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Traumatic Separation of the Lower Epiphysis of the Femur.

By JOHN H. PACKARD, M.D.,
Surgeon to the Pennsylvania Hospital and to St. Joseph's Hospital, Philadelphia.

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Traumatic Separation of the Lower Epiphysis of the Femur.

BY JOHN H. PACKARD, M.D.,

Surgeon to the Pennsylvania Hospital and to St. Joseph's Hospital, Philadelphia.

SEPARATIONS of the epiphyses are mentioned briefly by most surgical writers, with the statement that they are practically undistinguishable from fractures in the neighborhood of joints. To this, however, there is certainly one notable exception in the case of the largest of the epiphyses, that at the lower end of the femur. Upon this particular lesion a valuable and elaborate paper was published in 1884, by Delens, giving a case of his own, and quoting at more or less length twenty-seven others. But in fact there are now over sixty cases on record in which detachment of this portion of the growing bone is claimed to have occurred. With regard to some of these, indeed, the details given are insufficient; while in others there is ground for questioning the accuracy of the diagnosis, and in still others one can only pronounce the Scotch verdict of "not proven." Absolute certainty can scarcely be arrived at in this matter except where the injury is compound and the bone exposed, or where by amputation of the limb or the death of the patient an opportunity is afforded of dissecting the parts.

A case of my own may serve as an apt illustration:

Owen McK., aged 9, was admitted to St. Joseph's Hospital April 16, 1889, having had his right leg caught in the wheel of a wagon behind which he was clinging. From the appear-

ance of the anterior face of the limb, a hasty observer might have suspected a forward luxation of the knee; but upon examination the true nature of the lesion was at once apparent. At the lower and back part of the thigh there was a large wound, through which protruded the end of the shaft of the femur, bare of periosteum; the condyles were still partly in contact with the tibia, but the whole epiphysis was rotated so that its articular face looked forward (upward as the boy lay on his back), and the upper cup-shaped surface backward. This was due to traction by the two heads of the gastrocnemius muscle. Ether was given, and a careful examination showed that although there was great bruising and laceration of the soft parts, the vessels had not been torn, but with the nerve had slipped aside around the end of the diaphysis; they were, however, sharply stretched, and the blood in the artery was coagulated. Reduction of the protruding bone was found to be impossible, and an attempt to save the limb by resection seemed to be attended with so much risk, in view of the damage to the soft parts, that amputation was decided upon. The operation was done just below the middle of the thigh, and the boy made an excellent recovery.

Upon dissection it was found that the epiphysis had been almost cleanly separated; entirely so but for a very small splinter detached from the end of the diaphysis at the inner side. The skeleton of the removed limb is in the Museum of the Pennsylvania Hospital.

Dr. R. H. Harte informs me that he has in his wards at the Episcopal Hospital, in this city, a case very similar to the one now detailed. The patient, a boy about 14 years old, had his leg caught in the wheel of a carriage behind which he was clinging, and the lower epiphysis of the femur was cleanly separated, carrying with it the ossifying cartilage. The denuded shaft projected through the large wound. So great was the violence that the leg was torn off below the knee; and there was no rotation of the epiphysis such as existed in my case, perhaps because the lower connection of the gastrocnemius was severed.

Primary amputation was performed, and the boy is doing well.

In these instances, as in the twenty-four other cases in which the cause of the lesion was the entanglement of the limb in a moving wheel, the mechanism would seem clearly to have been chiefly an over-extension of the knee; along with this there was probably some lateral stress, and a certain degree also of twisting of the leg upon the thigh. Under such circumstances the ossifying cartilage between the diaphysis and the epiphysis breaks away, and the latter is stripped or peeled off from the former. In fact, this is a genuine avulsion of the thin cap of bone which constitutes the epiphysis, and differs materially from the supra-condyloid fracture of the femur sometimes met with in adults. This difference extends also, as will be presently shown, to the clinical history of the two forms of injury. No other epiphysis in the body is situated at such a disadvantage, in the leverage afforded by the leg, in the strong ligamentous connections with the tibia, and in the

width and thinness of the layer which is attached to the shaft through the medium of the ossifying cartilage.

Other forms of indirect violence have been known to produce this lesion, by a mechanism apparently the same. Thus in two instances the leg was caught in a cable, and in seven in machinery; in five the detachment took place as the result of surgical procedures, as for the forcible correction of anchylosis or deformities;[1] in three the patients fell while running, and in one a boy was precipitated from a height of eighty feet; in one the leg was caught between two beams, and in another it sank into a hole in the ground as far as the knee; finally, in one case a boy was playing leap-frog, and alighted on his feet with his feet widely separated.

Dr. W. B. Hopkins kindly permits me to mention here a curious case which came under his care some years ago. A girl aged 16 had bony anchylosis of one knee, at a right angle; she had a fall, and the lower epiphysis of the femur was separated from the shaft; under ether the limb was straightened and put up in plaster of Paris, and an excellent result was ultimately obtained.

Direct violence is said to have caused this injury in two cases by forcible contact with resisting bodies; in one by the fall of a mass of rope against the knee, and in one by the kick of a horse; in one the accident is described as a "colliery crush," and in four the little patients were run over by vehicles. Some of these cases would probably find a more appropriate place in the category of supra-condyloid fractures.

In eight of the reported cases no details are given as to the mode in which the injury was sustained. In one instance, which has by frequent quotation become classical, this lesion occurred during birth, by traction on the leg of a child. But as the child was dead, and putrefaction had already set in,[2] the case cannot fairly be regarded as one of traumatic separation.

The compound character of the lesion, which is distinctly mentioned as regards thirty-one of the cases in which details are given, may be ascribed either to the excessive tension of the skin, or to the outward thrust of the extremity of the diaphysis, or to both these conditions combined. And it may be noted that the amount of violence in all these cases was very great. Where it was less, as when the lesion was due to a mere fall, or occurred as an accident during surgical procedures, the damage to the soft parts was by no means so serious.

In very many of the cases of this injury there is found attached to one portion of the epiphysis a splinter of the shaft. Sometimes this has been of considerable size; in my own case it was extremely small. My belief is that such a splinter is always at the side of the epiphysis at which the rending terminates; and it does not seem to me to alter the essential character of the lesion.

The separation begins at and mainly

[1] Volkmann says: "I have three times seen separation of the lower epiphysis of the femur produced in cases of chronic inflammation of the hip-joint in children by very gentle force, as in handling the limb for the application of a plaster-bandage, or in the attempt to elicit crepitation in the hip-joint."

[2] "Mais, altéré par la putrefaction, le membre inférieur céda à mes tractions, le genou s'allongea, et les épiphyses se détachèrent du tibia et du fémur."—Mad. La Chapelle. *Pratique des Accouchemens*, tome ii, p. 225.

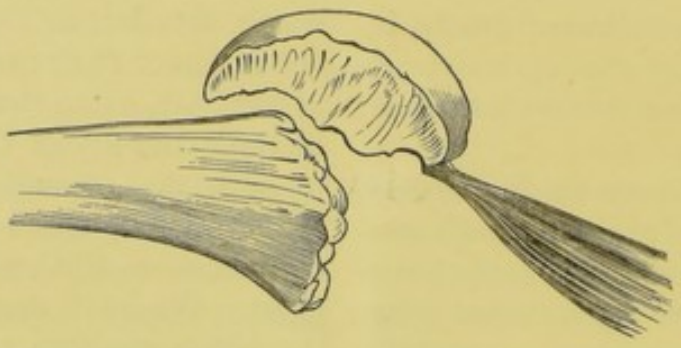
follows the upper surface of the conjoining cartilage, and the breaking off of a small portion of the diaphysis is a mere incident.

In Rougon's case, reported by Dolbeau, it is expressly stated that there were no bony splinters. Here the injury was the result of direct violence, a mass of rope striking the boy on the lower part of the thigh.

Bryant[1] gives a cut representing a museum specimen, in which the whole epiphysis is cleanly separated from the shaft; but nothing is said of the character of the case, or of the mode in which the disjunction was brought about. Holmes[2] speaks of four specimens in the Museum of St. George's Hospital, two of them being separations mainly following the epiphysial line, but detaching also splinters of the shaft, and the other two being separations in which the two condylar portions are broken apart. No histories are given, so that these specimens also lack the value which they might otherwise have.

In one instance, reported by Richet, it is stated that the ossifying cartilage was adherent to the protruding end of the diaphysis.

A very marked feature of this injury, noted in a large number of the cases, and probably present in all, is the stripping of the periosteum from the diaphysis. The explanation of this is to be found in the sudden projection downward of the end of the diaphysis, by which a sort of buttonhole is burst open in the periosteum, and through this the bone is forced, just as it is later through the skin. How far it may protrude is determined perhaps partly by the direction, and partly by the degree of the violence exerted upon the limb. In one instance, reported by Broca, the bone was bared as far up as the trochanters. It should be remembered that in early life the connection between the bone and its investing membrane is looser and more easily severed than in adult age. In one of Hutchinson's cases, it is stated that the periosteum formed at the posterior part of the epiphysis a fold which interfered with reduction. In the cases in which reduction has been effected, or in which the limb has been saved by resection of the diaphysis, it would appear that the periosteum closes in again upon



Tilting of epiphyseal fragment by gastrocnemius (p. 115). The patella is left out in order to avoid complexity.

[1] Manual for the Practice of Surgery. 2d Am. ed., p. 804.

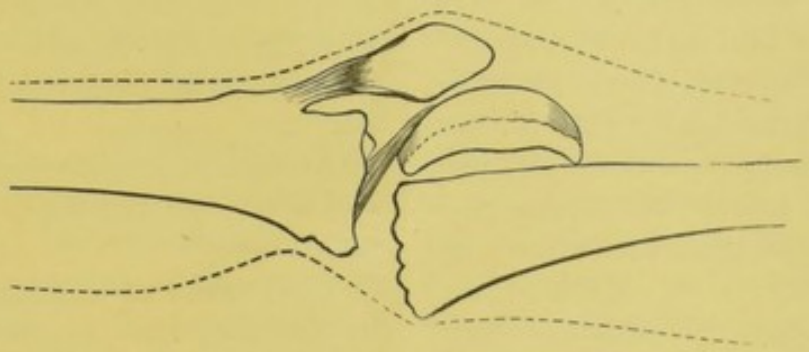
[2] Surgical Treatment of the Diseases of Infancy and Childhood. 1868, p. 258.

the bone, and that no permanent harm is done by the temporary separation.

The tilting of the epiphysis by the traction of the gastrocnemius, very noticeable in my case, has been observed also by Fontenelle, Liston, Hutchinson, Verneuil, Broca, Wheelhouse and Little. The fibrous structures of the knee would, of course, undergo much stretching, and probably the crucial ligaments have been sometimes torn away, but accurate observations on these points are wanting. In one case, Atkinson's, the epiphysial fragment is said to have been displaced anteriorly on to the anterior tibial artery was torn open, and in another, related by Dr. Willis S. Davison, of Pennsylvania, the popliteal vessels were ruptured."

In a case of Verneuil's, the end of the diaphysis had severed the artery and vein, but the nerve had slipped round to its outer side.

Gangrene has several times ensued from the pressure of the end of the diaphysial fragment against the vessels. Wheelhouse[3] says: "I have seen the popliteal artery and vein both cut across by a sharp sequestrum in making its way to the surface."



This cut shows diagrammatically the relations of the femur with its detached epiphysis to the patella and tibia. The dotted line shows the skin, which is tense and on the point of rupture by the end of the diaphysis thrust against it.

the shaft of the femur, and to have become firmly attached there by bony callus.

In a somewhat doubtful case recorded by Quain, and in one figured by Holthouse,[1] the epiphysial fragment has itself been broken in the middle, each condyle constituting a separate portion.

The condition of the vessels and nerve has varied considerably in different cases. Sometimes merely stretched, they have been in other instances, as in my own, slipped aside; in others again they have been ruptured. Gross[2] says that "in one case

Little says of a case treated by McBurney, that "the internal popliteal nerve was so stretched, the pain so intense, and the deformity so great, that amputation was resorted to. The case was of two or three months' standing, and strong bony union had taken place. The patient died of tetanus."

Damage to the knee-joint has been observed in a number of cases, but much more rarely than might *à priori* be supposed. It would seem sometimes to have occurred as a secondary consequence, as in a case reported by Adams, and in one by Liston. Total

[1] Holmes' System of Surgery, vol. i.
[2] System of Surgery. Ed. 1882, vol. i, p. 1019.
[3] Lecture on the Surgery of the Epiphyses. *Brit. Med. Journal*, March 7, 1885.

resection of the knee has been done in a few instances.

As to the age of the patients, the average of forty-five in which it is stated was a little over 7 years. The youngest was 18 months, and the oldest 18 years.

With regard to sex, there are nine cases in which the subjects are stated to have been girls; and of these, strangely enough, three sustained their injuries by entanglement in the wheels of wagons behind which they were clinging.

The symptoms usually attending this lesion have perhaps been sufficiently set forth, and a few words only need be said as to its diagnosis. There are but two forms of injury likely to be confounded with it: fracture of the femur low down and luxation of the knee. But fractures in this part of the bone, rare at any age, are especially so in children; they should present the ordinary rough grating of broken bone instead of a soft crepitus caused by contact of the rounded end of the shaft with the epiphysial fragment or with the head of the tibia. Of course, if there be a considerable piece of the shaft broken off along with the epiphysis, there may be grating also; but then the two conditions would be combined, and it would be an unimportant question between them. Reduction is, judging from the limited records of such fractures in children, as well as from experience in adult cases, a matter of no great difficulty; whereas in epiphysial separations it has often been found impossible, and always troublesome, either to effect it or to maintain it.

Luxations of the knee, except as the result of disease, are even more rare in early life than the fractures just referred to. In the very few reliable instances on record, the separation of the joint surfaces was not complete. But in my own case, as in one reported by Holthouse, the idea of luxation was at first suggested by the distortion of the limb. Such a mistake could not, of course, fail to be corrected, when the epiphysial disjunction is compound, upon examination; when it is simple, the abnormal mobility would serve to distinguish it from dislocation, in which the movements of the leg upon the thigh are restricted in a marked degree. Yet in non-compound cases swelling is apt to occur very rapidly, and obscures everything; as in an instance reported by Atkinson, in which twenty-five days elapsed before the outline of the limb could be defined.

The gravity of this injury is shown by the fact that in twenty-eight of the cases amputation was performed. In twelve it was primary, in nine secondary, in five it was done at a very late period, and in two the time is not stated.

Resection of the end of the shaft was resorted to in six cases, in four of which complete success ensued, in one the result was doubtful at the time the patient left the hospital, and in one it is not stated.

Resection of the knee-joint was done in two cases, in both of which amputation was afterward performed, although in one the reason for this course does not clearly appear; in the other the limb had been accidentally refractured.

Reduction was accomplished in fourteen cases, successfully except in an instance reported by Richet, in

which the patient died of purulent infection on the fifteenth day. One boy recovered with a stiff knee; two had good motion; of seven it is merely said that they did well, or had useful limbs, while in two it is only stated that consolidation occurred.

Amputation was demanded in the primary cases either by destruction of the limb or by damage to the bloodvessels. The secondary operations were performed for hæmorrhage, for abscess and for gangrene. Of the late operations, one was required on account of great stretching of the nerve, one for aneurism, one for abscess involving the knee-joint, one at the request of the patient after resection, and one for fracture after resection.

In three cases no operation is recorded, and the patients all died; in one the knee-joint suppurated, in another it was opened at the time of the accident and a fracture extended up the shaft, while in the third other very severe injuries had been sustained.

Concerning nine cases, we have mere mention without detail, so that but for completeness they might be set aside altogether.

As to the questionable cases: One, reported by Trélat, was only seen by him three years after the injury, the girl being then 18 years old. Another, by Quain, is said to have been a compound fracture through the external condyle, with simple fracture of the lower third of the femur; it occurred in a boy about 11 years of age by the entanglement of the leg in a wheel, but there is no evidence of genuine avulsion of the epiphysis. Turgis says that in his case he only suspected that the lesions had been of this character.

Lastly, in Halderman's case, it is stated that "the line of separation could with difficulty be made out, but it was finally located *two inches* above the articular plane in front," which clearly proves that the lesion was a fracture in the lower third of the femur, as indeed would appear also from the account of the dissection.

In determining upon the proper treatment to be followed in any case, certain points should first be ascertained.

Whether the injury be simple or compound, the condition of the vessels is of prime importance; if they are ruptured or irreparably damaged, amputation should be done at once.

Next, the possibility of reduction should be determined; and if this can be effected, the limb should be put in the best position for its maintenance. If reduction is out of the question, the end of the diaphysis may be sawn off and the attempt again made.

Delens suggests that the diaphysis should be sawn off as high up as it is stripped of the periosteum; but this is by no means necessary, and would often involve such a shortening of the limb as would be worse than its loss by amputation. On the contrary, only so much should be sacrificed as to permit of reduction being accomplished.

Division of the two heads of the gastrocnemius muscle might very readily be done to correct the rotation of the epiphysis; if there is a very large wound, through this, and if not, by a subcutaneous incision on either side. Such a procedure would

greatly facilitate reduction, and certainly would favor the restoration of the normal condition of the knee-joint.

Resection of the entire joint must be rarely required, and has, of course, the great disadvantage of leaving the whole limb stiffened.

As to the position in which the limb should be placed if an effort is to be made to save it, either with or without taking away any portion of bone, it would appear that the knee has always been kept straight except in one case (Simon's). In this case, about which we have no details, it is said that the leg was treated in flexion, with a back splint. Something must probably depend upon the chances for a movable knee; if this is out of the question, there can be no doubt that the straight position is the best. And where the epiphysial fragment is rotated so that the condyles look upward (the patient lying on his back), and this rotation in my case was very obstinate, flexion of the knee would, of course, carry the head of the tibia further away from the articular surface of the condyles, unless the rotation is overcome, and the condyles well brought down into place.

But if the natural relations of the parts can be restored, it seems to me that after a few days flexion may be gently and cautiously tried, and gradually increased, with passive movements, so as to prevent the necessity for the breaking up of adhesions at a later date.

For the retention of the parts in shape, a "back splint" has been generally employed, but I should prefer the application of splints of sheet zinc or of binders' board moulded along the whole length of the outer and inner sides of the limb, well lined, and held in place by a very accurately laid bandage. When flexion is to be made, fresh splints with suitable angles should, of course, be prepared. Suspension might very well be employed, and may add to the comfort of the patient. Perhaps I need hardly urge the importance of watching the condition of the foot, lest the circulation should be interfered with and gangrene ensue.

At the present day, no intelligent surgeon, dealing with a compound injury of this kind, would fail to give his first care to making the wound thoroughly aseptic; and if the knee-joint has been opened, this should, of course, be included in the sterilization.

It may be of interest to mention a case of this injury in a foal, communicated to me by Dr. R. S. Huidekoper. The animal, five months old, in rushing through a gateway struck the stifle of the near hind leg against a heavy post. When seen by Dr. H. in consultation, there was excessive lameness; but as the animal limped, the leg swung with an unnatural motion, and there was found to be looseness and slight crepitus in the neighborhood of the femoro-tibial articulation. The exact nature of the injury could not be determined on account of the swelling of the parts. Abscess ensued, the animal wasted rapidly, and was destroyed. The autopsy showed a separation of the lower epiphysis of the femur, with laceration of the surrounding tissues, and a large abscess.

Space is wanting for the citation at any length of the records of cases of the injury now discussed, but for the

convenience of those who may wish to examine them, I append a list of references, embracing all the writings on the subject which have been within my reach. Delens, in the paper before referred to, mentions two or three theses to which I have not had access.

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