A Clinical Lecture

ON

DELAYED UNION, NON-UNION AND MAL-UNION OF FRACTURES,

Delivered at Westminster Hospital.

By A. H. TUBBY, M.S.,

Surgeon to the Hospital.

GENTLEMEN,—On the last occasion when we met we discussed the methods by which a simple fracture is united, together with the treatment of simple fracture, and to-day it is proposed to speak of departures which occur from the normal process of union of fracture. Such departures are delay in union, failure of union, and union in bad position.

It is necessary to make a distinction between delayed union and non-union, and the two are not identical, for a fracture may be a long time joining, yet it may ultimately do so, and thus the case may serve as an example of delayed union. On the other hand, it may not join at all unless surgically treated; such is a condition of non-union. It therefore follows that non-union includes all cases of delayed union, but the latter does not always imply the former. Therefore it is important for clinical purposes to make distinctions between delayed union and non-union, and the first that occurs is that of the time element. If, for example, a simple fracture of the lower part of the tibia is not united in six weeks, the case comes into the category of delay; but if, after three months treatment, the callus is not ossified, it is a case of non-union. Yet this point, however, is rather arbitrary, for, in certain situations, union is naturally slow. An example of this is a fracture of the upper end of the tibia. It would not be correct to speak of delayed union at the end of six weeks after a fracture in this situation, for it is well-known that healing is slow to occur there.

Passing from the question of the time element to signs at the site of fracture, it is safe to say that if, some weeks after the accident, a mass of callus be present, and gentle, passive movement causes pain or inflammatory signs, the case is probably one of retardation rather than failure of union.

A striking example is the case of a patient, aged 56, in Hollond Ward, who was sent to me from Ramsgate as an instance of non-union occurring in the lower third of the right femur. Either on touching the skin over the fracture, or on attempting gentle passive movement, the patient experienced acute pain. The presence of malignant growth was suspected, and so I cut down to the site of fracture. It was then found that the compact tissue of bone was extremely thin, the medulla in a state of fatty degeneration, and that very little repair had taken place; but the irritation produced by an examination at the site of fracture set up a rapid reparative process, and, six weeks after the operation, the bones had united.

Another point of distinction between non-union and delayed union is the following:—

If there be much loss of voluntary movement with pain on passive movement delay is signified, but if there be no pain on passive movement non-union is present; and the presence of a large amount of callus generally indicates that union will ultimately take place.

DELAYED UNION.

Having, as far as possible, defined the terms, we may now proceed to discuss the causes of delay in the union of a fracture. The most common cause at work is absence of mobility of the fragments due to the following conditions:—In some positions it is almost impossible to effectively control the fragments, for instance, in the upper third of the femur it is exceedingly difficult to obtain effective purchase upon the upper fragment. Another cause at work is incomplete fixation of the limb by inefficient splints. They are often applied wrongly or loosely, or it may happen that a small portion of muscle is entangled between the fragments and contracting from time to time in harmony with the main body of muscle, it keeps the fragments in motion. Local anæmia, due to tight bandaging, is not seldom to blame for failure in the sequence of the normal processes of union. Thus, a tight bandage placed around the upper part of the leg will very likely result in a fracture of the lower part taking eight or nine weeks to unite instead of six. It is also quite certain,

that if the fragments are not placed in perfect apposition delay will occur. Such then are the chief local causes. There are also some general causes at work, but these will be discussed under the heading of non-union.

With regard to treatment it is of importance to ascertain if there be any condition of the patient which is responsible for general malnutrition. The most usual causes are: Syphilitic disease, anæmia, and the debility arising from ague. Having recognised them the treatment is self-evident. Locally the most important consideration is to immobilise the fragments effectively without undue pressure or interfere with the circulation. This, in the case of a simple fracture of the lower third of the tibia and in many other cases is best effected by the application of Croft's plaster-of-paris splints.

There can be no doubt that many weakly patients with fractured limbs are kept too long in bed, and delay in union arises from this cause, for if the limb be properly fixed in plaster-of-paris and the patient be removed from his bed and taken into the fresh air proper union rapidly sets in.

NON-UNION OF FRACTURE.

It is very difficult to draw the boundary line between delayed union and non-union, but, fortunately, non-union is of rare occurrence; that is to say, nearly all fractures unite ultimately with patient treatment, so that the probability of non-union is as small as from 0.2 to 0.8 per cent. of all fractures. There are, however, certain situations in which failure of the healing process occurs, and these are, in order of frequency: the upper third of the femur, due to an excessive displacement of the fragments, and the leverage of strong muscles; the middle of the humerus, due to the defective blood supply, owing to the fibrous nature of the periosteum in the neighbourhood of the insertion of the deltoid muscle; oblique fractures of the tibia; fractures of both bones of the forearm, and the lower jaw. The causes of non-union may be discussed under the headings of general and local. In compound fractures, especially those arising from gunshot wounds, excessive loss of blood is followed from time to time by a flail-like union; and, in a profound anæmia, such as is found in pernicious anæmia, when fracture occurs non-union frequently follows; so, too, it happens in the anæmia of malarial disease. The most commonly recognised cause of non-union is specific disease, and a rare one is the condition described by French authors as phosphaturia, wherein an excessive amount of phosphates is passed in the urine, and the bones become softened. Pregnancy also has afforded striking examples of non-union. One of them is the classical case of Dupuy's, the details of which are as follows:

A young woman, pregnant, at the third month fractured the shaft of the femur; the amount of bruising was slight. A splint was carefully applied for thirty days, and at the end of that time the patient was examined. The fracture was found to be completely mobile. The apparatus was then reapplied, with extension, for six weeks, but no union was obtained, although her general condition remained very good. Parturition took place at the usual time, and—remarkable to relate—one month afterwards the femur had completely united.

Rare causes of non-union are scurvy and rickets. It has been said that in old age non-union is particularly prone to occur; but this is a fallacy, as is shown by the case of a woman, aged 86, in Hollond Ward, who was run over eight weeks ago, and sustained a fracture of the lower ends of the right tibia and fibula. In her case good union occurred in six to eight weeks, and she was able to leave the hospital on crutches. I have also had under my care, during the last three years, two cases of fracture of the neck of the femur in old ladies, aged respectively 83 and 84. In both these cases good union, although with considerable shortening, occurred, and the patients were able to get about. The details of these cases I propose to put on record later. It is quite likely that the idea of age being a bar to union has arisen from the many cases of non-union occurring after fracture of the neck of the femur. The failure is not due to age only, but to the unique arrangement of the blood supply, for it has been shown that the arterial supply to the globular head of the femur is derived from the neck, and, when the former is separated from the latter, local anæmia occurs, with consequent failure in the production of callus. As to the matter of sex, non-union occurs seven times as often in males as in females.

With reference to general constitutional conditions, such, for instance, as rickets, mild varieties of this disease have no

influence upon the process of union, for fractures in these cases unite quite readily; as, for instance, in the case of a girl, aged 18, in Hollond Ward, who has had two fractures of the upper end of the left humerus, and one of the lower end of the right femur, which have joined quite well within an ordinary time. In the severer forms of rickets, and especially in that form associated with hæmorrhage beneath the periosteum, and known as scurvy rickets, non-union frequently occurs. Locomotor ataxy is sometimes quoted as a cause of non-union, but this is not so; for although spontaneous fracture occurs in this disease, yet it is curious to observe that many such fractures unite readily. Again, in the case of infantile paralysis, where the bones are often fragile and show signs of fatty degeneration, when fracture occurs, timely healing takes place.

The local causes, as a rule, are more important than the general. In a severe compound fracture, with much comminution of fragments, succeeded by necrosis and extrusion of

the action of strong muscles placed at the greatest mechanical advantage, exercises a deleterious influence. The interposition of a portion of muscle or fascia between the fragments has been quoted, and has been scoffed at, but Macleod has proved by a dissection that such was the exciting cause in one of his cases. Unfortunately, we have learned to expect fibrous union in certain spots, especially in the patella and olecranon, but, since the introduction of the method of wiring, failure to unite either by close fibrous tissue or by bone, has become less frequent.

There are certain supposed causes which are copied from one book to another which may be alluded to. One of these is the entrance of synovial fluid between the fragments. This, doubtless, is hypothetical; but, in the case of the patella, one can readily understand that if the torn synovial membrane itself is insinuated between the fragment, it is not likely that union will occur by bone. Again, it has been said that the direction of the nutrient artery in a bone has an

Fig. 1.—Roentgen-ray photograph. Side view of femur, showing mal-position of bone and overlapping of fragments.

fragments, non-union is likely to follow. This is particularly a condition which results from gunshot wounds, such as you saw in the patient in Northumberland Ward, who was wounded at the battle of Paardeberg through the lower jaw by an explosive bullet. He stated that a piece of his jaw was driven out, carrying the whole of the lower incisor teeth, and you have seen that these and the corresponding portion of the jaw are entirely absent, while the two fragments of the bone remaining can be easily moved one on the other. Defects in the local blood supply, as in the upper end of the humerus and the upper end of the femur, have been already alluded to, and it is possible that, in fracture of the patella, the firm application of crescentic-shaped pads above and below the fragments is responsible for some of the glaring examples of fibrous union which occur there, for there can be no doubt that such pads press upon the arterial plexus which surrounds the bone. Then, too, excessive mobility of fragments, as in the upper third of the femur and middle of the humerus due to

Fig. 2.—Antero-posterior view of A. S. B., showing mal-union of fracture of femur.

influence upon the question; that is to say, that fractures in that portion of bone towards which the nutrient artery is not directed are more likely to fail to unite than those occurring at the opposite extremity. Such, however, is not the case.

The result of non-union is the formation of a false joint, or *pseudarthrosis*. Several forms of pseudarthrosis have been described somewhat minutely, but, for practical purposes, the following varieties may be remembered. The bones are joined end to end by fibrous tissue; that is to say, the intervening callus has not proceeded beyond the fibroid stage. In some examples of this class the bone ends are of normal size, or tapered, while others are swollen and bulbous, owing to the formation of a certain amount of ensheathing callus around them. Or it may happen that, instead of a more or less complete cylinder of fibrous tissue intervening between the ends of the bones, their peripheries are joined by a membrane of fibrous tissue containing a cavity which has no resemblance to a true joint. Occasionally in the fibrous tissue more or

less isolated portions of ossified callus are found. In very rare cases there is a very close attempt at the formation of a true joint cavity: that is to say, there is a membrane of fibrous tissue uniting the bone ends; inside this membrane is an imperfect synovial membrane, while the bone ends are shaped so as to fit each other more or less completely.

The symptoms of non-union are the following:

The most striking one is abnormal mobility, and it is well to repeat that this mobility is often painless, especially in long-standing cases, with passive movements, thus affording a distinction between delayed union and non-union, for, in the former, the passive movement is painful. Of course, if the fibrous tissue in non-union be stretched beyond reasonable limits, pain ensues, as it always does when fibrous tissue is so treated.

The next set of symptoms are those due to functional troubles in the limb. Thus, if the fracture be near the trunk, most of the coarser movements are lost, and in the case of

two there is no sign of bony callus, non-union is impending, and this suspicion is strengthened if painless passive movement can be obtained.

As to the prognosis, it may briefly be said that the outlook depends upon the recognition of the causes of the condition and the success of the treatment adopted.

TREATMENT.

This may be spoken of under two headings: the treatment of a suspected case, and that of an established case. If union be so much delayed that it appears complete failure may occur, you are not called upon to operate immediately, but to adopt fully the lines laid down in the treatment of delayed union, and which may be summed up as follows: Be patient, improve the general health, immobilise the fracture and wait. In some cases massage, skilfully applied, may be of great value, and it is well to examine the fracture from time to time by the *x* rays. But too much reliance must not be placed

Fig. 3.—Side view of fracture in Figs. 1 and 2 after operation. The fracture is rectified and maintained in position by the steel screw.

the leg, there is inability to bear weight upon it, associating with a wasting of part. A striking example of this condition is sometimes seen when non-union follows osteotomy of the tibia and fibula after rickets. I have seen at least three cases of non-union due to such a cause. In one case of non-union which came under my care, in a child aged six years, the non-union was associated with acute fatty degeneration of the lower third of the leg and the foot, as was readily seen after amputation. I do not think it is fully understood that non-union after osteotomy of the tibia and fibula occurs in a somewhat surprising proportion of cases, and, to my mind, it affords a strong protest against indiscriminate operations of this kind. Unfortunately these sad examples are not seen at general hospitals, but they drift to those societies which afford charitable relief to the lame.

The diagnosis from delayed union can only be made by waiting and noting the effects of general treatment and appropriate local treatment. If in the course of a month or

Fig. 4.—Antero-posterior view of the limb in Fig. 3 and showing the final result.

upon this, for it is curious to note that even when fractures have become so firmly united, as in the case of the lower extremity, that the weight of the body is well borne, the newly ossified callus remains transparent to the *x* rays and gives the impression of fibrous tissue. Indeed, it is not until some months afterwards that this ossifying callus becomes opaque. After patient trial of several weeks, or even months has been made, the question of non-union must be entertained.

There are certain methods still quoted in textbooks, and they serve as a warning and are to be avoided. Such are the injection of irritating fluids, acupuncture, the introduction of setons and of foreign bodies and electrolysis. There are also doubtful methods spoken of, such as rubbing the ends of the fragments together and subcutaneous section of fibrous callus. It is quite possible that if you propose such measures to your patients and they allow you to carry them out the result will be disappointing, and it is a pity all mention of them is not expunged from textbooks.

There are, however, certain well-recognised measures which have become permissible since the advent of aseptic surgery. These are refreshment of the ends of the fragments as you have seen me carry out in a case in Hollond Ward; resection of the fragments and fastening them together, either by wire or by screws, or by the application of a bone ferrule, as described by Nicholas Senn, and finally transplantation of bone has been performed.

With reference to the method of wiring success depends very largely upon whether the anatomical conditions will allow safe access to the surfaces of the bone at the time of operation. As an example of where such may be safely attained the lower end of the tibia may be quoted. It is quite easy to reach the internal aspect and by tearing off the periosteum, carrying with it the artery and nerve, the external aspect may be safely exposed.

But in the case of the upper third of the femur the anatomical conditions are such that it is extremely difficult to fully

Fig. 5.—Roentgen-ray photograph of a case of traumatic separation of the lower epiphysis of the right femur and forward dislocation of the right tibia. The lower epiphysis of the femur A is seen lying on the front of the shaft, and attached to the epiphysis is a portion of the shaft B, which was removed at the time of the operation. The black broad line C to the right represents the splint in section. This photograph was taken on the day following the injury.

expose the whole circumference of the ends of the fragments. In front are the femoral vessels, behind is the sciatic nerve, externally are numerous vessels, branches of the external circumflex, and internally are the branches of the internal circumflex and the perforating vessels, while the bone lies at such a depth and imbedded in such a mass of muscular tissue that easy access to it is extremely difficult, and the whole field of operation is narrowed and obscured by hæmorrhage. In fact no operation of this kind should be lightly entered upon, and statistics show that in the case of operation on the femur for pseudarthrosis one patient in five dies. Therefore, you should consider whether the patient's life cannot be made tolerable by apparatus in preference to his undergoing the risk of so severe an operation.

MAL-UNION OF FRACTURE.

This condition ought to be rare, except perhaps in some situations. Such are the upper third of the femur and the middle of the humerus; but the occasional occurrence of mal-union in these situations should be no excuse for such an event in others; and I would beg you, in practice, to exercise the utmost care in accurately adjusting the fractures you meet with, and maintaining the adjustment until proper union has occurred. A badly set fracture will always be an annoyance to the patient and to you, and he will doubtless remind you of it from time to time in ways far from pleasant.

The main causes are insufficient treatment at the first, and negligent treatment afterwards. Insufficient treatment at first too often means non-recognition of the fracture, such as occurs in Colles's fracture, or in those about the elbow, but since the advent of skiagraphs, such want of recognition ought not to occur. A striking example of non-recognition of the fracture is seen in the case of the boy in Hollond Ward.

Fig. 6.—Roentgen-ray photograph taken four weeks after the injury. The forward dislocation of the tibia is seen to be partially reduced, but the epiphysis is still in its abnormal position. The shadows of the screws C are those of the double inclined plane which supported the limb.

Alfred S. B., aged six, was admitted into Westminster Hospital on account of vicious union of the lower part of the left femur, on October 31st, 1900. In March, 1900, the child fell on his left knee. He was first treated for a bruised bone in a home in one of the suburbs of London, and afterwards for a fractured knee-cap. Suppuration seems to have set in about the knee, and incisions were made, and some diseased bone taken from the neighbourhood of the knee-joint. His condition improved, but about three months ago, that is, in July, he fell and broke his thigh. The fracture was put up in the same home, and kept up for six weeks. The faulty condition of the limb was as follows:—

On admission there were several scars over the left knee-joint, which is bent at an angle of nearly 60 degrees, and has only about 4 degrees or 5 degrees of movement in it. The left leg and thigh are wasted, and the outline of the thigh, at its lower part, is entirely abnormal. In fact, the lower part of the thigh projects forward at an angle of about 30 degrees or more with the upper part of the bone; so that, with the combination of a bent knee and a malunited fracture of the thigh bone, the foot is several inches off the ground, and the patient is unable to walk. Two x-ray photographs were taken. (See x-ray photographs 1 and 2), and the condition is well seen in the photographs. The upper end of the lower fragment is directed upwards and backwards, and is overlapped by the lower

end of the upper fragment. It was felt that there was no alternative but to operate and attempt to remedy the condition.

Operation.—Esmarch's bandage was put upon the right thigh, and an incision five inches long was made on the outer aspect of the left femur. The site of the mal-union was exposed, and cleanly divided with a chisel, a small portion being removed with bone forceps, so that the two ends might be brought into contact. A steel screw, $2\frac{1}{2}$ inches in length, was then put in obliquely (see x-ray photographs 3 and 4), so as to traverse the lower end of the upper fragment and the upper end of the lower fragment. The direction of the screw was from above downwards, and from without inwards. The wound was then closed, and the limb placed on malleable iron splints at a suitable angle. On January 14th of this year complete union was found to have taken place, and so five pounds extension was applied to the limb, in order to overcome the flexion at the knee joint. Gradually the flexion disappeared, and the movements of the joint were found to be increased to between 30 degrees and 40 degrees. The final condition of the patient is seen in the skiagraphs 3 and 4. He has left the hospital walking well.

Negligent treatment means want of constant supervision after the fracture, and employment of unsuitable apparatus, such as ill-fitting splints, which fail to fix the fragments. It is not sufficient to put the fracture up, and to leave it for some

Fig. 7.—A Roentgen-ray photograph of the limb seven weeks after the injury and three days after the operation described in the text. At A is seen the shadow of the nickel-plated steel screw inserted into shaft and through the epiphysis to keep the latter in place. At B is seen the gap caused by the removal of a portion of the shaft which was adherent to the displaced epiphysis. The screw A is still *in situ*, and has given rise to no trouble at this date—November, 1901—that is, two years after the operation.

five or six weeks, but the patient should be seen at intervals of two or three days, to make sure that everything is going well.

In slight cases of mal-union of fracture, in which there is but little shortening of the limb, slight loss of movement, or slight deformity, the use of prothetic apparatus is sufficient. But, in severe cases, you may be called upon to consider the propriety of operation, always remembering that the same remarks made as to the danger of operating in non-union apply to mal-union. Some surgeons, especially the French ones, have advocated osteoclasis, a process which is expressed by the public as "breaking the bone again," and setting it. This is not to be recommended; as in the case of a long bone of the lower extremity in an adult, the instruments which

must be employed are very powerful, and great damage to the soft tissues must necessarily ensue, while the application of the force is often ill directed, and the result is far from good. The only recommendation of osteoclasis is that no wound is made, and risks do not arise from hæmorrhage and sepsis, but there can be no doubt that osteotomy is preferable, because more precise, and it should be done by the open operation. Difficulties will necessarily occur arising from the following conditions: the position and depth of the fragments, the hardness of the callus, and the removal of a sufficient portion of bone to allow the resulting ends to come into accurate apposition. Many of the conditions of such an operation are illustrated by the following case:—

Traumatic Separation of the Lower Epiphysis of the Right Femur: Subsequent Rectification by Open Operation: Epiphysis Retained in Place by a Screw: Fracture of the Middle of the Left Femur.—George B., aged nine, was admitted to Westminster Hospital on October 24th, 1899. He was going to school, when he ran after a four-wheeled cab, and grasped the back rail. In endeavouring to get down, he caught his legs in one of the wheels, and the limbs were carried round nearly to the level of the middle of the door, when the wheel became locked, with his legs projecting through the spokes. The child was brought to the hospital immediately.

On admission, the boy lay in bed with his knees drawn up, and in great pain. There was a slight abrasion on the front of the left knee, and another on the other side of the left leg. The left thigh was found to be fractured obliquely in its middle, and there was eversion of the foot, with an inch shortening. There was already considerable swelling around the right knee, which was flexed to an angle of 30 degrees, and the leg was rotated inwards. The patella was intact, but posteriorly two sharp points could be felt almost projecting through the skin in the popliteal space, and the pulsation of the popliteal artery was well marked. Anteriorly, a distinct mass could be felt lying on the front of the femur (see Fig. 5). The joint could be moved, but no true crepitus obtained. From the nature of the injury, and from the character of the displacement of the femur a diagnosis of separation of the lower epiphysis of the right femur was made, which was confirmed by a Roentgen-ray photograph. The foot was somewhat cold, but feeble pulsation could be felt in the anterior and posterior arteries. Neither of the fractures were compound.

The boy was placed under an anæsthetic, traction was applied to the right foot, reduction of the deformity effected, and the limb was put up on a double inclined plane, and an extension weight of five pounds applied. To the left femur a long Liston splint was applied, after reduction of the fracture, and the bone was thereby maintained in good position. The boy experienced great pain during the following night in the right knee-joint, and the foot became very cedematous and cold, there was evidently interference with the circulation, and it seemed that gangrene might follow. The angle of the inclined plane, which had previously been about 30 degrees, was now increased to 45 degrees, and after twenty-four hours the foot became warmer, and the oedema gradually decreased. But there could be no doubt that, during these frequent manipulations necessary to relieve the pain and the oedema, displacement of the epiphysis recurred, although this untoward occurrence was masked considerably by the great swelling about the knee joint anteriorly and posteriorly. The condition was uneventful until November 21st. It was then quite clear that the epiphysis was still lying on the front of the femur, and was evidently adherent to it, and pointing directly forwards, and the intercondylar notch was felt well defined. At this time, too, the sharp lower end of the shaft could be felt in the popliteal space, merely covered by skin, and nearly coming through it. Another radiograph (Fig. 6) was taken, and it is seen thereby that the epiphysis is lying on the front of the shaft, while the shaft itself is in contact, at its under part, with a small portion of the upper articular surface of the tibia, at its posterior part.

On November 27th, thirty-four days after the injury, the patient was again put under an anæsthetic, and an attempt was made to displace the epiphysis from its connections by tapping it smartly on its inner side with a mallet, the skin being guarded with thick felt. This attempt resulted in failure, as might be expected. So the tendo Achillis was divided, and it was decided to open the knee joint and replace the epiphysis. A long curved incision was made, commencing at the upper and inner angle of the patella, and passing horizontally outwards, and then curving downwards for about $3\frac{1}{2}$ inches, the total length being 8 inches. This incision completely divided the extensor tendon and the upper and outer part of the capsule of the joint. The patella and the superjacent structures were then turned downwards and inwards, and the displaced epiphysis was fully exposed by retracting the soft parts. The epiphysis was found to be so tilted that its articular surface looked forwards; its upper surface looked backwards and inwards, and on the inner side of the epiphysis was a piece of bone, the size of a walnut, which had been detached from the shaft of the femur with the epiphysis. This piece of bone was chiselled away, and then the epiphysis was chiselled off the femur, care being taken not to leave any of it behind as it was thought that the growing line was attached to the epiphysis, and this proved afterwards to be the case. The difficulty now was to lever back the epiphysis between the closely-locked tibia and the shaft of the femur. It was not possible to further detach the epiphysis from its soft connections as these had been left intact on the inner side only. But by applying vigorous extension to the limb and using a periosteal elevator as a lever the epiphysis was ultimately forced into position. Then, flexing the knee-joint to a right angle a gimlet was run through the epiphysis into the shaft of the femur and a nickel-plated steel screw (Fig. 7) driven home, care being taken that its head was flush with the under surface of the articular cartilage of the femur. Six deep sutures were then passed through the soft parts, including the divided portions of the extensor tendon, leaving a small opening for the insertion of a drainage tube. The limb was then put up on a back splint with a foot piece and two side splints. After the operation the temperature fluctuated between normal and 101° , and he was much troubled with sickness for

three days. There was also a great deal of oozing of blood and serum from the tube but no pus. On the fifth day the drainage tube was removed and on the twenty-eighth day the wound was soundly healed. On January 3rd, 1900, it was noted that the limb was not so straight as desirable, there being a considerable amount of genu valgum and the knee-joint was stiff. So on January 8th the boy was anaesthetised, the limb was straightened, some adhesions were broken down and the leg was put up in plaster. He was discharged from the hospital on January 12th, wearing a plaster-of-paris splint. The right leg measured 23½ inches from the anterior superior spine to the internal malleolus and the left leg 24½ inches, so that there was a difference of half an inch. In April the boy was readmitted, the plaster-of-paris taken off, and gentle movements of the knee commenced. Since then he has worn a trough splint applied to the outer and posterior aspects of the knee until now. The final result is that the left leg is straight, does not require support, has 25 degrees of flexion at the knee and is only half an inch shorter than its fellow, and the screw has given rise to no trouble whatever and is still *in situ*.

In this particular instance a nickel-plated screw was employed, but the ingenuity of the surgeon is often considerably exercised in deciding as to whether he should use wire or screws, and how he should put the binding material in to the best advantage. There are, however, some cases of mal-union which seem to defy successful operation. Such a one is seen in the case of cross union of the bones of the forearm with ossification of the interosseous membrane.

COLLES'S FRACTURE AND ITS TREATMENT.

By JOSEPH GRIFFITHS, M.A., M.D., F.R.C.S.,

Reader in Surgery in the University of Cambridge, and Surgeon to Addenbrooke's Hospital.

THE variety of Colles's fracture which I wish to speak of is the one in which the lower articular extremity, whether comminuted or not, is driven upwards and backwards upon the shaft of the radius. Other varieties of this fracture are occasionally seen, and each requires a special treatment of its own. This form is often found to be difficult to set, and frequently the displacement which accompanies this fracture is only partially corrected. This difficulty, which is a very real one, occurs so often that some surgeons go so far as to say that a Colles's fracture if deformity exists is rarely if ever properly set. Such a view receives substantial support from the fact that a large number of persons who have sustained this injury show permanent deformity with considerable limitation of movements in the wrist, and of supination and pronation of the forearm and hand; also, in a lesser degree it is true, from the numerous specimens in which the original deformity persists that are to be found in different pathological museums in this and other countries. The difficulty in the proper reduction of the displaced fragments is usually attributed to impaction, which causes fixation of the fragments one to the other. I hope to show that in the majority of instances impaction, such as is enough to defy manipulation with or without an anaesthetic, does not occur, and that it is not difficult to set the fracture properly, and that it is easy to redisplace and again to reset the fragments. When the fracture is properly set the several fragments fall into their natural positions, and the lower articular surface of the radius regains its normal contour and inclination, and owing to this the movements of the wrist-joint are not to any material extent interfered with. Under ordinary treatment, however, interference with the movements of the wrist-joint after this fracture is often considerable, and massage, early passive movement, and other manipulations are resorted to in order to reduce the degree of such interference to its smallest limit. Further reference will be made to this at the end, so I will at once proceed to review the methods now in use for the treatment of this fracture, leaving out of consideration the mechanism of its production.

The methods now employed in the reduction of the displacement may be classified as follows: (1) pull the hand straight out; (2) pull and flex the hand towards the ulnar side; and (3) pull the hand and flex the wrist-joints. To what extent the first two methods are effective in the hands of other persons I cannot tell, but I know that I have quite failed to produce any satisfactory impression upon the displaced fragments whenever I have adopted one or the other, or both in succession; pulling, as a rule, proves quite useless, and even when combined with ulnar flexion of the hand in my experience it is equally ineffectual. With the last method, on the contrary, I have invariably succeeded, and found no

impaction, or, I should say, no such degree of impaction as to defy ordinary manipulation. I now, however, find that a simple and full flexion forwards at the wrist-joint without any pulling suffices to reduce the deformity and to give back the natural contour to the broken radius. I have lately had an opportunity of testing this in a right forearm in which there was a recent Colles's fracture. During life—the man being in an unconscious state from injury to his head—as well

Fig. 1.—Taken from cast of hand and forearm, showing the usual deformity in Colles's fracture.
Fig. 2.—Section of radial half of radius and carpus as reflected in a mirror, showing the ordinary displacement of the lower fragment and carpus in Colles's fracture.

as after death, it was easy to reduce the displacement, which was of the ordinary kind, but by letting the hand go the fragments at once regained their displaced position. A plaster cast was made with the hand straight out, and another with the wrist fully flexed. In the former (Fig. 1), the deformity is seen to be marked and of the usual kind, but in the latter (Fig. 3) it is reduced and the natural contour of the wrist is seen.

Fig. 3.—Cast of same hand and forearm as shown in Fig. 1, showing complete disappearance of deformity in Colles's fracture by simple flexion at the wrist.

Fig. 4.—Section of ulnar half of radius and carpus, showing reduction of displacement when wrist is flexed (opposite half to that seen in Fig. 2).

The forearm and hand after their removal were sectionised in a median antero-posterior plane: one half was left with the hand straight out, but in the other the hand was bent forwards on the forearm in the positions corresponding to