femur. The disease commences and progresses along definite anatomical and pathological lines in a corresponding position in all bones.

Pathology.—It may be stated as an axiom that the great majority of cases of osseous tuberculosis owe their origin to infection from contaminated milk, and until this source of infection is better recognised and dealt with by the public there will be no diminution of the stream of children suffering from the disease which seeks admission to the hospitals. In a typical case the tubercle bacilli can be traced from the milk to the metaphysis of the bones. Possibly the child suffers from adenoids or enlarged tonsils, the cervical, bronchial, or mesenteric glands become involved. The bacilli in the first case, are carried through tributaries of the jugular vein into the pulmonary circulation.

Reaching the systemic circulation, the survivors of phagocytosis and endothelial activity are deposited in the metaphysis of bones, to remain latent or to set up active disease. The reason for the lodgment of tubercular emboli in this situation is an anatomical one.

Three sets of capillaries anastomose in the metaphysis of bones :—

1. The end branches of the nutrient artery (diaphyseal group).

2. Branches from the arteries supplying the joint entering the metaphysis (metaphyseal group).

3. Branches from the same source as 2 supplying the epiphysis (epiphyseal group) perforate the cartilage and anastomose with the diaphyseal and metaphyseal vessels.

The circulation through the cancellous spaces of the bone is slow, and this fact, combined with the free capillary anastomosis, makes it obvious why the site is a favourable one for the deposit of a tuberculous embolus.

A slight injury, breaking down some of the trabeculæ of the cancellous spaces may determine the onset (by setting free the embolus) of active tuberculosis.

Once established, the disease is at first frequently central, and subsequently is carried by the Haversian systems through the compact bone to the periosteum. An osteoplastic periostitis ensues, and a thin layer of new bone, very porous, and delicate, is laid down between the thickened periosteum and compact bone. Finally, as caseation and liquefaction proceed, an abscess forms in the soft tissues, and is followed by a sinus leading down to diseased bone.

The formation of the thin layer of porous bone, coupled with the presence of thickened periosteum, is responsible for the very important clinical sign seen early in these cases—viz., thickening. (Figs. 96 and 97). Tubercular disease may arise in the epiphysis or in the diaphysis, but for the reasons given, not nearly so commonly as in the situation just described. Furthermore, it is impossible to have a tubercular epiphysitis unless centres of ossification have already appeared in the cartilage. For example (with the exception of the epicondyle) the inner side of the epiphysis of the lower end of the humerus could not be diseased in a child under eleven years, nor could the outer side be affected until the child had reached the age of two (Stiles). On the other hand, the upper and lower epiphyses of the femur (but not so frequently as the metaphysis), owing to early appearance of ossific centres, may readily be the site of tubercular disease.

The relation which tubercular metaphysitis bears to disease of the neighbouring joints is very definite.

Thus, in the hip-joint, the metaphysis or juxta-epiphyseal portion of the neck is the first portion of the joint to be involved. But here the metaphysis is entirely enclosed within the capsule, and the joint cavity can scarcely escape rapid infection from direct extension.

On the other hand, the metaphysis of the lower end of the femur is not enclosed within the joint cavity of the knee, and is separated from it by a large epiphysis. In this situation the joint is not, as a rule, involved in the customary manner, the primary focus being either synovial or epiphyseal. What has been said of the knee-joint applies equally to the case of the shoulder-joint.

The three cases which I mention below, point to the

fact that tubercular metaphysitis of the lower end of the femur is no less common that in other situations. The disease progresses along the lines of least resistance, through the thin trigone of the femur, presenting as a popliteal abscess above and behind the knee-joint.

In the elbow-joint the metaphyses of all three bones are within the joint cavity, and, as in the hip-joint, tubercular metaphysitis is followed very rapidly by general joint infection.

FIG. 96.

FIG. 97.

Two specimens (actual size) of the lower end of the femur removed by operation. Note the new " bark "-like bone formed as a result of osteoplastic periostitis. The thickening felt clinically is thus accounted for.

Diagnosis.—There is little to be said concerning the diagnosis of central tuberculosis of the metaphysis in children. The only early diagnostic sign is thickening of the bone in the region of the epiphysis. Occasionally a similar condition is present in cases of congenital syphilis. In every case an X-ray photograph must be taken to demonstrate the tubercular focus and to estimate the extent of operation necessary for its treatment.

Treatment.—It is only necessary to dwell in this paper on the line of treatment adopted in the three illustrative cases—the

method is applicable to practically all cases, but I believe it has not been applied to cases of the femur prior to the publication of this paper.

In some instances the radical operation may give place to more conservative non-operative methods, the progress of the disease being kept under close observation in order that operation may be recommended in progressive cases before the formation of sinuses and mixed infection. The old operation of exposing the bone, and of eradicating the disease by a process of drilling, scraping and drainage may be indicated occasionally, and gives good results.

The operation of choice is, however, to divide the bone with a Gigli's saw at a level well above the disease, and to wrench the metaphysis and diaphysis away from the epiphysis by means of a powerful forceps. In no instance can the " epiphyseal line " be injured, for this is part of the epiphyseal mass, which could not, by the use of any reasonable force, be pulled away from the joint. As a rule, in the presence of disease at or near the juxta-epiphyseal line little force is required to remove the diseased portion from the epiphysis, and if difficulty is experienced a few touches of the chisel will complete the separation.

The periosteum in these cases is thickened, and easily separated from the bone. The latter is removed from the tube of periosteum, as is familiar in rib operations, only with very much more facility. Whatever the *rôle* of the periosteum in the production of new bone, it at least acts as a tubular guide to promote regularity of growth.

Without the aid of X-ray photographs it would be difficult to believe with what accuracy the bone is replaced by osteogenetic forces in a comparatively short time.

In my first case, operated upon in 1909, before Stiles' publications appeared or any similar cases had been put on record, I removed the lower third of the femur in a boy suffering from tubercular metaphysitis. In this case a mixed infection was present, and an old-standing sinus discharged in the popliteal space. The result of the operation is shown in the accompanying skiagram (Figs. 98 and 99). The boy has perfect use of his leg ; there is three-quarters of an inch shortening, the movements of the knee-joint are normal. The treatment after operation consisted in the application of an 8 lb. weight and pully with lateral sand-bags. (Thomas' splint has been used in recent cases.)

The second and third cases were also septic from the existence of old-standing sinuses, but nothing could have excelled the results of " metaphysectomy " (Fig. 100). The portions of bone

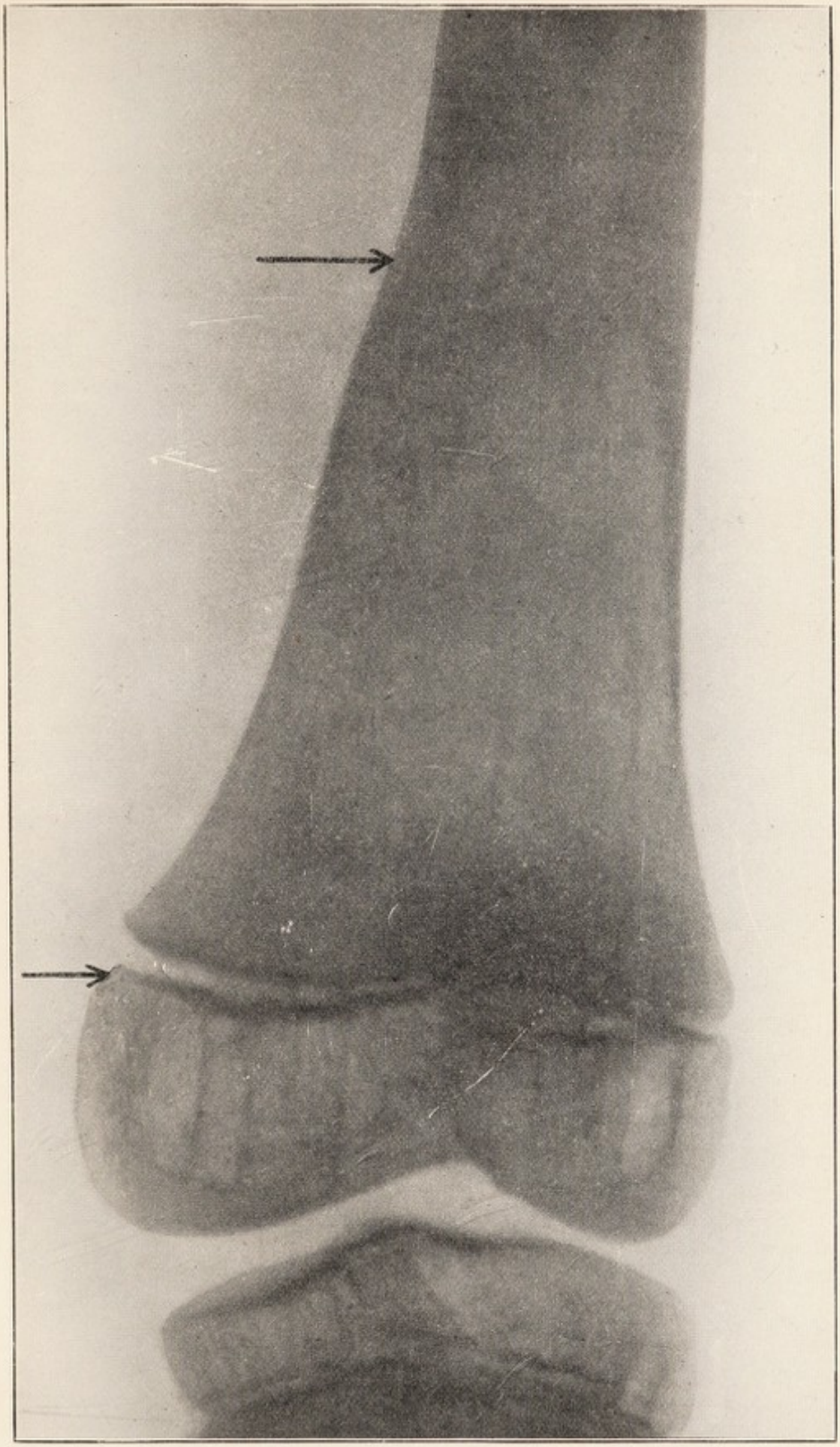

FIG. 98.—X-ray of first case, four years after operation. The lower third of the shaft of the femur was removed (between the arrows) and was accurately reformed as shown. Functional result perfect.

removed from the last two cases are illustrated (Figs. 96 and 97), the specimen from the first case, which was in every respect similar, but larger, was unfortunately lost.

I must again acknowledge my indebtedness to Sir Harold

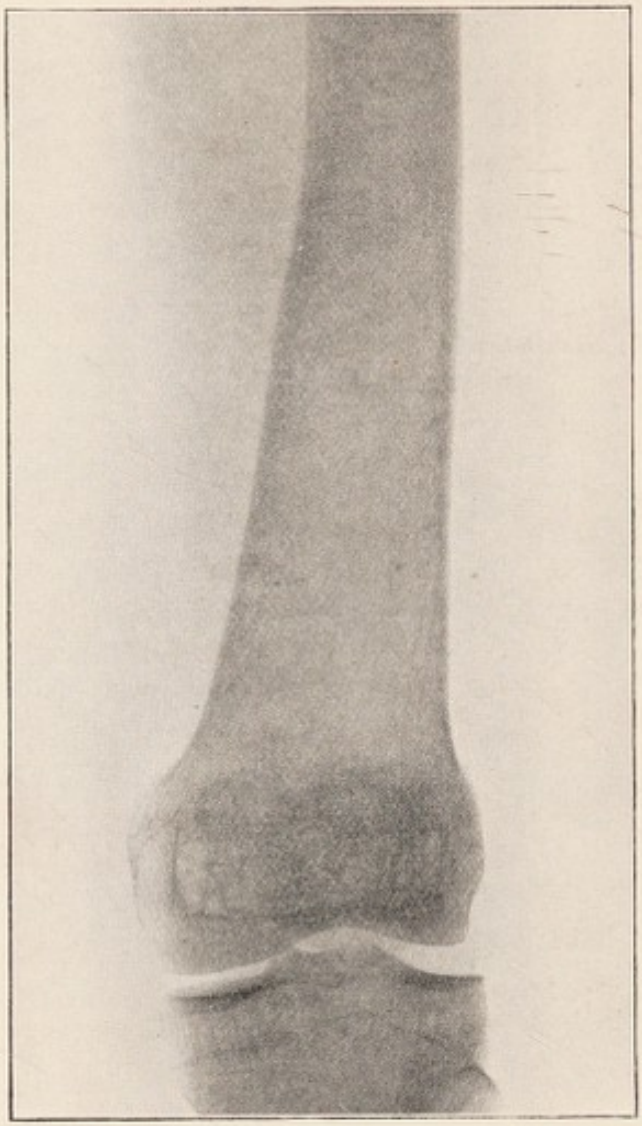

FIG. 99.—X-ray of same case, eighteen years after operation (1927).

Stiles, whose work I had an opportunity of seeing, and who has helped to put this whole subject on a sound and scientific basis.

NOTE.—Although these cases have been referred to as tuberculous, some recent cases which appeared exactly similar, were proved to be staphylococcic in origin. The exact type of infection is, however, only of academic interest.

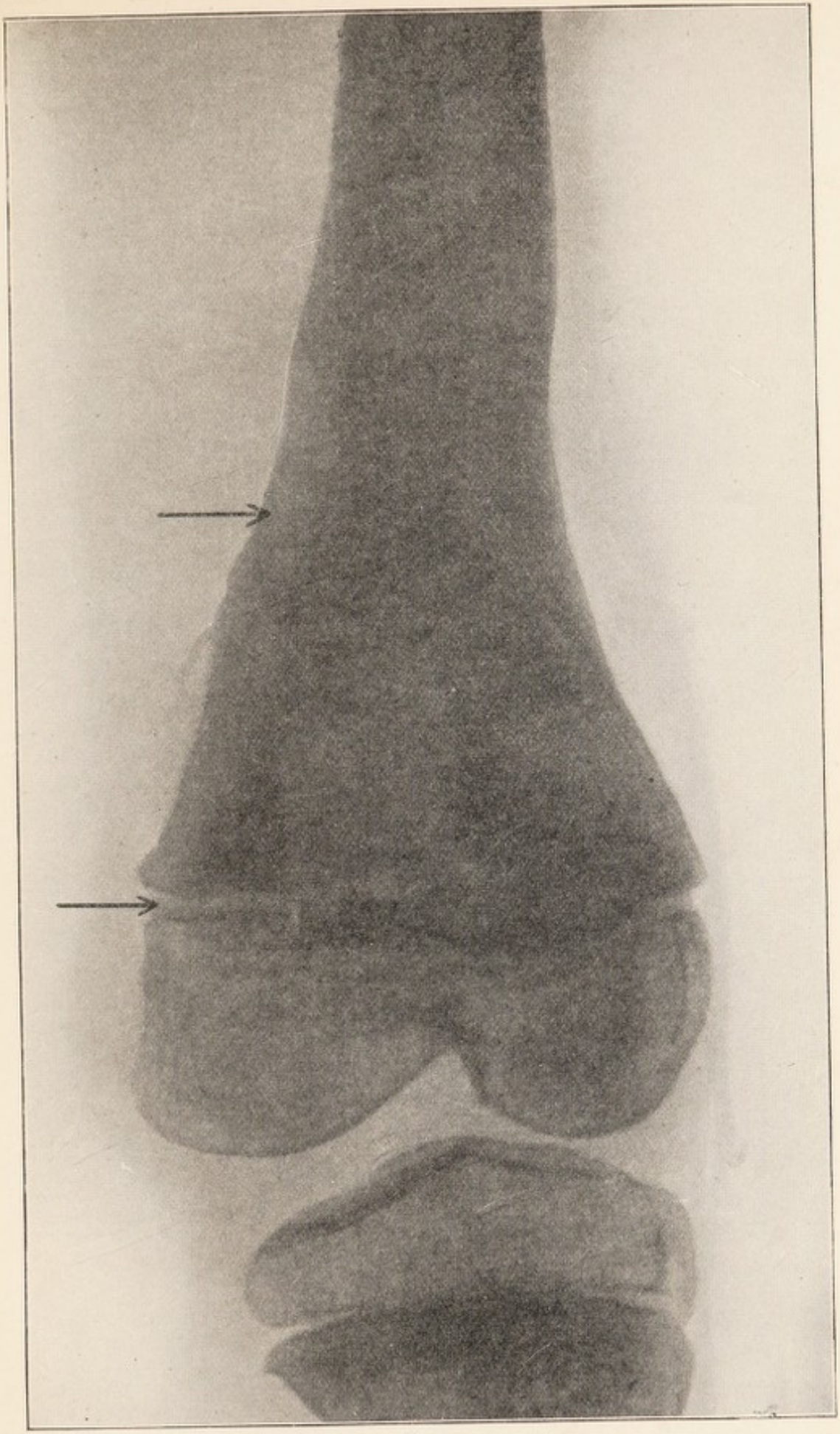

FIG. 100.—X-ray of second case, one year after operation. (The bone removed is shown in Fig. 69, and the new bone lies between the arrows.)

INDEX

Printed in Great Britain by William Clowes & Sons, Limited, Beccles, for Baillière, Tindall & Cox.