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CASES COLLECTED FROM THE LITERATURE.

The following comprise practically all the cases reported Hamilton, in his excellent work upon "Fractures and Dislocations" mentions several cases of separation of the epiphysis of the lower end of the humerus. He cites no personal ones.¹

Case 1.—Dr. Watson's case: Infant of two years, whose arm was violently wrenched by the mother while lifting the child. This case was seen on the fourth day following the injury. The swelling was so great as not to permit of an immediate diagnosis.

On the ninth day, to quote Dr. Watson, "it was apparent that the shaft of the humerus had been separated from the cartilaginous expansion at the condyles near the elbow." The fracture was reduced and good position maintained by means of angular splints of pasteboard. Union was brought about at the end of six weeks; no mention is made of the result as regards mobility of the joint.²

Case 2.—Dr. Reeve of Dayton, Ohio, sent Hamilton a specimen of epiphyseal separation occurring in his practice in 1864. The patient was a girl of ten years, who fell ten feet, striking probably upon the elbow. The result was a compound fracture which, at the end of three weeks, necessitated amputation. A small fragment of the shaft of the humerus was taken away with the epiphysis. The specimen in this case shows that the separation was above the epicondyles, closely following the epiphyseal line. Hamilton has a picture of this specimen on p. 290 of his work.

Case 3.—Drs. Little, Voss, and Buck have reported a similar case.³

Case 4.—Lange reported a similar case. In his case the epiphysis was removed from the wound and a portion of the shaft excised. The final result was a useful arm.⁴

Case 5.—Champion in 1818 reported a case of a boy of 13 whose epiphysis was torn away by his arm being caught in machinery. Amputation was necessary.⁵

Case 6.—Mr. Hutchinson, Senior, describes a case in which the fragment projected and was excised. The patient recovered with a stiff elbow.⁶ He also has seen "half a dozen recent examples of this form of injury; twice as many old ones in which advice was sought in consequence of the awkward deformity which often follows it." All these were backward displacements.

Cases 6, 6¹, 6².—Only one or two other cases similar to his were described by other surgeons about the same time. In these it was found that the epiphyseal line had been followed fairly well.

Case 7.—Clark reported a case, twelve years of age, in which death from gangrene occurred, due to tight bandaging. In his case the detached epiphysis did not include the epicondyles.⁷

Case 8.—Specimen in museum of Bellevue Hospital. This specimen shows the bones of the forearm of a child with cartilage detached which seems to be the lower epiphysis of the humerus. The history of the case is wanting.⁸

Case 9.—Hutchinson, Jr., had a case aged two years. Died

from croup fifteen days after the accident. The specimen from this case is in the Royal College of Surgeons' Museum. It shows that the line of separation follows the epiphyseal disc only half way diverging for the other half into the diaphysis.⁹

Case 10.—Hutchinson, Jr., child aged 13. Primary amputation. The detachment followed the epiphyseal line exactly except at the extreme external part.

Cases 11 to 35 Inclusive.—Were simple cases, in six the result, as regards deformity and elbow movements, was perfect. In eight a certain amount of limitation of motion, usually about twenty degrees, was present. In only one case was rotation affected. These cases were reported by Hutchinson, Jr.

Cases 36 to 41 Inclusive.—Compound-separation cases reported by Hutchinson, Jr., in which the diaphysis was reduced more or less perfectly.

Results.—No. 36 recovered with an almost perfect arm. No. 37 with thrombosis of the brachial. No. 38 (Volkmann's (?)) recovered with paralysis of musculo-spiral but with good movements of the elbow. Nos. 39, 40, and 41 suffered amputation.

Cases 42, 43, and 44.—Compound-fracture cases reported by Hutchinson in which excision of the joint, more or less complete, was done.

Results.—No. 42 recovered with fairly good movement. No. 43, with a stiff joint. No. 44, with a fairly movable joint.

Cases 45 to 50 Inclusive.—Compound cases reported by Hutchinson in which the projecting end of the diaphysis was excised to facilitate reduction.

Results.—Nos. 45, 46, 47, and 48 ended "satisfactorily." No. 49 recovered with a stiff elbow. No. 50, underwent amputation within three weeks because of non-union. (Hutchinson is not responsible for this case.)

Case 51.—Reported by Hutchinson. Wright's case. Pulsation in the radial ceased on the eleventh day owing to pressure of the brachial between an anterior splint and exuberant callus. Case recovered but with persistent backward displacement of the epiphysis.

Cases 52 to 58 Inclusive.—Complicated cases mentioned by Hutchinson.

Cases 59 to 64 Inclusive.—Five cases of old separation of the epiphysis. Cases No. 59 and 60 were operated upon by Bardenhauer. Part of the diaphysis was removed. There was great improvement.

Case 65.—W. McAdam Eccles: Boy of ten years fell from a swing, alighting on his right hand. Elbow was painful. Medical advice not sought until some time had elapsed. No splint applied. At the end of three weeks elbow stiff and swollen. Right arm in position of flexion. Not able to extend it voluntarily. Full flexion could be satisfactorily accomplished. The biceps was kept contracted. Forearm somewhat pronated. Supination impossible to be completely accomplished without pain. Examination under ether showed flexion to be free. Extension could be forcibly accomplished. Crepitus about the joint. Other movements nearly normal. Dimple over the tip of the olecranon. Bony prominences bore their normal relationship to one another, but appeared to be on a plane anterior to the shaft of the humerus. Measurement of the arm negative. Some apparent increase in the length of the forearm. Skiagraphs of both elbow-joints show dimple mentioned above; also that the breadth of the limb in the region of the elbow was distinctly increased. This, without any local swelling. The ossific centers of the epiphysis were displaced distinctly forward. Result, good movements.

Case 66.—Russell Fowler. (Here first reported.) M. P., female, aged 9 years, was seen by Dr. Callender, then ambulance-surgeon to the Brooklyn Hospital, at her home on the afternoon of April 9, 1898. Two hours previous to his visit she had fallen from a chair to the floor striking upon the palm of the hand. There was present considerable swelling. The arm was within twenty-five degrees of complete extension. Disability was complete as regards the elbow-joint. The wrist and fingers could be moved. There was fulness in front of the elbow. The relation of the epicondyles to the olecranon was normal. The long axis of the forearm seemed to be pushed forward. Neither the trochlea surface nor the capitellum could be felt. Arm could be fully extended but could not be completely flexed. There was very little crepitus and this was difficult to produce. Reduction was readily effected but as readily recurred. It was accomplished by slight extension and direct pressure upward and backward of the small mass in the bend of the elbow. The arm was put up in extension with anterior and posterior splints and two compresses, one posterior and one anterior, to the joint. The patient was referred by Dr. Callender to my clinic at the Brooklyn Hospital Dispensary. She reported next day and as she was free from pain and the dressing seemed undisturbed the verification of the diagnosis was left to a later date. On the following day she returned, and

as there were considerable pain and swelling then present the dressing was removed and the arm put up in a comfortable position. I saw her for the second time on the 12th. The arm was semi-flexed, enveloped in opium and lead compresses, and supported by a sling. There was absence of pain and the fingers and wrist could be voluntarily moved. What struck me most forcibly on inspection was the broadening of the joint and the fulness in front of the elbow. The joint itself was swollen and the tissues around it somewhat so. The skin was reddened and somewhat discolored. There was pain on pressure. Passive movement of the joint caused pain which was greatest on extension. There was no apparent spasm of the triceps tendon but spasm of the biceps tendon was marked. The antero-posterior measurement of the joint was increased markedly as compared with the unaffected joint. On extension the long axis of the forearm was in a plane anterior to that of the humerus. The relation between the olecranon and the epicondyle was normal. No trochlea surface nor capitellum was evident. There was no interference with the nerve-supply of the muscles of the forearm nor was there any anesthesia present. The broadened lower extremity of the humerus was in the same plane as the shaft of the bone. The fulness in front of the elbow could be felt to be bony and of a fairly straight outline directly in the line of the joint. It could be reduced with the forearm extended but reduction was painful and immediately recurred. Pronation and supination could not be voluntarily accomplished. Crepitus was difficult to elicit and when elicited was not true bony crepitus, but softer in character. There was no depression present above the olecranon. The radial pulse was of equal volume in each wrist. The previous history of the case as regards causation was the same as described by Dr. Callender. Posterior dislocation of the joint was ruled out from the above history as was also supra-condyloid fracture of the humerus. Posterior displacement of the fragment in an epiphyseal separation could be readily ruled out by the absence of spasm of the triceps and the presence of the fragment anteriorly extending all the way across the joint, and the forward position of the long axis of the forearm in extension. Knowing the rarity of this separation of this epiphysis, and particularly the forward displacement of it, I was exceedingly careful in my examination of the case. As before stated reduction while readily accomplished was difficult to maintain in the extended position, so the fragment was

reduced in extension and while the fingers of the left hand held it in place the forearm was carefully flexed and a compress substituted for the fingers in the bend of the elbow-joint. Lead and opium compresses surrounded the parts. Cotton was applied and a basket-splint of wire was fitted on and held in place by bandages. I saw the case on the 16th and reapplied the dressing. There was more swelling present on this occasion and the case was told to report in two days. On the 20th the case reported at the hospital and was admitted to the service of Dr. George Ryerson Fowler. There was considerable swelling in and around the joint. Pulsation of the radial was imperceptible when the case was first admitted and the entire forearm was cold and pale. There was some doubt as to our ability to save the arm. Dressing was removed, the child put to bed, warm cotton was applied to the entire extremity, and the arm laid upon a pillow and surrounded with hot-water bottles. Luckily the pulsation in the radial returned and the arm became warmer. The position of the fragment could not then be determined on account of the swelling. Some few days later the child was anesthetized. The position of the epiphysis was fairly good. Considerable callus was present. It was evident that this exuberant callus in conjunction with the swelling of the parts had pressed the brachial artery against the dressing and so compressed it. The arm was put up at a little less than a right-angle. The patient remained in the hospital until May 22nd. At the time of discharge the position of the epiphysis was fair, there was still rather abundant callus, the joint was capable of slight motion which gave promise of increase. I subsequently saw her once more. There was increased motion and less callus. She had been using the arm, as advised, and had experienced no ill effects. The entire arm had regained almost all its strength.

Case 67.—Case in the service of Dr. George Ryerson Fowler. (Here first reported.) V. S., a schoolboy, 11 years. Admitted to Brooklyn Hospital, March 19, 1898. Fell from a bicycle and sustained a compound fracture of left elbow, with musculo-spiral paralysis. Examination with the finger through the open wound disclosed a separation of the lower epiphysis of the humerus with its backward displacement. The end of the diaphysis projected externally one inch above the depression in anterior surface of elbow. Deformity was reduced. Iodoform-gauze drainage. Wet dressing. Arm put up in right-angled splint. Rapid healing. Musculo-spiral paralysis subsequently treated by neurorrhaphy after Bruns' method, April 28, 1898.¹⁹ The nerve was freed from

callus, fibrous cicatricial tissue split longitudinally beyond the limits of the cicatricial mass uniting the divided ends, and sewn together angle to angle with split kangaroo tendon. Plaster-of-Paris right-angled cast. Eleven months after function of nerve was restored. Movements of elbow good.

Anatomy.—The lower epiphysis of the humerus includes both epicondyles, the epiphyseal line being a fairly straight one and crossing the bone just above the two epicondyles. Directly over it lies the olecranon fossa. The epiphysis has at first five separate centers of ossification. These are subsequently reduced to three. The ossification in the capitellum is said to begin during the third year. Hutchinson has found it at eighteen months and Farabeuf says that it usually occurs during the second year. The width of the epiphysis increases during the first few years. The depth increases slightly. The nucleus over the internal epicondyle appears in the fifth year. The third nucleus over the trochlea appears in the eleventh or twelfth year. A small separate nucleus appears over the external epicondyle. Fusion with the shaft is completed in the sixteenth or seventeenth year. The epiphysis grows relatively smaller as the individual advances in years. The widening of the epiphysis causes it to become more distant from the olecranon fossa. From this brief account of the anatomy it will be readily seen that the time for separation must be before fusion with the shaft takes place, that is before the sixteenth or seventeenth year at the latest, and also that it is far more likely to occur before the twelfth year. Separation with the epicondyles still attached to the humerus must necessarily occur before fusion with the trochlea and epicondyles takes place, that is before the thirteenth year (Clark's case). It is evident that as the epiphysis is so closely associated with the joint, injury to it must be injury to the joint also. The above may be called predisposing causes. The exciting causes are severe wrenching of the arm, as by some person lifting a patient (example Case No. 1), or machinery accidents in which there is great wrenching (No. 5); falling upon the posterior part of the palm of the hand with the forearm either wholly or partially extended (so in the majority of cases); falling upon the elbow (Case No. 2).

Varieties of Separation.—In determining this we must form our conclusions exclusively from those cases resulting in necropsies, operations, either amputations or excisions, cases of compound fractures not operated on which admitted of direct examination, and from those in which X-ray pictures have been taken.

As in the etiology here also, account must be taken of the anatomy and development of the part at various ages. From the comparatively few cases reported it is exceedingly difficult to draw a definite conclusion. From the accompanying cases it is seen that there are three forms of separation; that in which the separation follows fairly closely the epiphyseal line, that in which it follows the line in part only and diverges into the diaphysis, and that in which there is separation without including the epicondyles. The cases from which we are to decide this point are Nos. 2, 3, 4, 5, 6, 6¹, 6², 7, 8, 9, 10, 36 to 58 inclusive, 65 and 67. These fulfil the conditions as they are cases in which autopsies, operations, or compound fractures occurred, or in which an X-ray picture was taken. As complete a history as is to be obtained will be found in the list accompanying this paper where due credit is given to each reporter. Of these, fifteen compound cases were under the direct observation of Mr. Hutchinson, Jr. He remarks that clean separation occurred only in the minority of his cases. These cases are Nos. 36 to 50 inclusive. Of the remaining cases we can throw out those compound fractures without direct evidence as to separation, *i. e.*, Nos. 51 to 58 inclusive. This brings the number of cases available for our conclusions in regard to this point down to eleven. Of these one (No. 7) did not include the epicondyles. This disposes of the third class of separation. Of the second class, those following the epiphyseal line for a part only and diverging into the diaphysis, we have two examples, Nos. 8 and 9. Of the first class, and these are fairly authentic cases, we have nine examples, Nos. 2, 3, 4, 5, 6, 6¹, 6², 8, 65, and 67. This shows that the epiphyseal line is followed fairly well in the majority of cases.

Displacement of the Epiphysis.—This may take place in three directions irrespective of the tilting of the fragment, *i. e.*, backward, forward, or laterally. Backward displacements comprise the majority of the cases. In all of Hutchinson's personal cases forward displacement was well marked but once. Eccles has lately reported one case (No. 65). In all of the elder Hutchinson's cases the displacement was backward. Some cases of lateral displacements are mentioned by Hutchinson, Jr., and probably some of the cases mentioned elsewhere in the list had this deformity. The author has seen one case (No. 66) in which the displacement was markedly forward. We may safely conclude that the very great majority of cases are displaced backward; that independent of this, or associated with it, there may be lateral dis-

placement; and finally, that anterior displacement is extremely rare. The three cases mentioned are all that are to be found in literature.

Diagnosis.—The elbow is slightly flexed and the forearm is supported by the hand of the uninjured side. The forearm is midway between pronation and supination and the arm is helpless. The deformity is marked in some cases, not so prominent in others. There is backward tilting of the epiphysis or its complete backward displacement. The latter resembles a posterior dislocation and undoubtedly has frequently been mistaken for it. This backward displacement is due to the indirect force applied through the forearm, as in a fall upon the hand with the forearm extended on the arm, and its continuance is due to the action of the triceps. The fact that there is no outline of the trochlea and capitellum in posterior displacement is of use in diagnosing the condition from posterior dislocation. In case no deformity is present, pressure just above the line of the joint will develop slight crepitus and a characteristic give. Lateral displacement, either external or internal, may be present and is due to direct violence. Forward displacement is rare and its diagnosis will be elaborated in connection with the case reported. The antero-posterior diameter is increased. The olecranon is more prominent posteriorly. The tendinous insertion of the triceps into the olecranon is plainly perceptible. There is slight shortening of the arm. The displacement is easily reduced and readily recurs. The relation of condyles and the olecranon is normal; that is in flexion, a line drawn from one epicondyle to the other in a vertical plane crosses the tip of the olecranon, and in extension a line drawn in an horizontal plane also touches the tip of the olecranon. Crepitus is present. Its character is soft as of two cartilaginous surfaces rubbing upon each other. It is not easily elicited. Lateral movements are difficult to elicit. There is considerable mobility of the joint. Extension increases the deformity; flexion decreases the deformity. Separation of the epiphysis occurs most commonly before the seventeenth year. It is rare in adults. Dislocations occur most frequently between the fifth and fifteenth year, and it is this fact that has led some observers to state that separation of the epiphysis is a frequent complication of posterior dislocations.

The diagnosis lies between posterior dislocation of the elbow, supra-condyloid fracture of the humerus, and separation of the epiphysis. Posterior dislocation can be readily ruled out as the

normal relationship exists between the olecranon and the epicondyles. Anterior dislocation or other forms of dislocation at the joint could hardly be mistaken for separation as the presence and position of the capitellum and trochlea surface would decide. The most difficult diagnosis is between separation and supracondyloid fracture. They have many symptoms in common. The direct cause is often the same. Wrenching would point in favor of separation. The age of the patient would be of use, the younger the case the more liability to separation in place of fracture with the same amount of indirect force. Separation is nearer the transverse line of the joint, in fact is in the line, while fracture is above it. The position of the arm is about the same but the prominence in the elbow is more marked in fracture than in separation; in fracture, occupying a position above the transverse line of the joint and in the center of the long axis of the extremity, while in separation it is in the transverse line of the joint and extends completely across it either posteriorly or anteriorly. The character of the crepitus differs materially. In separation it is difficult to elicit and soft in character while in fracture it is easily elicited and distinctly bony. The differential diagnosis between anterior and posterior displacement of the separation is to be made by the presence of the fragment in a line anterior to the long axis of the upper arm, the absence of spasm of the triceps tendon, the impossibility of palpating the fragment posteriorly, and the low degree to which the arm can be flexed.

Complications.—Rapid effusion into the joint and swelling around it.¹⁰ Exuberant formation of callus causing pressure on the brachial artery or injury to neighboring nerves. This injury may result in the case of the artery in gangrene if not rectified early. The symptoms are greatly weakened or absent pulsations of the radial artery at the wrist, increasing coldness of the extremity below the point of fracture, and a gradual increasing sense of numbness and heaviness. Hutchinson reports a case in which pulsation at the wrist was stopped by projection forward of the diaphysis and there were also marked signs of pressure on the median nerve. Reduction caused these symptoms to disappear and as a final result union was perfect and the motions of the elbow excellent, except that flexion was limited to ninety degrees. Hutchinson also mentions a case recorded by Wright, in which on the eleventh day radial pulsation ceased due to pressure of the brachial between exuberant callus and an anterior splint. The final result in this case was recovery, but with persistent back-

ward displacement of the epiphysis. Also a case that recovered with thrombosis of the brachial artery (No. 37.). The nerves in the neighborhood may suffer as a result of pressure of the callus. According to the nerve involved there may be symptoms of interference with the function of the radial, the median, or the ulnar, and in case of very excessive callus formation as sometimes happens when the reduction is imperfect, the musculo-spiral nerve may be affected. Cases illustrating each of these conditions have been reported. Hamilton records one case aged four in which deformity resulted and numbness over the ulnar area lasted into adult life. Another case operated on by Hamilton for forward projection of the diaphysis, complete loss of pronation and supination, persistent flexion of the wrist and fingers and paralysis of both median and ulnar nerves, the latter, having been displaced in front of the elbow, was replaced at the operation and some bone was chiseled away. Hutchinson remarks that the operation does not seem to have been a thorough one. No improvement followed. To the author's mind in view of the history of the case, it would seem that there was present paralysis of the musculo-spiral in addition to possible injury of the median and ulnar. Volkmann has recorded a case of compound separation. The protruding diaphysis was reduced and the result, as far as movement was concerned, was good but there resulted permanent paralysis of the musculo-spiral. In the author's own case there was absence of pulsation in the radial artery some days after the injury due to exuberant callus, swelling, and a recurrence of the deformity.

Compound Separation.—(1) May be primarily the result of the injury or secondarily the result of pressure of the fragments on the soft parts. This was present in fifteen of Hutchinson's cases. Among other cases on our list we find nine authentic cases of compound separation, making a total of twenty-five cases. Of these cases all but three were operated on.

Other Complications.—But one died of intercurrent disease. (Case 9.)

Prognosis.—As regards life, the prognosis in simple uncomplicated separations is excellent. They do not die as a result of the separation. In complicated cases the prognosis as regards life should be good. There were but two deaths in this series, one from croup (Case No. 9), the other from a tightly fitting bandage (Case No. 7). As regards a useful elbow the prognosis is not so good.

Hutchinson seems to have had the best results.

Amputation was necessitated in eight cases and done in a ninth without necessity (Nos. 2, 3, 5, 8, 10, 39, 40, 41, and 50). Excision, complete or partial, was done in twelve cases (Nos. 4, 6, 6¹, 6², 42 to 49, inclusive, also 50, which was subsequently amputated). Reduction without excision in four cases (Nos. 36, 37, 38, and 67). Out of sixty-seven cases, the result is not mentioned in twenty-three, stiff joint is mentioned in six cases, good movement in twenty-two cases, and a practically perfect result in six cases. Nine suffered amputation and one died from croup as before mentioned. Probably a little less than 50 per cent. recover with good movement.

Treatment.—Flexion is the position which is best suited to keeping the displacement reduced, while the fragment is to be reduced by slight traction in the extended position and direct manipulation over the epiphysis. A dressing which will immobilize the whole arm is to be recommended but pressure should be exerted over no portion of the elbow. A pad in the elbow with an acute-angled posterior splint of wire is best. The dressing should be frequently examined in view of the possible complications. The case should be under observation for from five to six weeks. Accompanying paralyses are best left until the callus has ceased forming. There are no special indications in the treatment other than the flexion of the forearm on the arm. Massage and passive motion should not be begun before the third week.

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