W. S. Crawford
On the Nature, Cause, and Treatment of Ununited Fracture
When a bone has been fractured, certain changes take place, the result of which is that new bone is formed around and in between the fractured parts. After a time, the duration of which varies in different parts of the skeleton, the fracture becomes firmly united by a firm union, and the bone regains its original rigidity. In the vast majority of cases, these changes proceed without interruption and we have perfect operative union resulting, but in a few instances, from some cause or other the epiphysial deposit does not take place, and when the bone has grown the fracture after the lapse of what in ordinary cases is a sufficient time, instead of the bone being firm and rigid, we find that more or less movement is permitted between the two surfaces. In this condition the name of ununited fracture is given. Although we find that a bone has not united in the manner which is generally sufficient for union of simple fractures of that bone, we must not conclude in every instance that we have that condition present which is under-stood by the term ununited fracture.
we know that under certain circumstances union may be retarded, and that if the ordinary treatment be continued for a little longer, the bone will unite perfectly well. The distinction between retarded union and non-union must be more or less arbitrary; but it is of great practical importance that we should be able to distinguish between these two conditions, because the treatment which is adopted in the first instance answers equally well in either case, and it is only on the failure of the simple means first employed that we are enabled to decide that the fracture will not unite without some active interference in our part.

Certain fractures rarely unite by bone, e.g., fractures of the neck of the thigh bone, fracture of the patella, of the clavicle, etc. Some bones are more liable to the occurrence of ununited fracture than others; thus we find it more frequently in the humerus and femur than in the bones of the forearm and leg.

The degree in which the usefulness of a limb is
impaired by an ununited fracture depends upon the amount of motion which is permitted between the surfaces. In most cases an ununited fracture under the limit perfectly healthy, and this is especially true as regards the lower extremity.

Before jumping to the causes and treatment of ununited fracture, I shall briefly consider the different modes in which the fragments may be connected. Some of these have been described. First there may be absolutely no connecting medium of any kind between the fragments. This condition is seldom met with, and when it occurs it is found associated with a very debilitated state of the constitution. The ends of the bone are atrophied, very movable, and as may be supposed, the limb is quite powerless. Second in a small proportion of cases the ends of the bone are found embedded in a mass of fibro-cartilage. This seems to be the provisional cellus ensnared in its development. Third, a few cases have been recorded in which a fracture exactly resembling
a natural joint has been found between the ends of the bone. In these cases we have a fibrous capsule formed which invests the ends of the bone. This capsule is lined on its inner surface with a smooth membrane which secretes a fluid similar to synovia. The ends of the bone become rounded off, and smooth, and in some cases they are studded with cartilage. This condition of fibro-

natural joint is its extreme case, but some observers doubt whether such a form of union ever occurs. Several cases however have been recorded by different authorities, and there seems to be no reason why we should doubt the accuracy of their observations. Sir E. Home gives a very good description of the appearances found on dissection of a fibronatural joint occurring in connection with an ununited fracture which had existed for nearly four years. He says, "the arm was carefully dissected to examine the state of the fractured parts, between which there was no callus, but a large bag filled with a gray fluid resembling synovia. The internal
The surface of the bony was smooth, like a capsular ligament, and its attachment to the bone was of the same kind, it adhered firmly to the surrounding parts which were thickened and consolidated rendering it very strong. The two ends of the bone were adapted to each other, all the irregularities having been absorbed. The surface of the bone was not completely covered with cartilage but were studded with it. For the greater number of cases the fragments are connected by a tough, fibrous substance, which is firmly united to either end of the bone; this ligamentous tissue may be entire, or it may be divided into two or more bands.

The extent of motion permitted between the fragments varies much; in some cases the connecting medium is very short and the two surfaces are retained in such close opposition that little or no movement can take place; in others it is long and flexible, allowing a considerable degree of motion between the fragments.
I shall now consider some of the causes of ununited fractures. An attentive examination of these is of much importance, as in those cases where one can discern the cause, we are enabled to take such measures as will tend to prevent the recurrence of the malady. The causes of non-union may be divided into Constitutional and Local.

Constitutional causes, fever and internal inflammation are the great causes of union in fractures, and may also cause re-softerning after repair has commenced. In these cases the cause is temporary in its operation, and, as the general health of the patient improves, union of the bone commences, and is completed in the ordinary way.

Extreme debility from exhausting disease, as Phthisis, that enfeebled state of the constitution induced by habitual debauchery, and old age, may all operate as causes of non-union. That state of the constitution which is in-
- and of pregnancy, has been regarded by some as a frequent cause of non-union. There can be no doubt that the group of non-union in fractures occurring during pregnancy, more especially at an advanced stage, is often much retarded. On the other hand there are many cases of fracture occurring during pregnancy which unite as well and as quickly as they would if the woman were not pregnant. Mr. Anstis states that he had not found union in fractures more frequently in pregnant women than in other fractures. He only met with two cases out of the large number which came under his observation, and in these he ascribes its occurrence to the insufficiency of the local means of treatment along with a rest depressed condition which is observed in some women during the period of gestation.

An insufficient quantity of food may prevent union taking place. Brodie mentions the case of two patients who
thought they were becoming too stout, and
in order to prevent this, first themselves
upon low diet. It so happened, that after
they had persisted in this course for
some months each sustained a
fracture, and in neither case did it
unite. Long says that in consequence of
bad and insufficient food almost all
the gun-shot fractures which he saw
in Spain were followed by non-union.

Wright, a habitual stimulant may prevent
union. Mr. Wilson relates the case of a
man who was a dram-drinker, and who
had broken her leg. For some time after
the injury she was not allowed her access
-a tonic stimulant, and during that time
the fracture showed no disposition to
unite. Afterwards when she was allowed
certain quantity of spirits daily union
began and progressed in the usual man-
ner.

Spirits seems to have a remarkable power on
the process of union. Not only does it pre-
vent union occurring in recent fractures,
but it has been known to dispute the con-
nection between fractures which have been
observed for months and even years.
This fact would seem to support the
view expressed by Mr. Heath, to the effect
that he had observed comminuted fractures
more frequently in those from whose
diet vegetables had for some time pre-
viously been either totally or to a very large
extent excluded. He illustrates this by stating
that during the year of the potato famine
he saw more cases of comminuted fracture
than in any three or four years before
the famine.

The different cacheria, asphalitis and cancer
have been said to be frequent causes of
non-union. At one time it was sup-
posed that the existence of the cancerous
cacheria was an effective bar to the
occurrence of union, but we now
know that even in cases where the
bones are as brittle as to break in consequence
of slight muscular exertion, union
may take place as rapidly as if the fracture
There have been a few cases of comminute frac-
ture, occurring in persons to all appearance
in perfect health, and in whom no apparent
cause existed, which might account for it.
In such cases non-union has been
attributed to some peculiarity of constitution.
This explanation seems to be the only one
which it is possible to give of some cases
which have been recorded.
Causes which are entirely local in their origin.
Local inflammation, an abscess, is an ulcer,
usually has the effect of retarding union.
Excessive and long continued use of seda-
tive and cooling lotion, by diminishing the
vitality of the parts in the neighbourhood of
the fracture, has had the effect of retarding
union.
Tight bandaging may retard and even prevent
union, by creating injurious pressure, and
in preventing a sufficient quantity of
blood being sent to the injured part. In order
the asestain the effect which a diminished
supply of blood would have in retarding the
group of repair, Sir R. Brodie instituted a series of experiments. He broke the bones of animals and immediately after tied the principal artery of the broken limb. He then killed the animals at different periods. In all of those killed before the seventh day he found the fracture in the same condition as if it had been examined immediately after the infliction of the injury. After the seventh day union commenced. We may infer that after the lapse of seven days the anastomosing vessels would be dilated to such an extent that the obliteration of the main artery would be compensated for by the establishment of a free collateral circulation.

Want of apposition of the fragments prevents union taking place. This is no doubt the principal reason why operations union is so rare in transverse fracture of the femur, and very probably the cause in its operation in those special fractures which are forming mentioned as being sensitive to bone. The fragments may be kept separate by mus-
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getting between them. If a portion of one or both fragments be removed, union will not be completed until the dead portion be re-

moved.

Motion is without doubt the most con-

venient cause of ununited fracture. Mr.

Anstey said it was the only cause. He

asserted it to be the cause in twenty two

out of forty four cases; and he suspected

it in others. The effect of motion in pre-

venting osseous union is seen in the

results of the treatment which is adopted after

resection of a joint; in this case the surgeon
does not want osseous union, and in order

to prevent it taking place he has recourse
to occasional motion between the surfaces,

which results in the bones becoming after a

time firmly concreted by fibrous tissue in-

stead of bone. We have already seen that un-

united fracture is much more common

in the humerus and femur than in the

bones. This is owing to the action of powerful

muscles, as the deltoid and the poveras. It is

sometimes a matter of considerable difficulty to
present motion, as in particular fractures where the displacing causes are powerful, or where from the situation of the fracture, we cannot apply a proper retaining apparatus; but these cases are few and in most cases where motion the bone is not kept properly immobile, the blame rests either with the surgeon or with the patient. The position of the limb may be unsuitable, or the mechanical means may be insufficient or inappropriate for relating the particular fracture in a proper manner. In many cases however the blame may be fairly held to rest with the patient, some persons being of such a restless and irritable disposition that they find it next to impossible to keep the limb in the position in which it is placed by the surgeon; others finding the limb intolerable and wishing to obtain a little temporary relief loosen the apparatus by means of which motion is prevented. In either of these cases motion between the fragments may take place and so prevent osseous union.
Treatment. The treatment may be divided into Constitutional and Local.

Constitutional. In those cases where non-movement depends upon a morbid state of the constitution one must employ the remedies which are appropriate in the particular case. In every case of ununited fracture, we must attend to the general health of the patient, see that his diet is ample and of good quality, and if he has been accustomed to the use of stimulants, these must be allowed.

Local. Many different means have been proposed and employed. The degree of their expediency obtains greater, and I shall be guided to a certain extent by that, in the order in which I shall consider the different methods.

Absolute rest of the limb is the simplest of all the means which have been used. Mr. Astley was the first to direct attention to the importance of maintaining perfect immobility of the limb in treating cases of ununited fracture.
In addition to keeping the parts at perfect rest he employed a certain amount of pressure upon the fragments and in this way he succeeded in curing many cases of comminuted fracture, and that even after the seton and the means had failed. But in more recent combined with pressure and no special apparatus is needed, as the ordinary splints, starch bandages, etc., are in most cases quite sufficient to secure perfect immobility of the limb. In almost any case of comminuted fracture absolute rest should be tried in the first instance; because we know that in many cases we have a cure following its employment and if it should fail, the limb is not in a worse condition than it was before. The chance of a cure following its employment is greater when motion has been the primary cause of non-union; but it is especially successful in cases of delayed union. It has been observed that in cases of delayed union, an accidental bruise or an at-tack of erysipelas sometimes hastened
The group ofunion. On this ground, the use of stimulating applications has been recommended. Lotions, salines, leeches, blisters, are among the means which have been employed and cases are recorded in which the heel of one or other of these has been successful. Friction of the limb and the use of stimulating applications have been found of great service in cases where the limb is atrophied and in that state of anaemia to which the name of "local atrophy" has been given. The only other cases in which the use of stimulating applications is of undoubted service are cases of truly union in superficial lesions. Blistering seems to be the best form in which we can employ means of this description, and in order that benefit may be derived from their use they must be applied within the first six or eight or ten weeks of the fracture. Rubbing the fragments against each other has been recommended with the view of setting up a certain amount of action in the parts. The fragments should be rubbed against one another for a few minutes
until some degree of pain be complained of. This practice may be repeated daily until the part becomes tender and painful. When the practice is instituted in the lower extremity, the same end may be accomplished by putting up the limb in a firm apparatus and then allowing the patient to walk on it. Friction seems to have proved useful in some cases and in many it may be tried as a rule, but care is taken it cannot be productive of much harm in any case, as it may prove unpleasant in some.

The plan of directly imitating the surfaces of the joint seems to have been first practiced by Mr. Hunter in the case of a man with contracted practice of the humerus. Sir E. Home describes the case as follows: "There was an artificial joint, and Mr. Hunter made an incision into it, and then having introduced a spatula imitated the whole surface of the artificial joint. This brought on a considerable inflammation which ended in ankylosis, and thus the patient was cured." This appears to be the only case in which this operation has
been performed.

The practice of passing a seton between the
fragments in order to cause union, was
first introduced by Dr. Physick. Since
then this method of treatment has been ex-
tensively employed with varying success.
From a statement made by Dr. Physick's nephew
as to the result of the operation with the seton
in the United States, it appears that in the
upper limb it had generally been successful
but in the lower, it had always failed to the lower.
Brodie mentions several cases in which the
seton had been used, and the result in this
country, up to the time when he wrote, was
that it had sometimes succeeded in the
upper limb, but only once in the lower limb.
Subsequent experience would seem to show,
that its use is attended with considerable
success in comminuted fractures of the leg,
forearm, and smaller bones. In these
fractures seem to be rare, for, out of twenty
five cases collected by Noriss, in which the
seton had been used, there was only one
in which it did not effect a cure. In
The unsuccessful cases are more numerous than the successful. The length of time during which the seton is allowed to remain has varied much. Physiologically, it has been recommended to remain for four or five months. Periods varying from ten days to two months have been recommended by others. As the object is merely to excite a certain amount of local action, we may withdraw the seton, so soon as the desired action is fairly set up. In one case the seton was left in only four days, and yet union took place; in the other hand, we have numerous instances where it has been allowed to remain for several months without producing union.

The objections to the use of the seton are that it is uncertain as a means of cure, and that its use may prove dangerous and even fatal. In two cases it has proved fatal; and the lives of patients have often been endangered by the subsequent suppuration which is frequently set up, or from attacks of erysipelas.
The use of a pointed instrument for the purpose of eviscerating and incising the ends of the bone, was first proposed by C. Bell who remarks as follows:

"In one case I thought myself by observations made upon animals I authorized to propose that a long and sharp instrument should be placed obliquely down upon the bone so as to work upon
and perforate the extremities of the bone.
By this means I imagined the wound made by the passage of the instrument would immediately heal and yet the extremities of the bone be so existed as to resemble the state of a simple fracture.
Mr. Bell never seems to have had an opportunity of carrying out his idea in practice. More recently Mr. Miller, seeing the great benefits accruing from the employment of substantiae osseae in the division of tendons, suggested that this principle might be made available towards the remedy of comminuted fractures. He says, "A strong needle having been passed
obliquely down to the part should have its edge first moved about in all directions as to cut up the ligamentous bond of union as well as the dense investment of the ends of the bone. The needle being then carefully withdrawn and the fragment covered by plastic or collodion. In this way we obtain all the good effects which can result from the employment of the seton without exposing the patient to the risk which attend its use.

Proceeding upon the fact, that foreign bodies lodged in bone become surrounded by a deposit of new bone, Iffenthal proposed, that several holes should be drilled near the extremity of each fragment into which ivory pegs are driven and allowed to remain until their presence shall give rise to considerable swelling. Then they are removed. By this means Iffenthal succeeded in procuring union in many cases. In England, it has been tried with
bony screws. This operation is apt to be followed by dyspnoea and pro-
 fuse suppuration; but it does not appear to have proved fatal in any case.

Destruction of the connecting medium by means of caustics has been practiced,
but not extensively. Different caustics have been used, Protea juice seems to be the best.

Resection of the ends of the bone was first practiced by White. He operated on the
humerus and tibia, and union followed in both cases in the latter owing to the difficulty of reaching the lower
fragment. He excised the end of the upper portion alone, and imitated the
lower by scraping it, and destroying the connecting soft parts by butternut
staining. In a number of cases it is impossible to remove both ends of
the bone. According to Dupuytren we
must never remove both ends, for he
considered that all the good effects of
the operation would be obtained by resect-


-ing on fragments, and wrapping or otherwise uniting the other. After reduction, the parts are very much in the same condition as after compound fracture, and, according to a certain amount of risk attends this operation. For a long time union of the fragments was very seldom restored, as it was found that union did not always take place after the operation. Novik gives fifty four cases in which the operation was performed on one or both fragments. In thirty seven cases the operation was successful. In the leg it always succeeded, and in the forearm failure was rare; but in the humerus and femur the result was different. Of twenty seven operations on the humerus, union followed in eleven cases only; of seven on the femur ten were successful. We see, then, that the operation has frequently failed in the humerus and femur, and the reason is evidently this, that in these bones it is more difficult to maintain that perfect immobility of the fragments, which
is necessary in order that union may take place. We find, that in cases where means are used sufficient to keep the limb at perfect rest, the operation succeeds perfectly well.

So the operation is always attended with considerable danger, especially in the case of the larger bones, it ought never to be performed until mild means have failed and in those cases only, in which the connection between the fragments is of such a nature that the limb is quite useless to the patient.

In some cases, by means of a mechanical apparatus, the patient is enabled to use the limb to a certain extent, and in such cases it will be better to leave the patient with an imperfect limb than expose him to the danger which may result from a severe operation like resection.

William J. Crawford