ON THE

# TREATMENT OF UNUNITED FRACTURE

BY MEANS OF

# ARTIFICIAL LIMBS,

WHICH

COMBINE THE PRINCIPLE OF PRESSURE AND MOTION AT THE SEAT OF FRACTURE,

AND LEAD TO THE

## FORMATION OF AN ENSHEATHING CALLUS.

ILLUSTRATED BY THE

HISTORY OF FOUR CASES OF FALSE JOINT IN THE FEMUR, EIGHT IN THE LEG, AND TWO IN THE HUMERUS.

BY

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WITH EIGHT WOODCUTS.

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The function of the bones of the extremities being to sustain the weight of the body, or aid in locomotion and prehension, any destruction of their continuity impairs the action of the muscles which are attached to them, and destroys the usefulness of the member. In accomplishing these functions, the bones are passive, and, therefore, resemble levers which are acted on by forces applied throughout their length. As when a lever is broken the splicing of the fragments may restore its usefulness, so, when a bone is fractured, the temporary and artificial union of its fractured ends may enable it to perform its functions nearly as perfectly as before the occurrence of the accident. Under ordinary circumstances, the reparation of the injury is the result of a natural action; but when this fails, no means of treatment seem more reasonable than that afforded by the application of such a constricting band as will afford artificial support at the seat of the injury. Saw a bone in two, and surround it at the point of division with a ferule, and it will again prove a lever of sufficient strength to sustain certain powers. Carry out the same ideas in an ununited fracture, and modify the means of support at the fracture, so that they may act properly on flesh and blood, and the nearly normal condition of the limb will be restored, or the patient, at least, will be enabled to use it for a great variety of purposes.

In the ordinary treatment of fractures, nature furnishes the bond of union, and, therefore, but little aid is required from the surgeon—rest and the apposition of the fragments being sufficient to enable her to accomplish the cure. But, when she has failed in the performance of this important action, surgery has always been ready to step forward and interfere, and, in some instances, has done so with a rudeness that has terminated either in the loss of the limb or the life of the patient.

In inviting professional attention to a successful plan of treating false-joint, which embodies the principles of pressure and motion in the part, I hope to induce surgeons to admit that a less dangerous and inconvenient method than the seton, resection, caustic, or wiring of the ends of a fracture, may do as much, if not more, than either of these well-known surgical means of treating false joint. With a view of showing the defects of many of the plans of treating this affection, heretofore recommended, I shall briefly enumerate

them, and then, after referring to the pathological conditions of the parts, as well as to the more recent physiological views of the formation of callus, cite a few cases, as illustrative of the advantages of pressure at the seat of fracture, when combined with the stimulus of gentle and frequent motion of the ends of the broken bones.

The formation of callus being due, under ordinary circumstances, to increased vascular action in the part, the means of treatment generally suggested for the cure of false joint have assumed the necessity of stimulus as a fundamental point. With the view of hastening nature in the formation of the much desired bond of union, and in some instances without much reference to the difference in the state of the bones in a recent fracture, and in one which has existed many weeks, surgeons have urged the employment of local stimulants to all cases, without specifying the conditions which demanded it. Of course, means which were useful in one period of a fracture, could not be equally so in another; yet, but little distinction has, in many instances, been made between the treatment of a false joint of three, or of eighteen months' standing. Thus, friction might be useful in the first, but of no service in the last; whilst resection might be attempted in an old case, and yet not be justifiable in a recent one. The following plans of treatment, which have been suggested from time to time, sufficiently illustrate the views of surgeons in the pathological condition of false joint, as well as the ingenuity of each surgical period, and its dissatisfaction with the means of treatment previously recommended.

The most ancient of the plans of treatment proposed for the consolidation of a false joint, was friction of the ends of the bone. This was advised by Celsus, and subsequently recommended by John Hunter and others; and when followed by rest, sometimes accomplished the cure of cases in which union was rather retarded than entirely absent. It is generally regarded as especially applicable to the very recent cases of fracture in which the so-called callus does not harden, or is not sufficiently abundant. Next to the direct excitement of the local circulation by irritating the bone, was its development by indirect means, such as blisters and caustic issues, applied to the soft parts around the fracture, as advised by Dr. Joseph Hartshorne, of Philadelphia, in 1805; Walker, of England, in 1815; and subsequently by Wardrop and Brodie, as well as by Velpeau. The use of the tincture of iodine, as an injection into the fracture, and of stimulating liniments and plasters, also belongs to this class; whilst electricity, galvanism, and acupuncturation, are only modifications of the same idea. These means, like friction, necessarily develop a certain amount of vascular action; but can only prove useful in the recent cases of delayed or tardy union, rather than in the more ancient forms of false joint. As a more certain and permanent stimulant, we have next the suggestion of the introduction of a seton between the ends of the bones, as advised by Winslow, and urged, with especial reference to the humerus and jaw, by the late Dr. Physick, of Philadelphia. The employment of this means of ex-

citing action was, however, far from being invariably followed by consolidation, though the patient wore it as directed for four or five months; and, in accordance with recent views, does more harm than good.[1] In the case of false joint in the thigh, it generally failed so completely that it was admitted by Dr. Physick to be a very doubtful remedy in the treatment of this condition of the fragments in fracture of the femur.[2]

In more obstinate cases, it was proposed by White, of England, and subsequently practised by others, to *resect* the ends of the bones which constituted the false joint, establish a new surface, and then, by rest, attempt a cure; but so dangerous has this operation been deemed, from the severe constitutional excitement it often produced, that the celebrated French surgeon, Sanson, was induced to think that "all prudent surgeons would agree that it was better to leave the patient with his infirmity than to attempt to cure him by this operation." As illustrative of its dangers, I would refer the reader to the details of a case in which I performed it on the bones of the leg,[3] and in which the patient barely escaped with her life. Where the surgeon has not wished to saw off the ends of the bones, he has endeavoured to create a new surface by the application of caustic or the actual cautery; whilst, in order to insure the rest and apposition of the fragments, when thus freshened, either by caustic or the saw, they have even been wired or tied together, and yet the operation has failed in accomplishing a cure. The development of a new action in the part, by inserting ivory pegs into the bone, near the fracture, as suggested by Dieffenbach, or by subcutaneous drilling of the ends of the bone, as recently advocated by Dr. Brainard, of Chicago, together with a variety of similar means, are additional instances of the difficulties and defects of preceding plans, and of the efforts of surgeons to remedy the evils of the other methods which have been suggested.

In all these varied plans of treatment, it is important to remember that the patient has either been confined to bed for many weeks, at the risk of losing his general health, or, after suffering from the performance of an operation, been exposed to excessive suppuration, phlebitis, hectic fever, or purulent absorption, especially when the bones were resected. They are, therefore, not only attended with great inconvenience, but often with great danger, whilst frequently their failure has necessitated the amputation of the limb.

In most of the means of treatment thus briefly alluded to, it is easy to notice the effect of the pathological description of the condition of parts in false joint or ununited fracture, as furnished by Boyer, to wit, that, in ununited fracture, a true joint, or a condition approaching it, is usually found, in which may be noted the rounded surface and smooth face of an articulation, as well as a capsular ligament with synovial fluid. The fact that this descrip-

[1] See Transact. Am. Med. Assoc. vol. vii. p. 557. Prize Essay of Dr. Brainard, of Chicago, 1854.

[2] Dorsey's Surg. p. 135.

[3] Am. Journ. Med. Sci. vol. xv. N. S. p. 84. 1848.

tion has been so generally received as correct, might be supposed to be proof of its exactness; yet more detailed and extended observation has shown that, though frequently existing, this condition is not invariably seen, the bones being sometimes joined by a fibrous tissue, and often deficient in anything like a capsular ligament, synovial membrane, articular cartilage, or fluid.

As it is essential to a correct plan of treatment that we should possess a correct knowledge of the pathological condition which is to be relieved, a reference to the varied changes of structure found in an ununited fracture, and often modified both by time and position, will prove useful; whilst an allusion to the ordinary steps of reproduction in bone, may tend to elucidate the modus operandi of certain plans of treatment.

The most ancient theory of the formation of "callus" was that the new bond of union was due to an exudation of a gelatinous or viscid fluid (like glue) around the seat of fracture; that it was the product of effused blood, and that this viscid fluid kept the bones in contact, and gradually hardened into an osseous condition. This doctrine seems to have prevailed from an early period, and to have continued in an indefinite state until the experiments of Duhamel, Dupuytren, Breschet, and others, showed the agency of the periosteum in causing the formation of the mass, and the analogy existing between the repair of injury in a bone and that seen in the repair of a wound in the bark of a tree.

After following for many years the opinions of the French school in relation to the growth of bone and the formation of callus, physiologists have recently had their views materially changed, and their ideas enlarged by the developments of the structure of bone, as made by (that great modifier of physiological doctrine) the microscope. The existence of the Haversian canals, spaces, and ossicles, as well as of the osseous granules and cartilaginous cells, having all been thoroughly demonstrated, the study of the formation of the bony tissues has been pursued with an accuracy that has done much towards the advancement of a more correct knowledge of osteogeny, and with it of the process pursued by nature in the production of callus.

As the results of a minute and extended observation by microscopists, and especially of the opinions expressed by Mr. Paget,[1] it is now admitted, "that in the fracture of a long bone the injury is seldom limited to the bone, but that the adjacent tissues participate in it; that the periosteum, though rent, is rarely much damaged, and seldom stripped off the broken ends; that the extravasation of blood about the fracture is not only uncertain, but unequal in the different tissues, being often very slight in the periosteum; that the cellular tissue in and near the seat of the injury, is soon infiltrated with lymph, or a serous-looking fluid, which contains cells like those of granulations; and that the so-called *callus*, in its early stages, does not differ materially from the material formed for the repair of other subcutaneous injuries; that the

[1] Paget's Lect. Surg. Phathol. Phil. edit. p. 160, *et supra.*

bones are ultimately united by the formation of granulations, in which are found nucleated cells as the embryo forms of fibrous tissues, and that this structure becoming subsequently the seat of granular osseous deposit, leads to the formation of an intermediate bond of union, rather than an "ensheathing callus," the latter being, in Mr. Paget's opinion, rarely found in the fractures of the human subject, though often seen in animals. When seen in man, it has been in the ribs, clavicle, and humerus, and was due, in his opinion, to the disturbance of the proper mode of repair by motion.

In a case of ununited fracture of the femur in a hale man of 20, recently placed under my care, the condition of the ends of the bones exhibited in a very marked degree the effect of motion in inducing the formation of this provisional or ensheathing callus, there being a mass around the end of each fragment, as felt through the soft parts, which created a tumour nearly of the size of a child's head at two years of age. In this case, there had been imperfect rest throughout the treatment, and nature had, therefore, apparently acted in this man in the manner often seen in the experiments on animals, and thrown out an amount of new material capable of sustaining the bones under these circumstances.

It is an inquiry worthy of note in passing, whether, in the treatment of fractures, very perfect rest may not be one cause of the deficiency of the new bond of union, and consequently lead to the formation of a false joint. In the cases of false joint, hereafter reported, moderate motion has certainly induced union, and this question should therefore receive attentive consideration, especially in treating cases of tardy union not actually resulting in false joint, lest it prove that rest in the treatment of fractures has been too strongly insisted on.

In studying the formation of the "intermediate," or, as it is more frequently termed, "the definitive callus," Mr. Paget says, that the course of nature in its formation is well exemplified in the condition of the end of a bone after amputation. In this case, as well as in compound fractures, granulations, he remarks, "are always seen to form within and on the medullary canal, and gradually to protrude like the rounded head of a mushroom;" a description which every surgeon has doubtless verified in the delayed union of stumps, and there is, I think, no doubt that in old fractures, as in amputations, the ends of the bone are disposed to take on a similar action, and that the granulations formed on the ends of the fracture lead sometimes to the development of bone in the cancellated portion of the fracture without the formation of any fibrous or cartilaginous deposit. At the same time, the vascular action in the lacerated edge of the external periosteum creates granulations on the edge of the compact matter of the bone, so that the granulations of the centre and of the circumference of the bone being gradually approximated, a bony convex cap is formed, which closes the surface of the bone whether as left by the saw in an amputation, or by nature in an ununited fracture; thus creating a round, solid extremity, devoid of external periosteum,

yet having this membrane extending as far as its circumference—that is, up to the original point of division of the fibres of the compact structure. Such, at least, is the condition which I have more than once seen upon a careful examination of the ends of the bone removed in an old and well-marked case of false joint. Of course, in this state of the parts, we cannot anticipate union from the capped extremities of the bone, though we may, as will be hereafter shown, obtain it from the periosteum on each side of the fractured ends. When, instead of the formation of granulations and osseous granules upon the fractured extremities of a bone, there is only the fibrous or cartilaginous cell, it will be found that the bone will be closed by the attachment of a fibrous or cartilaginous structure, which, as Mr. Paget suggests, is the ordinary state of the parts in fracture of the patella, olecranon and intra-capsular neck of the femur, and which, it is well known, is the condition seen in certain recent forms of false joint, the union being either fibrous or cartilaginous, as in the false joint of the radius, and some of the other bones. As the deposit of osseous granules and the formation of bone is hardly probable in this form of ununited fracture, except in very recent cases, or those which are more correctly instances of retarded union, we must here look to some other point than the ends of the bone for a bond of union, and again find it in the periosteum which surrounds the bone up to the seat of the fracture, this periosteum being capable, under proper excitement, of uniting the ends of a fracture.

To prove this, I now urge the employment of the following plan of treatment in ununited fracture, believing that when, in any false joint, whether recent or ancient, the two fragments are permitted to overlap moderately, whilst, at the same time, such action is excited by the pressure of one periosteal surface against the other, as may be obtained by gentle and long-continued motion in using the limb, a growth of callus will be often induced and accomplished with much less local and constitutional disturbance than it can possibly be by friction and rest, pressure and rest, the seton, resection, drilling, or the use of ivory pegs, as heretofore recommended; whilst the patient will escape confinement, free suppuration, phlebitis, hectic fever, and the serious effects which have often resulted from these plans of treatment.

That pressure and friction of the surface of the external periosteum will lead to the formation of bone, has long been known to surgeons, and exemplified in the formation of a new acetabulum in cases of luxation of the head of the femur upon the pubis, two specimens of which are now in the Wistar and Horner Pathological Museum in Philadelphia; and other instances from the head of the humerus are doubtless well known, as the result is not a rare one. If, then, a rounded, smooth bone like the head of a femur, can, by pressure, lead to the absorption of the edge of the iliacus internus and psoas magnus muscles, then of the periosteum on the ilium and pubis, until it exposes the compact matter of the surface of the pelvic bones, and then induce an osseous deposit around the free edge of the ulcerated or absorbed periosteum, why should the same results not follow the application of similar

forces when the two periosteal surfaces are in apposition near the seat of a fracture? It most certainly does so, and leads to the development of an amount of provisional or ensheathing, as well as of intermediate or definitive callus, fully equal to the support of the body.

How this pressure and motion, acting on the external periosteum, lead to the growth of new bone, or callus, is fully explained by the recent observations of histologists. From the remarks of Mr. Kolliker on the histology of the osseous system,[1] it appears that in the growth of bone, the elementary processes in the layers of the periosteum are as follows: The periosteum of the primary cartilaginous bones being proportionally very thick and vascular, consists, as early as the fifth month, of common connective tissue and fine elastic ligament. On the inner aspect of this fully formed periosteum there is deposited an ossific blastema (4), firmly adherent to the bone (see Fig. 1),

Fig. 1.

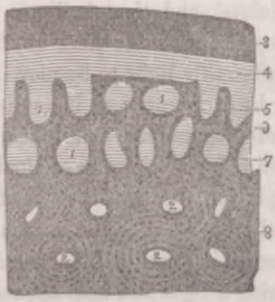


Fig. 1. Transverse section from the surface of the shaft of the metatarsus of the calf, magnified forty-five diameters. 1, 1. Rudiments of the Haversian canals of the compact substance. 2, 2. Area of the canals. 3. External periosteum. 4. Ossifying blastema. 5. Young layer of bone. 6. More developed layer of bone.—After Kolliker.

so that, when the periosteum is removed, it remains upon the bone as a moderately thick, soft, whitish-yellow lamella, in which the microscope shows fibrous tissue, and granular, oval, or round nucleated cells, measuring 0.006.001 of a line, from which, after a time, the bone cells are formed, out of the formative cells of the blastema (page 325), the soft bone lamellæ passing into the blastema. The development of the ossifying blastema Mr. Kolliker regards as due to the numerous vessels of the young periosteum, the origination of its fibres being from fusiform cells, as he has frequently observed it in man and animals. The formation of bone in this blastema occurs, he thinks, wherever it is in connection with bone.

Although these observations of Mr. Kolliker are chiefly limited to the action of the young periosteum, there is reason to suppose that the adult periosteum continues to act in the same manner, although not so rapid in its formation. If, then, pressure of the two sides of the fragments of an ununited fracture lead to an absorption of the outer layer of the periosteum, and thus expose the blastema or structure described by Mr. Kolliker, as between the compact structure and the inner face of the external periosteum, it is easy

[1] Manual of Microscopical Anatomy. Phil. edit. p. 324.

to understand how the periosteum may, under the stimulus of this pressure and motion, be enabled to create a sufficient amount of irregular bony deposit, or intermediate and provisional callus, to serve as the bond of union for the ends of a false joint.

Without, however, enlarging on these physiological points, it may suffice to say, that it is evident from the action of the periosteum in old luxations, as well as in certain diseases and injuries of the bones, that it is capable, under stimulus, of throwing out a mass of new bone, and that it is only necessary to excite it properly to lead to the formation of such an ensheathing structure as will restore the continuity of the bone, and consequently of the action of the muscles attached to it; thus reproducing the usefulness of the limb. Such means, I think, will be found in the use of the apparatus hereafter described, the formation of which is based on the following proposition. If a patient, after amputation of the leg or thigh, can sustain the weight of the body upon an artificial support, which is only a series of hollow cones, so adjusted as to play upon each other (at the joints), and thus facilitate progression, why may he not obtain the same support with his limb on, from some similar mechanical contrivance, made sufficiently light to be moved by wasted and weakened muscles? Surely, but little mechanical ingenuity is necessary to the development of such means of progression; and, in calling attention to those subsequently employed, I wish to lay no claim to originality. It is the surgeon's duty to suggest the principle for the construction of an instrument or apparatus, and the business of the cutler, or other mechanic, to develop it in the material most capable of furnishing the qualities required of the apparatus, and the credit of manufacturing a light and neat apparatus for the treatment of false joint, either for the upper or lower extremity, in accordance with my views and suggestions, is due to Mr. Rohrer, cutler, of North Sixth Street, Philadelphia. The application of the principle of pressure and motion is the result of considerable observation of the defects of the treatment of false joint by the ordinary plans, as well as of several dissections made by me of uncured cases.

The results of my plan of treatment are shown in the histories of the following cases, which I present as furnished to me, or as found in my notes of the patients as they were presented to me:—

Case I.—*False Joint in both Bones of the Leg, of ten months' standing, cured whilst walking about, by the use of the Artificial Limb.*—Account furnished by Dr. Wm. Waters, of Frederickstown, Md.: "You request me to give my experience of an apparatus introduced by yourself in the treatment of pseudarthrosis.

"In the first place, permit me to tender you my acknowledgments for the cases reported by you;[1] as that principle has been completely successful in one case with me, of an aggravated character, and from report is acting very bene-

[1] American Journal of Medical Sciences, vol. xxi. N. S. p. 106, 1851.

ficially in another, which has only been wearing for about a month the apparatus made by your ingenious cutlers, Messrs. Rohrer & Sons.

"Mr. S——, æt. 35, had received a compound comminuted fracture of the tibia and fibula, on the 4th of September, 1849. The accident occurred from the wheel of a tender to a locomotive passing over the right leg obliquely, about two and a half inches below the knee, comminuting somewhat the tibia and the fibula, and piercing the soft parts nearly opposite the injured tibia. The fracture of the tibia was obliquely inwards, about two and a half inches below the insertion of the ligamentum patellæ. In passing my finger into the wound (it could be introduced opposite the spine of the tibia and carried around the face to the under surface of the bone), some comminution of the fracture could be ascertained in the lower shaft, but there was very slight displacement of the ends, as one slab or piece, which could be felt depressed slightly beneath the lower shaft, was raised with my finger to its place. The foot was of the natural temperature five hours after the accident; the dorsalis pedis and posterior tibial arteries were very feebly felt; but his pulse was pretty good and firm, though somewhat enfeebled. Drs. Gerry and Strong, of Harper's Ferry, near where the accident occurred, yielding in an effort to save the limb, he was brought, by return train of cars, to this place, where his family resided. He had some fever for a week or more, and suppuration, and a slough about the size of a large pear occurred over the fractured shafts of bone, which resulted in necrosis, exfoliation of the surfaces, and caries of the ends of the bone until April, 1850. In February, the immovable apparatus was applied, and subsequently a carved splint fitting the outside of his leg was fastened by a roller on the entire limb. Injections of nitrate of silver to the tibia were also tried. About twelve months after the accident, a seton was passed between the shafts of the tibia, the fibula having united in the early stage of the case. The leg was splintered for months; the seton was withdrawn, or rather it cut itself out in four weeks, on the principle of Lourme's modification of Physick's plan; this also failed. During November and December, 1850, acupuncture was also used to excite inflammation in the part, the patient's health being good at this time, from previous generous diet and tonics. My patient now became anxious for excision of the fibro-cartilaginous ends. But the pseudarthrosis being near the knee-joint, the loss of bone from the block to be removed would have been at least from one and a half to two inches in width, and would have encroached upon the ligaments on the inside of the knee. I therefore prevailed upon him to try an apparatus like yours in the case reported in Vol. XV., New Series, of the *American Journal of Medical Sciences*, except that it extended some six or seven inches above the knee. As soon as this was applied, our patient, on the 26th of March, 1851 (about eighteen months after the accident), immediately, with a cane, walked across the floor with a pretty firm step. The mobility of the artificial limb at the knee and ankle had otherwise a twofold desirable purpose, as it permitted the exercise of the knee and ankle-joints, the latter having become considerably impaired in motion, from an injury he had sustained about a year previously. In from four to six months, the tibia became sufficiently strong to walk without the apparatus, and his ankle also improved. The fractured bone firmly united, and in six months after wearing it, he resumed his situation, in the employ of the Baltimore and Ohio Railroad Company. I have not seen him for some time; but am credibly informed by his family, that he has had no occasion to wear the supporter for upwards of a year. Indeed, he might have dispensed with it earlier, but I advised him to wear it as a precautionary measure.

"I feel every confidence in the success of the other case under treatment,

who is a respectable physician of our county. I saw a brother of his to-day (April 28, 1853), who informs me that the leg is becoming more stiff, although the doctor has only been wearing the artificial limb about a month. This fracture was oblique in the lower third of both bones; the fibula readily united, but the tibia did not. The case is only of five months' standing."

CASE II.—*Pseudarthrosis of the Bones of the Leg, of five months' standing, cured by the Use of the Artificial Limb in nineteen weeks.*—Reported by Dr. WM. WATERS, of Maryland. "On the 28th of November, 1852, Dr. J. W. J. fractured his left tibia and fibula, about the lower third of the leg; the fracture was simple, but oblique. His leg was placed in Roe's apparatus, by Dr. R. H. Thompson, of Urbana, and in a few days was changed to another; but, in three or four days, the shafts of the tibia were thrown out of position, and the spine of the tibia was rather more than half an inch out of line. He suffered considerably from the irritation of the fracture. I saw him with Dr. T., the attending physician, ten weeks subsequent to the fracture, and found the provisional callus only of a ligamentous character, and very soft, so much so that we endeavoured to reduce the shafts of the tibia to a rectilineal position, but failed, in consequence of the ligamentous union. We therefore proposed breaking up the slight union, and resetting the limb. This was not consented to by Dr. J. The knee of this leg had been anchylosed for many years, as it was injured during his boyhood, and had very properly been fixed at a slight angle to facilitate his walking with that limb. We now applied to the ununited fracture, the immovable apparatus of Suetin, and also advised tonics and exercise in his carriage, or upon crutches, with generous diet, as his general health had suffered from confinement to bed. About the twelfth week, the limb was examined, when but very slight, if any, improvement was noted, and the bone is still flexible. In consequence of erythema, and occasionally neuralgia in the limb, the apparatus had to be removed, and his sufferings were considerable for a simple fracture. This may be ascribable to two causes; first, the overlapping of the bones to some extent; and, secondly, his nervous temperament, he having suffered from dyspepsia previously; and, indeed, his great toe had some gouty thickening around the first joint. On the 6th of April, 1853, upwards of four months, we exchanged the apparatus of Suetin for that employed in the previous case. After wearing Dr. Smith's apparatus about five months, the tibia became firm, and since then our patient has been walking about with only a cane."

*February* 20, 1854.

CASE III.—*Ununited Fracture of the Femur, of five months' duration, cured in seventeen weeks by the Artificial Limb, so that he could walk with only a cane.*—Jno. K——, aged 40 years, was admitted into St. Joseph's Hospital, in the fall of 1852, under the care of the late Dr. WM. E. HORNER, labouring under a recent fracture of the lower third of the left femur. After being treated by Dr. Horner, with Dessault's long splint slightly modified, the bone was discovered to be ununited, the amount of callus being very small and permitting free motion at the seat of fracture. Friction of the ends of the bone being freely practised, blisters were applied around the limb at the seat of fracture, and the patient took cod-liver oil freely, with full diet and porter; when, after a few days, the splints were again applied and the limb kept at rest for four weeks. A second examination yet showing no improvement, the limb was carefully bandaged from the toes to the groin, and splints of binders' board applied around the thigh, when he was placed on crutches and directed to walk about as much as possible. When I took charge of the wards, a short

time after this, I found him unable to move the limb or bear his weight upon it, but continued the treatment of Dr. Horner for some time longer, whilst the artificial limb was being made. On the 17th of April, the dressing was removed and the motion at the fracture found to be free in nearly all directions, the limb being shortened nearly three inches, except when extension was practised. The new apparatus being applied, he was at once placed on his feet with crutches, and walked across the floor, putting his foot to the ground and bearing some weight upon it. The apparatus requiring alteration, he was kept in bed for five days, at the end of which time he again applied his artificial limb and walked about the grounds freely, spending much time in the open air as warm weather came on. When the apparatus was removed, after six weeks' trial, there was an evident firmness in the fracture, and on October 3, 1853, seventeen weeks after its second application, the bone was so firm that he was permitted to walk without the splint, and in a few days walked freely with only a cane, and left the hospital. In December, he left the artificial limb at my office, being well able to walk with a high-heeled shoe, the shortening measuring by accurate measurement two inches.

Case IV.—*Ununited Fracture of the Femur of six months' standing; Suppuration; Great exhaustion; Hectic; Cured in nine weeks by the use of the Artificial Limb.*—The history of this case is given as furnished me in the following letter, dated May 22, 1854, from Dr. G. Dock, of Harrisburg, Pa.:—

"The bearer of this letter, Mr. Neelan, is desirous of having his brother placed in St. Joseph's Hospital, for the treatment of an ununited fracture of the femur. As a short account of his case will be of interest to you, I will give it to you, as far as I can. He is twenty-eight years of age. It appears his thigh was fractured by the falling of a bank of earth on him, whilst excavating a cut on the railroad. The accident occurred last fall. He was placed under the charge of a physician of this place; but, after he had been under his treatment for *three months*, the physician was discharged, and I was called in to attend him.

"I found him in the following condition: first, his general health much impaired; hectic fever; foul tongue and breath; pulse 115 to 120; irritable; slept but little; no appetite; and a torpid, depraved condition of the excretory system. The leg was in a long poplar box, in a state of extension; the bandaging from the foot up to the thigh very tight, and he suffering much pain. I next took a survey of the limb (thigh), and at once saw it was crooked and much too short. I then applied a tape and measured the injured limb from the anterior superior spinous process of the ilium to the centre of the patella; then measuring the sound one, I found the fractured limb nearly three inches short. I then removed a mass of sheet-iron splints, about a peck of bandages, &c. &c., from the thigh, and found the bones, as I anticipated, the upper fragment drawn up by the muscles of the pelvis, the upper end of the lower fragment being drawn backwards by the strong flexor muscles of the thigh, thus causing it to pass up under the upper fragment to the extent I have mentioned. I took everything off, placed a nice Scultet's bandage on a padded *double inclined plane*, and flexed the thigh and leg. I then coaptated the bones (which I found ununited), reducing the limb to its proper length very easily, as the muscles were so soft and debilitated as to offer but little resistance. I then adjusted the bandage and placed splints on each side with an extending point and a buckskin perineal counter-extending band, all working pretty well for some days.

"As I then discovered a spot of *blood* oozing through the bandage, under the calf of the *leg*, I removed the bandage and found a gangrenous ulcer

about as large as a half dollar, and three or four lines deep at this point, the foot and leg being purple and with a low degree of vitality, several spots existing on top of the foot and ankle, and threatening to slough soon. I was therefore obliged to loosen everything about the thigh that could obstruct the free circulation, and favoured the suppuration of the leg by gentle dressings and warm fomentations.

"The next morning, the foot and leg were enormously swollen and œdematous, and sloughs were open on the upper and lower sides of the ankle and top of the foot. To these I applied warm poultices of flaxseed meal and yeast, gave him a grain of opium at night and wine-whey through the day, with an occasional dose of solution of quinine, and a little beef tea. But it is unnecessary to detail my treatment. I succeeded in saving his leg and improving very much his general health, and as his thigh was a secondary matter then, and, of course, no deposit of plastic or osseous matter expected under the circumstances, I just retained the limb in as favourable a *position* as possible, and could apply no retentive means on account of the enfeebled condition of his system, his skin bearing scarcely the pressure of the weight of the limb itself, much less any firm splinting, etc. It is now about eight weeks since I first saw him. Any attentions he may receive from your hands in your official capacity will be gratefully appreciated by his friends, and be of no little satisfaction to me."

The following history was furnished by Dr. Hoyt, the Resident Surgeon of St. Joseph's Hospital, after his admission :—

"Michael Neelan, aged 29, was admitted into the hospital on the 23d of May, with an ununited fracture of the femur. He was at the time in an exceedingly debilitated condition; indeed, was almost in the last stages of hectic. He had little appetite, was extremely emaciated, and had decided night-sweats. His pulse was feeble, and ranged considerably above a hundred. His tongue was clean but pale.

"On examining his leg, I found a small ulcer on the under side of the knee, which discharged healthy pus. The leg and foot were enormously swollen; the ankle was nearly anchylosed, and the toes possessed little motion. The muscles of the thigh were excessively attenuated. The bone was fractured at about the junction of the upper with the middle third. The upper fragment overrode the lower, and at the same time the two fragments formed an angle outwards of about thirty degrees. The limb was shortened three inches. There was a complete false joint at the seat of fracture. Moving the limb in any direction gave little pain unless carried to a considerable extent. He was put on good diet, with the use of tonics. His leg was bandaged every day with a flannel bandage; at the same the joints were freely moved.

"On the 28th of May, as the leg had been much reduced in size, the bandage was discontinued, and Dessault's apparatus for fracture of the femur was applied in order to maintain extension until the appropriate apparatus should be prepared. Dessault's apparatus was continued until the 13th of June, when it was removed and the flannel bandage reapplied. The foot had become considerably swollen during its discontinuance.

"The suitable apparatus (artificial limb) having been prepared, was applied for the first time on the 19th of June. He was able to walk with a little assistance on the same day. Though still weak and emaciated, his health and appearance have much improved. From the time he commenced walking his improvement was rapid. He acquired new strength and vigour. A mass of callus was gradually formed, uniting the two fragments, until, on the 9th of August, it had acquired sufficient hardness to render it safe for him to walk with the assistance of crutches without his apparatus, which had been sent to

undergo alterations. During the whole of this period, he gradually improved in the facility with which he walked. He at first required two crutches, and even then walked with difficulty; but as he grew stronger, a cane was substituted for one crutch, and then for another. The broken limb measured, on the 19th of August, two inches and a half less than the other. We may certainly hope that, should he continue to improve, he will eventually have a highly useful natural leg in the place of the artificial one, which I firmly believe he would have required but for this valuable apparatus."

This patient soon afterwards recovered the use of his limb to such an extent that I returned him to the charge of Dr. Dock, at Harrisburg.

Case V.—*False Joint in the Femur, of twenty weeks' standing, cured in six weeks by the Use of the Artificial Limb.*—Report furnished by Dr. R. J. Levis, of Philadelphia. "The case in which I advantageously applied the apparatus, proposed by yourself, for the relief of pseudarthrosis, was that of an ununited fracture in the upper third of the thigh-bone, occurring in a heavy muscular man aged about fifty-five years, of general healthy appearance, but of rather irregular habits. The fracture had been treated with the long, straight splint; the apposition of the fragments seemed quite correct, and with no apparent shortening; but yet, at the end of about four months, there had evidently no bony union taken place, and there was an unimpeded mobility of the limb in all directions at the seat of fracture. No favourable change, for a month after, taking place in the condition of the parts, and the patient suffering much and becoming intolerant of the confinement, it was deemed advisable to make use of mechanical support, and, if possible, to place him on his feet. This indication was answered admirably by the appliance constructed by Mr. Rohrer, similar to others which had been previously formed after your direction by him, and fitted to the limb. The patient was at once placed in a walking attitude, and continued for some time moving about with the assistance of a crutch or cane. At this time the fragments had taken a permanent position, overlapping each other, and projecting somewhat outwardly. The limb continued to acquire more firmness, until, after five or six weeks, he was able to dispense with the support of the apparatus entirely, and has now a somewhat deformed and slightly shortened, yet substantially useful limb."

Case VI.—*False Joint in the Humerus, of six months' standing, relieved, and permitting the use of the Arm in "type-setting."*—From Dr. George Dock, of Harrisburg, I have recently received the following notes of a case of false joint in the humerus:—

"A man, about fifty years of age, has been recently presented to me for treatment for a false joint in the left humerus, just above the insertion of the pectoralis major. The history of the case showing that the dressing of the fracture had been very imperfect, I was not surprised at finding a false joint of its character, and doubt whether anything short of a seton or Dieffenbach's pegs will bring about union; but if you can devise an apparatus that will suit him, be kind enough to write to me." The cost of the limb, $15, being beyond the patient's means, Dr. Dock writes as follows, October 24, 1854: "My man with ununited fracture of the humerus was unable to purchase an apparatus. I consequently made one for him myself, and he is now at his daily work (type-setting), and bids fair to recover with an united bone."

Case VII.—*False Joint in the Humerus.*—Treated by Dr. Ashby, of Alexandria. Another case of false joint in the humerus, of long standing,

has been for some time under treatment by my friend, Dr. C. W. Ashby, of Alexandria, by means of an apparatus forwarded in accordance with the measurements sent. Although a combination of difficulties has retarded the treatment, yet Dr. Ashby in a very recent note says: "K—— wore the splint nearly three months, and although it was rather too short, it afforded him so much comfort and support, that at one time I anticipated a favourable result." This patient was subsequently started by Dr. Ashby for Philadelphia, to be treated by myself, but for some unexplained reason never got beyond Baltimore.

Although these cases in the humerus cannot be cited as cures, they are sufficient to show, as Dr. Ashby has remarked, "the correctness of the principle," and may, I hope, induce others to try the same means (see Figs. 2, 3) when a false joint is presented in the humerus.

In order to present a summary of the cases already treated by my method, I add the following recapitulation of those published in this and a preceding paper in this journal. (See vol. xxi. N. S. 1851, p. 108):—

Case 1. Under the care of Dr. Wm. Waters, of Fredericktown, Md. False joint in both bones of the leg, of eighteen months' standing, cured in five months.

Case 2. False joint of both bones of the leg, of four months' standing, cured in nineteen weeks, by Dr. Waters, of Maryland.

Case 3. False joint in the femur, of five months' standing, cured in seventeen weeks, under my own care.

Case 4. False joint in the femur, of six months' standing, cured in nine weeks, under my own care.

Case 5. False joint in the femur, of twenty weeks' standing, cured in six weeks, under the care of Dr. R. J. Levis, of Philadelphia.

Case 6. False joint in the humerus, of six months' standing, under treatment, and at present relieved, by Dr. G. Dock, of Harrisburg.

Case 7. False joint in the humerus, under the care of Dr. C. W. Ashby, of Alexandria.

In addition to these, I had previously noted a case of false joint in the femur of a man of upwards of seventy years of age, which failed to unite, but which was made so firm by the apparatus that the patient walked only with the assistance of a cane. One case of false joint in the leg failed, but though the bones did not unite, the patient is yet able to walk; and I have now from Mr. Rohrer, the cutler, reference to two other cases in the leg, cured by surgeons at a distance, who have failed to respond to my communication respecting them. We have, therefore, a total as follows:—

| | Cases. | Cured. | Relieved. | Failed, but able to walk. |
|---|---|---|---|---|
| False joint in the femur | 4 | 3 | | 1 |
| " " " leg bones | 8 | 7 | | 1 |
| " " " humerus | 2 | | 2 | |
| Total | 14 | 10 | 2 | 2 |

The apparatus employed in these cases is represented in the Figures 2, 3, 4, 5, 6.

Fig. 2.

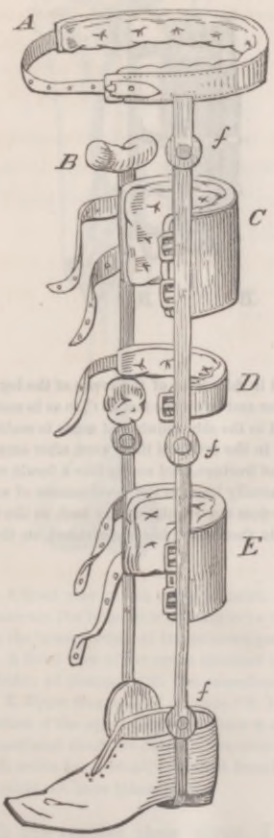


Fig. 4.

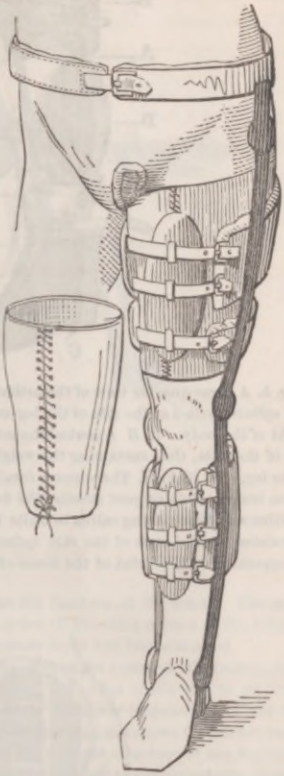

Fig. 3.

Fig. 2. A three-quarter view of the artificial limb applied in the treatment of false joint in the femur, and worn in the cases detailed above. *A*. A band and belt to surround the pelvis. *B*. A padded crutch-head to support the weight of the body upon the perineum. If the portions of the apparatus are made so as to form a cone, the apex of which is towards the knee, this head may be dispensed with, as the support on the thigh will act as it does in the artificial limb worn after amputation. *C*. The back and upper half of the cone or splint which supports the thigh. The front half buckles around the limb, is formed of sheet-iron, well padded, and, by forcing the limb against the rest of the splint, gives firmness to the fracture, and acts as a ferule. *D*. Another portion of the thigh support, which is sometimes continuous with that at *C*. *E*. A conical piece for supporting the leg. The front splint is here also to be buckled to the limb, and keeps the tibia directly in the line of the femur. *f*, *f*, *f*. Joints in the side-pieces of steel, to favour the motion at the ankle, knee, and hip, thus obviating the anchylosis so apt to result from long confinement and rest in one position. As there is always some shortening of the femur (say two inches), a false heel is placed *inside* the shoe. When the limb has united, the patient's shoe, if thus filled, will enable him to walk without attracting attention.

Fig. 3. A buckskin piece to surround the thigh, and prevent chafing of the skin.

Fig. 4. A three-quarter view of the artificial limb as applied. McNeelan walked with this apparatus whilst there was no union at the seat of fracture. In measuring a patient for this or any other of these artificial limbs, moderate extension and counter-extension is necessary in order to prevent subsequent shortening. When the artificial limb is well fitted, subsequent shortening is prevented, the chief support being above the seat of fracture, and the resistance below it.

Fig. 5.

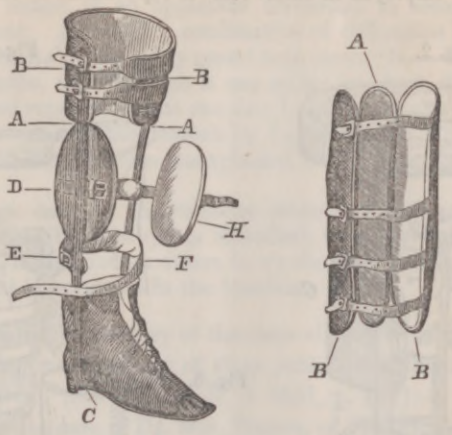


Fig. 5. A three-quarter view of the artificial limb employed in false joint of the bones of the leg. *A, A.* Steel splints applied at the side of the leg and connected under and below the foot at *C*, so as to sustain the weight of the body. *B, B.* A conical-shaped support attached to the side splints and made to embrace the head of the tibia, thus sustaining the weight of the body as in the artificial limb worn after amputation of the leg. *D, E, F, H.* The support furnished at the seat of fracture, and acting like a ferule upon the broken bones. This support steadies the fragments, and generally leads to the development of sufficient definitive and ensheathing callus to unite them. This shoe does not require a false heel, as the support is furnished by the ends of the side splints at *C*. Very little shortening has supervened on the use of this apparatus in false joint of the bones of the leg.

Fig. 6.

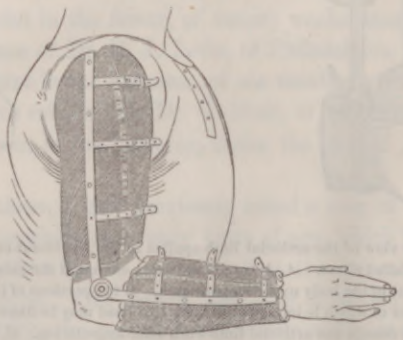

Fig. 6. A side view of the artificial limb applied to false joint in the humerus. In measuring the limb for this apparatus the humerus should be drawn as nearly as possible to its original length, and the artificial limb should rise well over the shoulder and fasten by straps to the opposite axilla if the false joint, has followed a fracture of the surgical neck of the bone.

Having thus shown the means of treatment and the results in the cases just related, it remains to exhibit the specimens which illustrate the method in which nature has accomplished the cure; and in the following drawings, taken from preparations in my possession, I think this will be readily seen to be due entirely to an "intermediate callus" produced at the expense of the external and internal periosteums, as exhibited in Figs. 7, 8.

Fig. 7. Fig. 8.


Fig. 7. A front view of the mode of union accomplished in an old fracture of the femur. The callus formed between the fragments appears to be chiefly due to the action of the outer surface of the bone, or rather to the inner surface of the external periosteum after its outer layer has been absorbed.

Fig. 8. A front view of the union obtained in a comminuted fracture of the humerus of a turkey, showing the fusion of compact with the cancellated structure of bone. 1, 1. Line of the saw in making a section. 2. Upper fragment of fracture. 3. Intermediate fragment. 4. Lower fragment. An end view of the section of the upper half of the bone is seen at the side of the drawing, and shows the perfect fusion of the cancellated structure of the intermediate fragment 3, with the compact structure of the fragments 2, 4. This union has evidently resulted from the absorption of the outer layer of the periosteum, without which it could not have taken place.

With the results thus given, I hope that others will be induced to repeat the treatment just advised, and give the profession the results of their experience; and that the more severe modes of treatment heretofore advised will be avoided until after the failure of the application of the artificial limb for six months. As the patient will have considerable use of the member during this period, the duration of the treatment and its inconvenience (if any) will hardly be complained of, whilst if it fails to accomplish the union of the ends of the bones, the patient will yet have a very good and useful member.

The hopeless condition of the limb, after the trial of some of the means heretofore employed, has more than once been illustrated, both in the United States and in Europe, by the willingness of both patient and surgeon to consent to amputation. Very recently[1] we notice the fact of an amputation of a limb for false joint, performed by Mr. Stanley, of London, whose work on *The*

[1] Med. News, Oct. 1854, from Lond. Times, July, 1854.

*Diseases of the Bones* is so well known. In this case, the use of ivory pegs, as advised by Dieffenbach, and even wiring of the fragments, had failed to induce a cure. A case is also reported where Mr. Lawrence, after employing the immovable apparatus without success, has resorted to the seton, the case being under treatment at the last account; and amputation has more than once been performed in the Pennsylvania Hospital, after the failure of the seton in the femur. When a comparison is made between the use of a seton with confinement to bed for six months, or between the other means requiring confinement, and this, which permits free exercise of the limb in the fresh air, few will, it is thought, fail to give the preference to the treatment by *pressure and motion*, as accomplished through the artificial limbs.

PHILADELPHIA, *October*, 1854.