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UNUNITED FRACTURE

SUCCESSFULLY TREATED,

WITH REMARKS ON THE OPERATION.

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WITH

ABSTRACTS FROM DR. BIGELOW'S CLINICAL LECTURES ON THE SUBJECT, AND CASES.

[Reported by Richard H. Derby.]

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UNUNITED FRACTURE SUCCESSFULLY TREATED.

THE following paper gives the details of eleven consecutive cases of ununited fracture, successfully treated, with the exception of one, in which the bone was diseased. Such continued success justifies the belief that this operation will effect the desired object with more uniform certainty than any other method now in use.

Two cases are appended in illustration of the extent of the osteoplastic power of the periosteum. In one of these the condyles of the humerus were reproduced after excision. In the other the periosteum failed to form a new bridge for the nose, after a rhinoplastic operation.

Having failed, in a number of cases, to effect by rest, compression, blisters, seton, drilling, excision of bone, dovetailing, &c., a union of ununited fracture of the humerus, and having in mind the experiments of Ollier* for the production of bone from periosteum, I determined, when the opportunity presented, to avail myself of the osteoplastic function of this membrane. In trying the experiment for the first time (Feb. 14th, 1860), I was not aware that any previous attempt had been made to produce bony union of ununited fractures by preserving the periosteum for that purpose; but in the ensuing spring, at the time of the successful issue of the case alluded to, I happened to meet with a paper recently published upon this subject, a superficial perusal of which seemed to show that its author had covered the ground, at least of novelty, in the method. The pamphlet was mislaid, and I thought no more of the matter, but had not infrequent occasion to repeat the operation, with successful result, and annually referred to the subject in my lectures before the class of Harvard University. A report of this method was also published† incidentally in connection with the testimony of the writer in a suit for malpractice, and afterwards alluded to in the London *Medical Times and Gazette*,‡ in which I stated that my own operation had

* Gazette Médicale, 1859, Nos. xiv. and xv.
† Boston Medical and Surgical Journal, vol. lxix. p. 218.
‡ February 6, 1864.

been anticipated abroad. Within a few weeks, however, my attention was directed, by my able house-surgeon, Mr. R. H. Derby, to the following paragraph in Holmes's System of Surgery:*—

"Jordan ascribes the failure of resection to the removal of the periosteum. He, therefore, by means of some blunt instrument, as the handle of a scalpel, dissects this membrane from the portions of bone which he is about to remove, and leaves the two empty pouches passed one within the other, and, in some cases, connected by suture, to form new bone. The suggestion is undoubtedly theoretically sound. Its practical value, however, remains to be proved. In two of the three cases which Jordan records, it failed of success; and he admits its failure in the hands of M. Sedillot."

Upon again examining more carefully the original paper of Mr. Jordan,† I find that his method differs so essentially from my own as to explain both the failure of two out of three cases cited by him, and the almost uniform success of the cases reported in this paper. Briefly, in the method of Mr. Jordan, no means are taken to secure the perfect and permanent coaptation of the bones—a measure which underlies the success of the whole proceeding—if we except a suture of the periosteum, which is wholly inadequate to that object, and which must also give way in a short time. This omission alone is fatal to any considerable success in the operation.

2. The muscle is detached from the periosteum,‡ and the periosteum then pounded to detach it from the bone; measures both tending materially to devitalize the tissue upon which success most depends.

3. Mr. Jordan believes that suppuration hinders bony union, and therefore ingeniously modifies the whole operation for the purpose of preventing a suppuration which is in reality inevitable, and which must therefore be met and provided for, controlled and directed, and which does not prevent the desired result.

Finally, it may be added that an oblique section of the already tapered bone, as recommended by him, and especially the *rabbet*,§ is not to be advised, as it tends to denude and devitalize the protruding extremities; while an apparatus of plaster is hardly sufficient to ensure subsequent immobility, and one of gutta percha, by confining transpiration, is irritating to the skin.

Abstract from Dr. Bigelow's Surgical Lectures at the Massachusetts Medical College.

The chief cause of ununited fracture is undoubtedly the severity of the local injury, although perhaps the constitution of the patient or an obliteration of the osseous artery may, in a few cases, have to do

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* Vol. i. p. 804.

† Traitement des Pseudarthroses par l'Autoplastie Periostique. Par Joseph Jordan, F.R.C.S., Chirurgien en chef de l'hopital de Manchester. Paris, 1860.

‡ See Plate III.

§ An interlocking, called also in carpentry *rebate*.

with it. It occurs in an arm which has been run over, or after accidents from machinery, which bruise and devitalize the part. The obstinacy and persistence of this lesion under treatment are well known, and have arrested the attention of surgeons, who have devised many expedients, though often unsuccessfully, for its relief. The present operation must be deemed a successful one. * * *

Operation.—The extremities of the false joint are to be attacked where they approach nearest to the surface, unless vascular or nervous trunks are in the way; in the arm, in all the cases I have seen, upon the outside; a free incision being contrived in each case with especial reference to the free exit of pus. In the arm, the musculospiral nerve, which is often displaced and tied by the lymph, is to be carefully looked for and avoided, and were it not for the care here requisite the bone might be exposed by a single incision. The principal bony extremities being found, the interval, which is sometimes quite irregular and interlocked, is gradually divided, and the ends turned out, the dissection being materially aided by an assistant who powerfully flexes the false joint. As it yields, care is taken to prevent the muscles from being stripped from the periosteum, which they adhere to and aid in nourishing. When one extremity is fairly exposed, a crucial or other regular incision is to be made in the ragged callus which overlies the periosteum at its tip, which should be then seized by strong-toothed forceps and efforts made to tear it out of the rugous inequalities of the formerly inflamed bone. After a little delay and dissection, the flaps begin to yield; with some coaxing, the terminal adhesions are detached, and the sound bony shaft is reached, where the periosteum is only too easily stripped from the bone, requiring great care lest the shaft should be denuded higher than the intended section. The soft tissues being now protected by spatulæ, or flexible strips of copper, the end of the shaft is removed by a common saw, the length of this fragment being determined by the amount of periosteum it has been necessary to detach. A half an inch of good cylindrical periosteum, with half an inch more of ragged tissue hanging at its extremity, has usually covered from three quarters to an inch and a half of bone. Perhaps half an inch of sound shaft, with an irregular or conical extremity varying in extent, is a good rule for the excised piece in most cases. The other extremity is now to be turned out and treated in the same same way, and this terminates the dissection, leaving only the wire to be inserted. For this purpose holes are bored in each extremity with a good bone drill, larger than the wire, at a little more than half an inch from the end, and through one wall only. A pure silver or plated copper wire is inserted from without inward in one end, and inversely entered in the medulla from within outward in the other; the size of the wire ordinarily used is No. 10 of Stubbs's iron wire gauge. The ends are brought together accurately, and the wire twisted long enough to protrude at the ex-

ternal wound. The incision is then brought together by sutures, leaving an abundant exit for pus, and the apparatus is applied.

Apparatus.—The best apparatus for the humerus I have found, on the whole, to consist of a firm concave splint of iron and leather, made to fit the top and outside of the shoulder as low as the axilla, and thence horizontally to the neck, and secured by a strap around the opposite axilla; a similar gutter to receive the elbow and forearm flexed at a right angle; and the two united by a narrow iron strap on the back, and another on the front of the humerus, adjustable as to its length. The splint can be thus shortened when in place, so as to keep the extremities of the bone in contact, and nearly immovable, in spite of the great leverage of the arm upon the wire, while the dressings can be readily applied in the open interval, without disturbing the apparatus.

For the thigh, a pasteboard splint may be moulded to the anterior aspect of the thigh and leg, and then stiffened with dextrine, an interval for the wound being left. The whole limb is then secured to this by bandage; and surmounting the whole, a Smith's anterior splint is applied, by which the leg is suspended from a railway on a framework over the bed.

I have usually employed water-dressings at first, and poultices or oakum to absorb the discharge afterwards. The patient has remained in bed for several weeks, and in fact till some stiffening has taken place, after which fresh air has been enjoined as an invigorating and osteoplastic agent. The diet has been as generous as the appetite would bear, and the phosphates have been generally administered upon the principle of giving egg shells to hens.

The wire has remained in place until the bone was firmly united, generally during several months, and there has been in no case evidence of any ill effects from its presence, either in producing necrosis or undue inflammation. In fact, it has, in some cases, remained quietly in place after the arm was in use, and before the patient returned for its removal. In Case II. the wire remained for two years.

To remove the wire, the loop is best divided with cutting pliers, and forcibly drawn out; hence an advantage in flexible wire. This loop is sometimes quite superficial, but in other cases is so deep as to require an incision to reach it.

It may be remarked that a partial stiffening, dependent on the inflammation of the soft parts, may take place in a few weeks, but the bone afterwards becomes gradually loose if the periosteum fails to do its duty.

The one great point to be observed in treatment is the prevention of abscess, or, in other words, the early and free evacuation of imprisoned pus, by large and dependent incisions, which here as elsewhere are incomparably less injurious to the tissues than the burrowing of pus. Again, the formation of an abscess is always attended

with fever, which destroys appetite and weakens the patient. Hence especial care is needed to detect any inflammatory induration supervening after suppuration has begun, and the first decided pointing should be the sign for an opening, to be explored by the finger, and enlarged inside or outside accordingly. I need not say that it is, in general, cruel to use the knife without an anæsthetic, but here the careful exploration and the tearing of the adjoining sinuses with the finger, if adequately done, absolutely demands it, for the comfort of both surgeon and patient. After a long experience, I have never seen a patient, unless already moribund, really worse for ether, and I have often seen a weak person prostrated by the excitement and suffering of an operation, when it was withheld by the timidity or haste of the surgeon. As for freezing, it is sometimes more convenient for short and superficial incisions, and in private practice, but when its novelty is gone it will yield in other cases to general anæsthesia.

In operating upon the humerus, the musculo-spiral nerve demands especial consideration. Winding around the outside of the arm near the usual place of incision, it is sometimes difficult to avoid it, especially when displaced by the deformity, and tied into an indurated mass of lymph. I have twice accidentally divided it, in spite of more than ordinary care; once completely, and once leaving only a single fibre at one side. In one case, an operation had been undertaken one month only after a previous one, while the arm was still inflamed. It was on that account absolutely impossible to keep the wound dry, and after a protracted dissection the knife was at last used beneath the blood; the nerve was imprisoned and concealed in a deep groove in the new bone, and was divided in separating the bones. On this ground, I should not advise a second operation until the traces of active inflammation from a previous one had disappeared. In this instance the neurilemma was re-united by a small suture. In both cases, the power of the paralyzed extensors ultimately returned, completely and unequivocally. In another case, now under treatment, partial paralysis ensued after the operation, but the nerve had been no where seen, and could hardly have been divided. On the other hand, the fragments were so short that a powerful and continued effort had been required to make their ends protrude, jamming the muscles in their interval, and very likely thus injuring the nerve. The fingers are now regaining their motion. In the same case, which was one of gun-shot wound, the operation twice failed, there being still some necrosis about the bone, of which the lower fragment was enlarged to at least double its diameter. In a future case, I should consider that necrosis contraindicated the operation, if there were any good chance of getting rid of it by time or interference.

The case most favorable for operation is undoubtedly that of a healthy subject, where the bony extremities are of natural size. In a case of long standing, atrophy tapers the bones, which need in

consequence longer excision. Other things being equal, it is better not to wait unnecessarily.

The only case I have encountered of ultimate failure, was one of extreme softening of the bone by interstitial absorption, a condition which was not ameliorated by invigorating measures, including the free and protracted use of the phosphates.

Case I.—Humerus.

Patient, E. J., aged 22, entered the Hospital, October 15th, 1857. Eleven months before, his right arm was caught in a "splitting machine," and drawn in between the cylinders. A compound, comminuted fracture of the radius and ulna was produced at about their middle; and a compound fracture of the humerus rather below the middle. The fracture of the humerus did not unite, that of the forearm did.

October 14th.—A seton was passed between the fractured ends.

February 24th, 1858.—No union. Seton removed. Subsequently, emplastrum cantharidis was applied over the fracture; the ends of the bone were rubbed together.

May 12th.—No union. An incision was made over the fracture; the two ends were exposed, and an inch removed from each.

November 21st.—He was discharged, not relieved.

November 15th, 1859.—He returned to the Hospital; the arm was perfectly useless, and occasionally caused pain. He was prepared for anything that should offer a reasonable prospect of success, or even amputation as a last resort.

December 17th.—He was etherized, and, with the view of producing irritation, each fractured extremity split with a pair of strong forceps, made for the purpose with chisel blades (which punctured the skin at opposite points, and slowly penetrated the bone, the ends of the forceps being placed in a vise), and a splint applied, consisting of a shoulder-cap, with a band around the opposite side, and a cap for the elbow and forearm. These two caps were made to advance towards each other by a screw, so as to crowd the ends of the bones together.

18th.—Comfortable.

January 15th, 1860.—In consequence of pain about the shoulder, the apparatus was removed, and the arm bandaged. Little or no union.

February 14th.—*Operation by Dr. Bigelow.* He was etherized, and a crucial incision made over the external surface of the arm over the fracture. The band of ligamentous tissue connecting the bones was divided, and each extremity of the humerus turned out. The periosteum was carefully detached, for an inch or more, from each end. The denuded ends were then sawed off. A hole was drilled through each end, and a stout silver wire passed through. The ends

of the wire were then twisted, and the ends of the bone brought into exact apposition. The external wound was united with sutures; the ends of the wire were left protruding, and the former splint re-applied. After the operation, opiates were needed and freely given.

21st.—Wound smelling badly. A solution of chlorinated soda injected under the apparatus.

25th.—The apparatus was removed, washed and reapplied.

March 5th.—Wound closing by granulation. General condition good.

23d.—Arm apparently stiff.

29th.—To-day, the arm and shoulder becoming somewhat painful from pressure of splint and necessary want of cleanliness, everything was with great care removed; on slight examination of the arm, no motion was detected. The arm and shoulder were then carefully washed, lateral splints applied, and the hand and elbow supported in a sling.

April 4th.—The dressings were again removed. Slight mobility was detected at the point of fracture. As, however, only six weeks had elapsed since the operation, it appears to have progressed as rapidly as any compound fracture of an equally severe character could be expected to do. External wound nearly healed.

23d.—Apparatus frequently removed. Union firmer.

June 13th.—Union appearing to be very firm, and the wire causing some pain, there appeared to be no further indication for its remaining longer. He was etherized; the wire was untwisted and removed.

July 1st.—Arm was stiff and strong, with considerable motion in the elbow.

July 12th.—At request, patient was this day discharged, being able to return to his work, which is that of a leather splitter. The arm appeared to be nearly as useful as the other one.

Case II.—Radius.

Patient, A. D., farmer, aged 56, entered the Hospital February 6th, 1861. Four years before, he received a fracture of both bones of the right forearm, with other injuries, by being caught in machinery. Splints were applied and kept on for nine weeks, the patient being confined to bed during this time on account of necrosis of both tibiæ, resulting from the injuries sustained. At the expiration of this time there was no union. A starch bandage was applied and allowed to remain for four months, but no union was secured at the point of fracture. During this time his health continued good. Nine months after the receipt of the injury, an incision was made over the lower border of the forearm, the ends of the fractured ulna were turned out and sawed off, and the extremities then wired together. Various other means were subsequently resorted to, but with no success.

On entrance, the fractured ends of the ulna could be felt distinctly; there appeared to be some ligamentous union in the radius. He had a very considerable use of the hand.

February 9th.—*Operation by Dr. Bigelow.* He was etherized; a tourniquet was applied over the brachial artery to keep the wound dry. An incision was then made along the upper border of the radius, about two inches in length. The ends of the bone were turned out, the periosteum was dissected up, and about half an inch of each fragment sawed off. A hole was now drilled through the upper wall into the medullary cavity of each end, and the ends of the bone firmly wired together by means of a stout silver wire passing through the holes and twisted. Two small arteries required ligature. The edges of the wound were drawn together by sutures and a compress applied. The arm was placed in an external angular splint, and bandaged firmly, to prevent motion.

12th.—The pain in the arm is quite severe and constant. Considerable swelling about the wound. The bandage is daily removed.

March 1st.—Wound nearly healed about the wire. Appetite and strength excellent.

23d.—Patient allowed to go home, to return for the removal of the wire.

February 13th, 1863.—Patient has been able to saw wood with his right arm. He came to have the wire removed, which has remained since the operation.

14th.—He was etherized. An incision half an inch in length was made over the point of fracture; the wire was divided, and easily removed, two years from the time of its insertion.

Case III.—Humerus.

Patient, J. C., laborer, aged 24, entered the Hospital November 4th, 1861. Eight months before, while turning the crank of a hand-car, he became entangled in some way, and his left arm was drawn under the crank and fractured above the elbow. A physician applied splints to the arm, and for two weeks took them off and reapplied them every day. At the end of eight weeks the splints were removed, but no union found at the point of fracture. Four months ago, the fractured ends of the bone were rubbed together, but with no success.

Now, the left arm is about one inch shorter than the right, from the ends overlapping each other. The fracture extends from a point about four inches from the lower end of the humerus, on the outer side of the shaft of the bone, obliquely inwards and downwards, terminating at a point about two inches above the internal condyle. Crepitus and motion in the fracture are very distinct. There has apparently been no callus thrown out around the fracture. Motion in the elbow-joint is perfect.

November 9th.—*Operation by Dr. Bigelow.* Patient was etheriz-

ed. An incision, three and a half inches in length, was made through the skin over the seat of fracture. The subjacent fibres of the triceps were then divided, as was also, accidentally, the musculo-spiral nerve, with the exception of a single fasciculus, by which the extremities hung together, and which was afterwards carefully respected. The ends of the fractured bone were then turned out; the periosteum was carefully detached from both; a piece one and a half inches long was sawed from the lower fragment, and a piece one inch long from the upper. A hole was then drilled through each end of the fractured bone, and the two surfaces kept in apposition by a silver wire, passed through the holes and the ends twisted. An inside and outside angular splint, well padded, were then applied. A single suture was introduced to keep the edges of the wound slightly in apposition. The extensors of the hand are paralyzed.

13th.—Splints were removed and reapplied. Position excellent. Slight suppuration in wound.

16th.—Splints removed, and arm dressed.

21st.—He has slight paralysis of sensation on the posterior radial aspect of forearm, and no sensation over the back of thumb and radial side of forefinger.

29th.—Appetite poor. Pulse accelerated.

December 17th.—Slight stiffening at point of fracture.

27th.—Considerable stiffness in humerus. Wound nearly closed.

January 10th, 1862.—Union moderately firm.

March 1st.—On careful examination, a slight yielding was detect ed at the point of fracture.

11th.—A small piece of necrosed bone came away from wound.

May 10th.—Patient was etherized. An incision was made down upon the wire, which was then extracted.

22d.—Discharged, well.

This patient wrote, April 28th, 1867, that he was a "section hand on the Northern Railroad," had not lost a day since he left the hospital, and was "well, doing the hardest kind of work." Sensation and motion in hand perfect.

Case IV.—Humerus.

Patient, E. D., laborer, aged 31, entered the Hospital December 4th, 1862. A year before, his left arm was caught by a revolving shaft, and the humerus fractured. The skin was much contused, but not penetrated. A physician was called, who, after examination, pronounced the humerus comminuted through nearly its whole extent. He applied splints, bandages, &c., and on the third week reapplied them, at the same time making considerable extension to bring the fragments into position. At the end of the fourth week he announced that the union was getting firm, and a week later he removed the splints and applied strips of pasteboard. A few days after this, by a sudden movement, the fragments were displaced, although very

slightly. After two weeks, they had become firmly united again, by the report of the physician. In the middle of May, he reported that all was well united, but not strong, and applied bandages, &c., with the intimation that it would be a year before the union would be strong enough to bear hard usage. Three weeks after this, the patient had the bandages removed to wash the arm, and his wife at once declared that the bones were loose. Various measures were then taken to procure union. For the past four months he has not interfered with the false joint, but has given his attention to recovering the motion of the elbow, stiffened by long disuse. Now, he has a false joint a little below the middle of the humerus.

December 6th.—*Operation by Dr. Bigelow.* Patient was etherized. An incision, four inches long, was made over the outer aspect of the false joint, and the ends of the fragments were exposed. Both ends were irregular in shape, especially that of the upper fragment. They were bound together by a tough, pearl-colored, gristly material, quite firm to the knife. The periosteum was dissected up and turned back from about an inch of the end of each fragment; the ends were then sawed off square, and a hole bored through each fragment at a point a quarter of an inch from their ends. The two fragments were then brought into apposition and held in place by a silver wire passed through these holes and twisted. The free ends of the wire were long enough to project from the wound. Sutures were then inserted, and angular splints, external and internal, were applied.

10th.—Suppuration well established. Splints removed, and wound dressed.

20th.—He has lost appetite during the last twenty-four hours. On removing splints, an erysipelatous blush was seen over the whole upper arm. ℞. Quiniæ sulphat., gr. ij., ter die. Beef-steak and wine, if he will take them.

24th.—Splints changed. Doing better.

January 2d, 1863.—Patient is quite strong and cheerful. On removing the splints to change dressings, considerable stiffness is found in arm. Suppuration is moderate; the wound is closed, except immediately about the ends of the wire.

4th.—Considerable pain at the point of fracture, and in elbow.

14th.—He walks about.

16th.—The pus has burrowed towards the elbow. Much weaker. Beef-steak, wine and eggs.

23d.—There is tenderness and redness over the internal condyle, apparently from the commencement of a large abscess.

27th.—He has been very wretched since the last record, from great pain in the abscess. The splints were unbearable and were removed yesterday. The arm is laid on a large poultice, with an external straight splint. The abscess was freely incised under ether, and the various sinuses were torn into one.

31st.—Patient was etherized, and the wire cut and withdrawn.

February 4th.—Patient is improving wonderfully. He sits up all day, and walks about freely.

18th.—Wound entirely closed.

26th.—The arm is quite stiff at the point of fracture.

March 9th.—Discharged, well.

Case V.—Femur.

Patient, B. H., teamster, aged 27, entered the Hospital March 10th, 1863. Five hours before admission he was run over by a heavy team, the wheel passing over the middle of the left thigh. The whole of the left thigh is greatly swollen and ecchymosed, shortened about two and a half inches. The fracture is perhaps comminuted, and at the middle of the femur. Desault's apparatus was applied.

April 18th.—Comfortable since the last report. Desault's apparatus was removed to-day. Limb in excellent position. There is apparently considerable callus, but the thigh appears flexible at the point of fracture.

21st.—A starch bandage, stiffened with pasteboard, applied to the limb from the middle of the leg to the upper third of thigh.

30th.—He sits up daily.

May 4th.—Upon examination to-day, it was found that there was no union.

6th.—Desault's apparatus re-applied.

7th.—Apply over fracture emplastrum cantharidis (6 by 4).

23d.—No union. Apply extension by weight.

August 1st.—Starch bandage was applied over leg and thigh. ℞. Calcis phosphat., gr. x., 3 t. d.

15th.—The starch bandage was removed, and extension by weight applied.

September 2d.—After a careful examination, it was decided that there was no union at the point of fracture.

8th.—A starch bandage was applied, and he was allowed to sit up.

December 5th.—Patient now came under Dr. Bigelow's care. No union. He was etherized, and a seton passed between the fractured ends of bone and out through the other side of the thigh.

16th.—Profuse discharge from lower wound.

27th.—Seton removed.

February 2d, 1864.—Discharge from wound diminished. Apparently but little stiffness.

June 4th.—Patient has continued in the same condition since the last record. There is no union. He was etherized, and the ends of the fracture were drilled in several different places.

18th.—There has not been the slightest inflammation in the thigh, produced by the drilling.

July 20th.—There has been no change in the thigh since the last report. The ununited ends of bone are surrounded by a large amount of indurated tissue, which makes it very difficult to get at

them. He was etherized, and the ends of the bone were again and more thoroughly drilled. At most parts the bone was quite hard and normal, but at one point it was soft, and on withdrawal the drill was followed by quite a stream of oil from the degenerated marrow. The limb was placed in a straight splint.

November 4th.—There is no stiffness at the point of fracture.

12th.—*Operation by Dr. Bigelow.* The patient was etherized. A long, semi-circular incision was made on the outside and back of the thigh, its convexity downwards, over the ends of the bone, to favor the discharge of pus. The muscles of the thigh were found to be indurated, so that the ends of the bone were turned out with great difficulty. The ends of the bone were smooth, rounded and conical. The periosteum was then turned back for about one inch on each end, and the bones, thus denuded, cut off with a chain saw. The medullary substance was slightly degenerated and fatty. A hole was then drilled through each extremity of the bone, and a wire passed through these holes and twisted, not tight, but leaving a small space between the ends, to allow of sufficient motion to prevent breaking the wire or the bone. The periosteum was then brought together and the wound closed by sutures. The limb was placed in a McIntyre's double-inclined, iron splint, bent at an angle of 135°. The operation occupied about two hours, during which time the patient was kept thoroughly etherized. Cold-water dressing.

13th.—He has considerable irritative fever to-day. Pulse 132. Tongue thickly coated. The pain is relieved by acetate of morphia, one sixth of a grain, subcutaneously.

15th.—Much brighter to-day. Pulse 100.

16th.—Suppuration has commenced.

23d.—The leg and thigh have remained until to-day on the McIntyre splint, but the suppuration has increased so much that it requires removal for daily dressing. A pasteboard splint has been moulded to the anterior and inner part of the thigh and stiffened with dextrine; to this the thigh and leg are firmly bound, leaving the wound open. Above this a Smith's anterior splint was applied, by which the whole leg is swung from a framework over the bed.

27th.—The splint works admirably. Less pain. The wound looks well, and is suppurating freely. Appetite good.

December 24th.—The bandages and splints were removed and reapplied. There seems to be considerable stiffening, and the bones are in good position.

January 13th, 1865.—No motion is observed at the point of fracture.

February 12th.—The limb is so firm that it was laid on a pillow, with only pasteboard splints applied.

April 26th.—Under ether, the wire was cut down upon and removed.

May 17th.—He is up and dressed. Appetite and general health excellent. He wears a dextrine bandage for the support it affords him.

June 1st.—He walks about on crutches. The knee is quite stiff.

July 1st.—Wounds entirely healed. The motion in the knee is returning.

12th.—The femur is perfectly firm and free from pain. He was furnished with a thick-soled shoe. Discharged, well.

November 10th.—He came to the Hospital to-day. He is able to walk without the aid of a cane. Not the least motion can be detected in the femur. The knee is flexible.

Case VI.—Humerus.

Patient, T. C., soldier, aged 41, entered the Hospital April 15th, 1864. He was wounded by a Minié ball in the right humerus at the first assault on Port Hudson, summer of 1863. The bone was broken at about the junction of the middle and upper thirds, and was considerably splintered. According to patient's account, the surgeon sawed off about an inch from each end, and then approximated the ends of the bones by means of splints, but did not wire them. He was then put in an ambulance, carried fifteen miles over a rough country, then in a steamer for some distance, so that it was two days before he arrived at a hospital. The wound soon healed, but the bones did not unite, and have not since.

April 16th.—*Operation by Dr. Bigelow.* He was etherized. An incision was made over the point of fracture. The ununited ends were forcibly everted. The periosteum was carefully dissected up and reflected, and the denuded ends sawed off. A hole was then drilled through each end of the fragments. A wire was then passed through these holes and twisted. The periosteum was brought together, and the wound closed by sutures. The arm was placed in an outside angular splint.

20th.—The arm has moved from the splint, and is quite out of position, so that the ends of the bones are at a slight angle with each other. The angular splint was removed and the arm placed on a broad straight splint, with two shorter side splints to keep the fragments in place.

23d.—The wound is suppurating freely, and the arm is in good position.

May 2d.—The wound has nearly healed, except at the point where the wires emerge.

June 10th.—Patient walks about the yard, with the arm firmly supported. There is considerable firmness at the point of fracture.

24th.—The arm is stronger. Discharged.

September 17th.—He returned to the Hospital to-day with the arm so strong that he can use it for all ordinary purposes. The wire was removed, and the humerus was found to be perfectly firm.

December 16th, 1865.—The arm is perfectly firm, and for some time he has done a great deal of heavy lifting, such as wheeling coal, without favoring the injured arm in the least.

Case VII.—Humerus.

Patient, E. S., female, aged 45, entered the Hospital Nov. 10th, 1864. She had an ununited fracture of the right humerus, the result of a compound fracture received a year and a half previously. Seven months after the accident there was no union at the point of fracture. A seton was passed between the ununited ends, and allowed to remain for a month. Notwithstanding this and other forms of treatment, no union followed. On entrance, there was a fracture of the humerus in its lower third; the ends of the bone were drawn widely apart by the weight of the forearm, unless held in place by an apparatus which she had worn for the previous seven months. She was a large, corpulent woman, with flabby tissues.

November 19th.—*Operation by Dr. Bigelow.* She was etherized. An incision, three inches long, was made on the outer and posterior aspect of the arm, just above the external condyle. The ends of the fragments were then turned out, the periosteum was dissected back for about an inch and a half on the lower fragment, and two inches on the upper. The denuded bone was then sawed off; on the upper fragment by a single stroke of the saw. The bone was much atrophied, softened and degenerated, the holes for the wire being easily made with an awl, and the bony tissue easily cut with a knife. A wire was then passed through the outer sides of the shaft of the bone, and twisted so as to bring the ends nearly but not quite in apposition, lest the tight wire should break the bone. The edges of the wound were brought together with sutures, and the arm placed in an inside angular splint.

P. M.—The arm is so unwieldy that it cannot be sufficiently confined in the inside splint. It was therefore laid on a flat right-angled splint.

27th.—Pulse and appetite good. Wound clean, and suppurating healthily.

December 30th.—℞. Calcis phosphat., gr. x., 3 t. d.

January 7th, 1865.—The wire has apparently torn out of the bone. No stiffening at point of fracture.

March 20th.—No union.

April 1st.—Patient was etherized. An incision was made down upon the bone, and the wire was removed. The ends of the fragments were turned out and found so degenerated that they could be easily broken with the fingers. Forearm œdematous and tender.

26th.—The arm was to-day amputated, at the patient's desire. The end of the upper fragment was removed.

May 21st.—Stump has nearly closed.

June 17th.—Discharged, well.

Case VIII.—Humerus.

Patient, W. W., carpenter, aged 28, entered the Hospital January 2d, 1865. He had his left humerus fractured, twelve weeks before entrance, by the falling of an elevator in the Pacific Mills. The fracture was simple, and treated in the usual way with splints, but there never had been any attempt at bony union. On admission, there was an ununited fracture of the left humerus at a point a little below its middle. The ends of the fragments were in apposition. ℞. Syr. hypophosphit., ʒ ij., 3 t. d.

January 7th.—He was etherized. A narrow-bladed knife was pricked through the integument and muscles to the bone, at the point of fracture. A small drill was then introduced through the wound, and each end of the bone was drilled in three places. The arm was placed in an inside and outside angular splint.

26th.—On removing the splints, no union was detected.

February 25th.—*Operation by Dr. Bigelow.* Patient was etherized. A straight incision was made through the integument, on the outside of the arm, to the bone. The musculo-spiral nerve was so drawn out of place and embraced by the bone that it was accidentally divided in the blood which welled up from the tissues, still inflamed from the operation of six weeks before. The ends of the bone were dissected from the periosteum, everted and sawed off. A piece, half an inch long, was taken from the upper fragment, and three quarters of an inch from the lower. A hole was then drilled through each end, and a silver-plated, copper wire passed through and twisted. A suture was passed through the neurilemma of each end of the divided nerve and the extremities brought together. Several arteries were tied; the wound was closed by sutures, and the arm placed in an inside angular splint, to which it was first firmly bandaged, and then placed upon a flat angular splint, reaching from shoulder to hand.

26th.—He complains of great numbness over the dorsal surface of thumb and index finger, and has general paralysis of the extensors of the wrist and fingers.

March 3d.—Wound suppurating healthily.

8th.—Hand considerably swollen, and elbow looking angry and red. The wound is everywhere open. The suture applied to neurilemma came away to-day. ℞. Pil. ferri iodidi., gr. v., 3 t. d.

16th.—Wound closing.

31st.—Considerable stiffness at point of fracture.

May 6th.—Humerus quite stiff.

25th.—But little discharge from sinus about wires. Appetite and general health excellent.

June 24th.—Under ether, the wire was untwisted and withdrawn. The humerus is perfectly stiff. Sensibility has returned to the thumb and index finger, but motion in all the extensors of the hand and wrist is absent.

March 17th, 1866.—He reported at the Hospital to-day. He has worked at his trade since last August, without inconvenience. Motion in the extensors of hand and wrist has returned perfectly. The humerus is perfectly firm and free from pain.

Remarks.—The union of the musculo-spiral nerve, which was completely divided and brought together by suture of the neurilemma, with restored function, is a point of great interest.

Case IX.—Humerus.

Patient, T. G., laborer, aged 26, entered the Hospital June 12th, 1865. A year before entrance he was thrown from a hand-car, one wheel of which passed over the middle of the right humerus, inflicting a compound fracture. The arm was placed in an inside angular splint, and kept in position for six weeks. The external wounds healed readily. At the end of this time, the arm was again broken at the original point of fracture and never again united.

June 21st.—*Operation by Dr. Bigelow.* An incision, three inches long, was made on the outer aspect of the arm, over the seat of fracture. The musculo-spiral nerve was then sought, carefully dissected in its sheath from the bone, and turned aside. The periosteum was stripped back from the end of each fragment. A piece, half an inch long, from the lower, and three quarters of an inch from the upper bone, was sawed off. The ends were then drilled on the outer side, and a silver wire passed through; the ends of the bone were placed in apposition, and the wire twisted by four half turns. The arm was placed in the same apparatus as that used in the previous case. The edges of the wound were brought together by sutures.

23d.—Apparatus re-applied. The bones are in good position. Some œdema of the arm.

27th.—Suppuration is established. ℞. Calcis phosphat., gr. x., three times a day.

July 3d.—The arm is much swollen about the wound, and covered with an erysipelatous blush. He complains of some headache and nausea. ℞. Quiniæ sulphat., gr. ij., three times a day.

10th.—The swelling and redness have disappeared. No union at point of fracture.

28th.—An outside angular splint was applied, the arm supported by a leather sling, and he was allowed to sit up.

August 7th.—Apparatus removed and re-applied. There is slight stiffening at point of fracture.

22.—Only slight motion can be detected in the humerus.

September 11th.—The arm is stiff, but he complains of pain at the seat of fracture when it is examined.

November 4th.—All discharge and soreness having disappeared, and the humerus being perfectly stiff, a pair of curved scissors were thrust down, the wire cut close to the bone, and easily withdrawn.

December 15th.—The humerus is firm. Discharged, well.

Case X.—Humerus.

Patient, W. M. W., carpenter, aged 33, entered the Hospital January 26th, 1866. He was wounded with a minié ball at the battle of Gettysburg, and suffered a compound comminuted fracture of the right humerus. July 5th, the bone was resected and about three inches removed. The wound healed in five months after exfoliation of the sawn extremities of the humerus. No attempt was made to keep the bones in apposition, and no union was obtained. He resumed duty and served out his full time with his regiment. The wound has never re-opened or caused him any trouble. Now several inches of the middle of the right humerus are gone, and the two extremities can be felt, pointed and considerably absorbed. The whole arm is quite small from disuse. The motion in the shoulder and elbow is perfect, but the arm hangs useless from the loss of substance in the shaft of the humerus.

January 27th.—Operation. Being temporarily disabled, Dr. Bigelow requested Dr. Hodges to perform the operation. Patient was etherized. A longitudinal incision was made over the ends of the fragments. The end of the lower fragment was then everted; the periosteum was carefully detached for a sufficient distance and turned back, and half an inch was sawn off from the end of the bone, which was firm and healthy. The upper fragment was treated in the same way, but the end, three quarters of an inch of which was removed, was degenerated and quite soft. These ends were then drilled; silver wire was inserted and the ends approximated, leaving a small interval to allow slight movement. The periosteum was returned to its place, a few vessels were tied and the external wound partly closed by sutures. The arm was placed in an internal angular splint. Water dressing.

30th.—The arm is in excellent position. Suppuration is beginning.

Feb. 21st.—A large abscess above wound evacuated itself to-day.

March 11th.—He walks about every day. Apparently some stiffening at the point of fracture.

17th.—An abscess is forming on the inner aspect of arm.

20th.—The abscess was opened and discharged freely.

31st.—The humerus is quite firm. He was discharged to-day, to return once a week.

April 27th.—Scarcely any motion can be detected at the point of fracture.

May 23d.—An incision was made down upon the wire, which was cut and withdrawn. The union of the fractured ends is firm. The apparatus was removed. Patient returned to work.

Case XI.—Humerus.

Patient, P. M., laborer, aged 23, entered the Hospital, January 12th, 1867. He was wounded at the battle of Cedar Mountain,

1862, by a musket ball. The left humerus was shattered at a point a little above its middle. The small pieces of bone were removed; the ends sawed off and the fragments approximated. Six months later there was no union; the ends were again sawed off and the bones wired together. At the end of two weeks the wire was removed. In October, 1864, a number of pieces of necrosed bone were removed from the seat of fracture; there was no union. In November, 1865, he entered the Hospital. The left humerus had a false joint at its middle. There was necrosed bone at the bottom of a couple of sinuses in the lower fragment. An incision was made over the fracture; the periosteum reflected and the ends of the bones sawed off. In March, 1866, there was no union. March 31st, Dr. Bigelow again operated. The periosteum was detached from both fragments for a sufficient distance; about one and a half inches was sawed off from the lower and one inch from the end of the upper fragment. The ends were drilled, silver wire inserted, and the fragments placed in apposition. The periosteum was then replaced and its edges united by sutures. April 28th, the arm had stiffened at the point of fracture. June 10th, he fell upon the arm and broke it. July 15th, he was discharged with an ununited fracture, to return when the arm looks and feels better.

January 12th, 1867.—*Operation by Dr. Bigelow.* Patient was etherized. An incision, three inches long, was made over the outer aspect of arm and carried carefully down to the point of fracture. The two ends were found to be much roughened. Great difficulty was experienced in everting the ends of the now short fragments and in detaching the periosteum. The bone was finally separated from the periosteum for a sufficient distance, and a piece, one inch long, sawed from the upper, and one, three quarters of an inch long, from the lower fragment. The lower fragment was two inches in diameter; the upper one was of normal size but with fatty degeneration of the marrow. A hole was drilled through the sides of both fragments; a silver wire was inserted; the ends were placed in apposition and the wire twisted. The periosteum was replaced and its edges united by sutures. The external wound was partly closed by sutures. A folded towel was placed in the axilla to lift out the short upper fragment, and the arm secured to the side, the forearm across the chest.

13th.—There is almost complete paralysis of the extensors of the fingers of the left hand. No nervous trunk was known to have been divided in the operation, and the paralysis is perhaps due to a compression of the nerve in very forcibly everting the shortened fragments.

21st.—The arm was placed in an apparatus, which consists of a firm cap about the shoulder, secured by a strap around the chest; this is made firm by two steel bridges to a splint that invests the

27th.—The arm remains in excellent position. The power of extension is returning to the fingers.

February 3d.—The wound is contracting by healthy granulation.

6th.—Slight stiffening at point of fracture.

16th.—℞. Calcis phosphat., gr. x., 3 t. d.

March 4th.—Allowed to walk about.

April 16th.—The humerus is quite firm at the point of fracture. He flexes the forearm and raises the humerus from the side freely.

22d.—Discharged, probably well, although sufficient time has not elapsed to determine the fact.

Remarks.—As will be readily inferred, this humerus was materially shortened by these consecutive operations, two before entering the Hospital, and three subsequently by Dr. Bigelow. In fact, by measurement it was *seven inches* shorter than its fellow, yet the biceps and triceps were fulfilling their functions, and the patient was regaining excellent motion. There can be no comparison in the value of an arm of this sort, however short, and an ununited humerus. In the first operation and during the existence of undefined necrosis, the bony tissue of the substance of the lower fragment was of a reddish hue, and of a dense, brittle and amorphous texture, sometimes to be observed in the denuded walls of the cavities of sequestra, when chiselled. At the end of about a year, at the next operation, when the probe no longer detected dead bone, the operator was agreeably surprised to find that this tissue had given place to a comparatively healthy one, with cancellated interior.

Conclusions.

1. This operation is a successful one.
2. Though not a trifling operation, it is not dangerous.
3. In the operative procedure the points deserving attention are, the *incisions*, which should be arranged for the free escape of pus. The *periosteum*, which is not to be detached from the muscles, and which, after incision, is best torn out from the rugous inequalities of the bony extremity, and subsequently attached by suture or not. The excision of at least a quarter of an inch of sound cylindrical *bone*, besides the irregular and tapering end. The *wire*, which should not be twisted too tightly, lest it break out of the bone.
4. The wire may be left in place indefinitely without danger of necrosis; and usually until union has unequivocally taken place; a period of from two to six months.
5. Burrowing pus is to be evacuated, when it approaches the surface, so that the wound will ensure it free and permanent exit.
6. The patient is to be invigorated by such food as he bears, fresh air, and other stimulus if required.
7. The operation may be repeated if it fails, but only after several months' interval.

RECAPITULATION.

Case.	*Bone.*	*Causes of Injury.*	*Duration.*	*Wire remained.*	*Result.*	*Remarks.*
1	Humerus.	Arm caught in a splitting machine.	3 years.	4 mos.	Well.	*Seton; blisters; rubbing ends of bone together; excision of ends of fragments.
2	Radius.	Arm caught in machinery.	4 years.	2 years.	Well.	
3	Humerus.	Arm caught in a hand-car crank.	8 months.	6 mos.	Well.	*Rubbing ends of bone together.
4	Humerus.	Arm caught by a revolving shaft.	1 year.	2 mos.	Well.	
5	Femur.	Crushed by a heavy team.	20 mos.	5½ mos.	Well.	*Blisters; seton; drilling ends of fragments twice.
6	Humerus.	Gun-shot wound.	11 mos.	5 mos.	Well.	
7	Humerus.	Compound fracture.	18 mos.	4½ mos.	Amputation.	Softening of the bone.
8	Humerus.	Arm struck by a falling elevator.	5 mos.	4 mos.	Well.	*Drilling ends of fragments.
9	Humerus.	Crushed by wheel of hand-car.	1 year.	4½ mos.	Well.	
10	Humerus.	Gun-shot wounds.	5 years.		Well.	*Excision of ends of fragments; excision of ends and wiring fragments; two operations by Dr. Bigelow.
11	Humerus.	" " "	2½ years.	4 mos.	Well.	*Excision of ends of fragments.

* Previous operations, which had failed.

The following cases, condensed from the hospital record, are introduced in this connection as evidence upon the question how far the periosteum may be relied on to reproduce bone. In the first of these cases the condyles of the humerus were regenerated so as to afford an excellent attachment for the muscles. In the second, a rhinoplastic operation, no new bone was formed.

CASE XII.—PERIOSTEAL REPRODUCTION OF THE CONDYLES OF THE HUMERUS AFTER EXCISION OF THE ELBOW JOINT.

Sept. 14th, 1857. O. P. F., aged 29, married, clerk. Is a light-haired, unhealthy-looking man. His family are liable to scrofulous affections. Five years ago, while at work hoisting goods, he struck his right elbow a violent blow, causing great pain. The elbow swelled, and he was laid up a fortnight. Since that time, whenever he struck this joint, it would swell up in a similar manner. Last July, a fistulous opening appeared a little outside of the olecranon, and a week or two later a second one broke about two inches below the first. These discharge a thin, purulent fluid. A probe passes under the skin from one opening to the other. No diseased bone is felt.

From this date until March 27th, 1858, the record states that various sinuses formed and were laid open.

March 27th.—Etherized. Dr. Bigelow made an incision over the olecranon, and found in the bone a cavity with carious walls, the size of an almond. The diseased parts were removed by the gouge.

28th.—Very little pain. Doing well.

April 21st.—Abscesses continue to form.

June 19th.—*Operation by Dr. Bigelow.* Patient etherized. Joint opened by a semicircular incision, and the ulnar nerve sought and turned aside. The ends of all the bones were found to be much diseased, and about an inch of the ulna and an inch of the humerus were removed. The head of the radius was also excised. But little blood was lost. No arteries tied. The periosteum being firmly attached to the coral-like surface of the bone, was torn out from the inequalities with strong forceps. Wound brought together by sutures. Flaps riddled by old fistulous openings. Arm placed on an angular splint, with water dressing. Evening.—Very little pain. Skin warm. Pulse 100. No hæmorrhage.

22d.—Edge of wound looks sloughy. Stitches removed. Patient comfortable.

26th.—Pulse good. General condition as good as before operation. Edges of wound have opened and sloughed. Sinuses clean. No pain. Porter.

August 17th.—Wounds closing slowly. Discharge much diminished. Appetite good. Walks out every day.

22d.—Wounds flabby. No dead bone felt. Adhesive straps.

Sept. 5th.—General health is very good. Ulcers have contracted somewhat. Patient advised to go into the country, and is discharged.

Nov. 11th, 1858.—Since leaving the Hospital has been in the country. Has had more or less cough. Looks as well as when last seen. About a month after his discharge, an abscess opened, two inches below head of radius. Now, integument around elbow is red and inflamed. There are five fistulous openings which connect with one another and centre in a cavity formed by the removal of the bones. No dead bone can be felt. The discharge is very slight. No pain. Still keeps on the angular splint. Has made up his mind to have the arm off, and enters for the purpose of operation. House diet. Ale. Poultice.

16th.—Has more or less cough. Cod-liver oil, ʒ ij., thrice daily.

20th.—*Operation.* Patient was etherized, and the arm amputated just above the elbow.

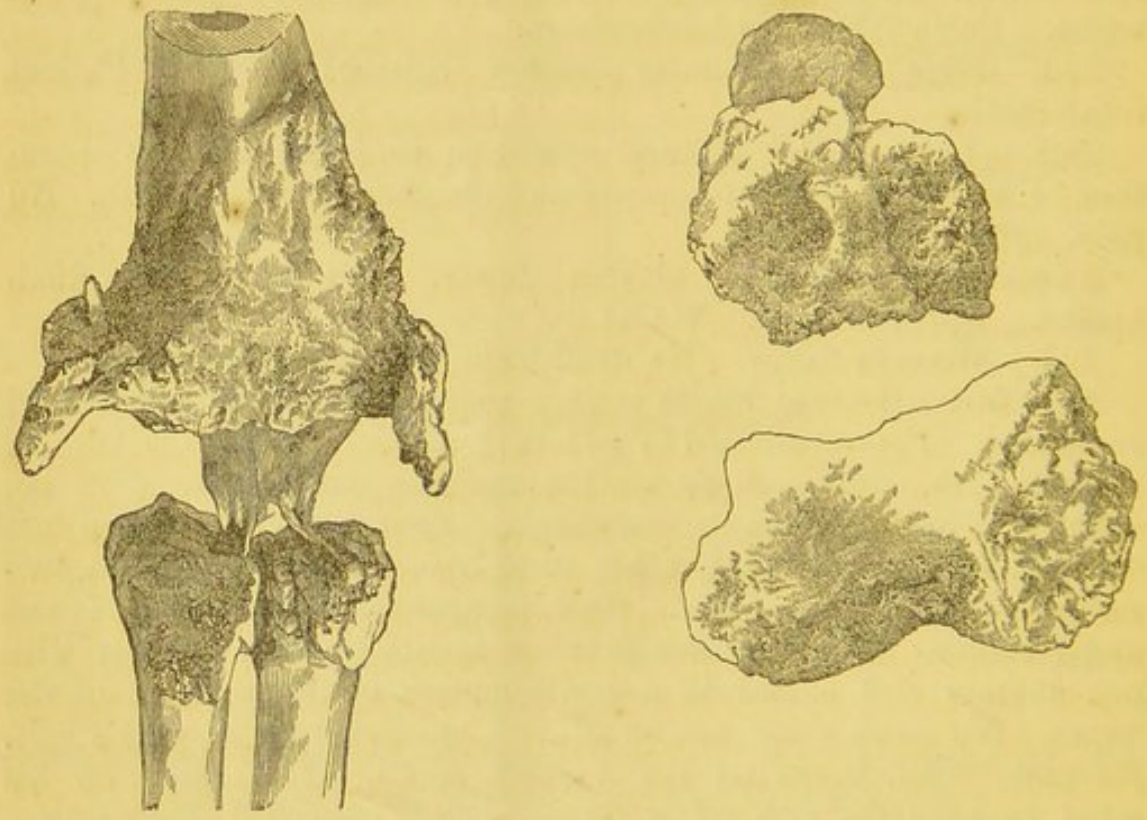
Feb. 28th, 1859.—Discharged, well.

It has lately been ascertained that this patient, who manifested indications of tubercular disease of left lung before his arm was removed, died of phthisis about Dec. 1st, 1859, the disease not having been arrested by the amputation.

The interesting points in this case of excision of the elbow-joint are:—

1. The reproduction of the condyles of the humerus by the periosteum, which was torn from the interstices of the surface of both the original condyles. The horns which were reproduced for the insertion of the extensors and supinators and of the flexors are conical processes, each somewhat more than half an inch in length, and regularly curved forwards and inwards, as seen in the accompanying wood-cut from a photograph of the bone. The rugous surface of the excised condyles is also shown.*

2. The unfavorable issue of this case corroborates what seems to be the fact, viz., that while the elbow is a most favorable joint for resection in cases of recent injury and in healthy subjects, yet when this articulation which is so near the centre of the circulation, and which should therefore be well nourished, and prompt to take on the reparative process, becomes carious from disease, it implies a general feebleness of constitution, which calls rather for amputation than excision.



CASE XIII.—PERIOSTEUM OF THE FOREHEAD TRANSPLANTED IN A RHINOPLASTIC OPERATION. NO NEW BONE FORMED. NECROSIS OF THE EXPOSED SKULL.

Dec. 1st, 1866. A. B., aged 22. This young woman, at the age of ten years, was attacked with scrofulous lupus, which resulted in the destruction of the principal part of the nose, including the bones and as far down as the alæ. A hole of the size of a silver dime, surrounded with cicatricial tissue, exposes the nasal cavity. The

* For a somewhat similar specimen, from the practice of Prof. Syme, of Edinburgh, the reader is referred to the *Lancet*, March 3, 1855.

margin of the alæ remains half an inch wide and retracted into the cavity of the nose, especially upon the right side.

15th.—*Operation by Dr. Bigelow.* The alæ were dissected from their adhesions within the nasal cavity, and being cut square, left a margin a quarter of an inch in width. A flap was taken from the forehead, in the usual way, and brought into place so as to form a nose and unite at its lower margin, with that of the alæ and septum. In dissecting up the flap, the periosteum to which it was attached was carefully removed from the skull, in the hope that it would form a new bridge.

16th.—Wound looking well.

19th.—Every other suture removed.

20th.—Remaining sutures removed.

25th.—It is now evident that the exposed bone is becoming necrosed.

March 2d, 1867.—The margins of the wound upon the forehead have shown little tendency to approximate over the exposed surface of bone, the whole of which is dead, and is becoming gradually elastic and detached from the subjacent tissue. To-day (eleven weeks after the operation), forceps were introduced at the edge of the wound and the entire bony surface lifted off in two fragments, being itself a scale of almost papery thinness, covering a healthy granulating surface.

31st.—Patient was etherized, the pedicle divided, and the eyebrow transplanted to its normal position.

April 30th.—Wound of the forehead completely healed.

May 15th.—No bone can be detected in the new nose.

Remarks.—Having, in four previous instances, had occasion to make an entire new nose from the forehead, and having been on the whole dissatisfied, owing to the tendency of the new nose to flatten, with the want of resemblance in the result of my own efforts to the classical nose usually portrayed in standard works on surgery as the result of the rhinoplastic operation, I determined in this instance to invoke the aid of the periosteum in the formation of a new bridge. This had already been done abroad; with what result, I have not learned. I had, however, been previously deterred from the experiment, in apprehension of the injury to the bone, which has been mentioned as having occurred in the present case. The necrosis of the whole surface of the exposed bone, in connection with the entire absence of osseous formation in the new nose five months after the operation, is not favorable, so far as the evidence of a single case may be relied on, to a repetition of this experiment. It may be added that the cicatrix of the forehead is more than usually pronounced.