Resection of Joints.
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March, 1886) says that (1) in one case the removal of both epiphyses at the end of ten years gave 25.5 cm. shortening; (2) in one case at the end of two years there was 10 cm. shortening; (3) the loss of the femoral epiphysis alone in one case gave 17 cm. shortening at the expiration of six years; (4) the loss of the tibial epiphysis alone in two cases gave respectively 15.5 and 16 cm. shortening in six years; i.e., an average of 10.7 cm. Petersen (Archiv f. klin. Chir., xxxiv., p. 445), in a child of six years of age, at six years from the time of the resection, found a shortening in the femur of 10.2 cm., of which 8.5 cm. was due to the loss of the lower femoral epiphysis. In the tibia, there was 5 cm. shortening, of which 3 cm. was due to the loss of the upper tibial epiphysis.

FIG. 4085.

It is to be remembered that when the knee is flexed the extension of the synovial membrane above the femur and beneath the quadriceps femoris tendon scarcely reaches above the articular cartilage of the femur; when the leg is extended, the same rises to a much greater distance.

Incisions.—Many incisions have been recommended for this operation, and of the great number variously used by Park, Moreau, Fergusson, Mackenzie, Bird, Volkmann, Langenbeck, Ollier, Textor, Sanson, and Bégin, no one seems to me to be as advantageous as that recommended by Mackenzie, Faraboeuf, Erichsen, and Kocher, i.e., the transverse curved incision of Textor.

The object of this resection is usually to produce ankylosis without considerable shortening, i.e. without shortening over 10 cm., which can be corrected by a high shoe and by the inclination of the pelvis. For this reason only such incisions are useful which will expose all parts of the joint and enable one accurately to remove only the diseased tissue. To obtain this exposure, the transverse incision is preferable to the longitudinal. The longitudinal incisions were designed to save the patella and to aid in producing mobile joints, but the best results are usually those in which ankylosis exists, and in these the patella is not necessary.

The operation by the longitudinal incision is difficult and tedious, and in disease fails to expose all parts of the synovial membrane. For this reason alone, in disease, the transverse is to be preferred to the longitudinal incision. In some few cases of injury with partial resection of the bones, the longitudinal incision is indicated, but in the vast majority of cases no incision is so satisfactory as the transverse.

Method of Operation.—Typical resection. The patient lies upon the back, with the leg at the end of the table, so that in flexion at the knee the foot may rest on the table. The surgeon stands upon the side to be operated. One assistant, opposite the surgeon, manages the thigh, another manages the leg. A third manages the sponging, etc. During the skin incision, the leg is held firmly flexed upon the thigh. The incision, at first involving the skin and subcutaneous tissue, passes from the epicondyle of one side to that of the other in a broad curve, which crosses the ligamentum patellae midway between the tubercle of the tibia and the lower margin of the patella (Fig. 4085). This incision avoids, as it approaches the internal epicondyle, injuring the saphena magna vein and the internal saphenous nerve. The flap marked out is dissected from the capsule and the patella and is reflected above the upper border of the patella. An oval-shaped piece of the anterior capsule, including the patella and the synovial membrane, is now excised
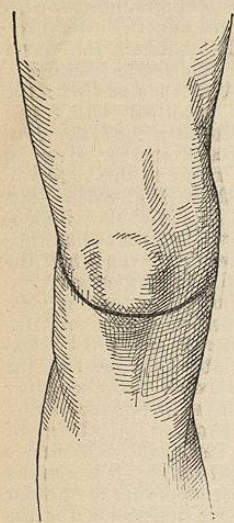
by two incisions passing from the posterior borders of each lateral ligament across the upper and lower extremities of the patella (Fig. 4086). With the removal of this piece the joint is fully exposed. This is the method of procedure in non-tuberculous processes, in injuries, and in deformities, where the ultimate aim is ankylosis. In tuberculosis Kocher's suggestion is the proper one. After reflection of the skin and subcutaneous tissue as above, an incision is carried through the lateral ligaments, the fascia of the vasti muscles, and the quadriceps tendon in a curve above the patella down to but not through the synovial membrane. The flap above is cleared from the synovial membrane until the attachment of the latter to the femoral articular cartilage is reached. In like manner, the flap below is separated from the synovial membrane as far as the latter's attachment to the tibia, the ligamentum patellae being divided at its attachment to the patella. In this manner the tuberculous synovial membrane, together with the patella, is removed in one piece. Whichever way one has proceeded the joint is now open and the crucial ligaments are seen. With increased flexion by the assistant, the crucial ligaments are rendered more evident and the division of the anterior and then the posterior close to the femur is made. The leg now hangs loosely upon the femur. It is flexed to a right angle, with the foot resting upon the table and the femur raised. In this position the femur is cleared of its soft parts—including the periosteum if desired and if indicated by the local condition—up to the line of intended section. The popliteal space is protected by a broad retractor and the bone is sawn with a solid-bladed saw. The plane of section is sagittally at right angles to the axis of the femur. Frontally it is parallel to the plane of the articular surfaces of the condyles.

The tibia is now pulled forward while the foot still rests upon the table. The popliteal tissues are put upon the stretch and brought into a lower plane than the articular surface of the tibia. This is exaggerated by freeing the tibia posteriorly where the ligament of Winslow is attached. The tibia is now held firmly in this position and is cleared of all tissues to the line of bone section. It is sawn at right angles to the axis of its shaft. The section in the bones is in the young always within the epiphyseal line; in the adult, the section is made as often extra-epiphyseally.

The tissues in the popliteal space are in no danger, since they are placed at a lower level than the bone section, owing to the traction upon the leg held in the vertical position. In non-tuberculous cases and in cases of deformity, the synovial membrane is now dissected from the bones and the capsule. It is usual to begin with that above the femur and beneath the quadriceps tendon. This with the bursa is removed as a continuous membrane and can in almost all instances, except where disease has advanced beyond its limits, be removed without further incisions. In the more extensive cases a vertical incision must be added to the transverse one. So infrequently is this the case and so thoroughly can one, by means of this additional incision, approach without excessive injury the space beneath the vasti and quadriceps tissues, that I have rejected entirely all incisions with their curve upward (Hahn, Verhandl. der deutschen Gesell. f. Chir., No. xi.) which are designed more fully to expose this region.

The advantages obtained by this method of procedure are, taken all in all, more than those derived from inci-
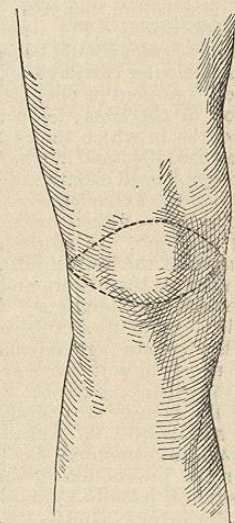

FIG. 4086.

sions destined to expose the space beneath the quadriceps muscle at the expense of the knee. The areas next in importance are the immediate neighborhood of the tibia and the popliteal space. The synovial membrane about the sides and front of the tibia and the adjacent synovial membrane are now removed, including the bursa beneath the ligamentum patellae. At this stage an assistant places his hand in the angle formed by the tibia and femur, and by pushing apart these bones puts the tissues in the popliteal space upon the stretch, which renders the removal of the bursae already referred to an easier matter than when their tissue is not firmly stretched. If removal of the disease in the rest of this region is now undertaken and if sinuses exist here, it is best to locate first the position of the artery and vein and then to proceed to the removal of the diseased parts. Providing the resection has been an extensive one, it is my custom at this time to remove the Esmarch bandage and to tie the articular, the anastomotica magna, and the recurrent tibial arteries. All hemorrhage from the bones stops when they are apposed. If the operation has not been an extensive one, then in all probability these vessels have not been cut or at most only one or two of them; under these circumstances I do not remove the Esmarch bandage, but rely entirely upon the firm dressing and the elevation of the limb for controlling the hemorrhage. Two openings are now drilled in the femur and in the tibia, and through them are passed large-sized chromicized catgut sutures, which, after the popliteal tissues are held away from the bones and after the bones are apposed, are tied tightly. These stitches are not for the purpose of holding the bones after the operation is completed but rather at the time of applying the primary dressing. They enable the assistants to feel that the bones remain *in situ* and have not slipped from their original position. Complete reliance is placed upon the dressing for holding the bones in position.

Drainage is established only to give exit to the excess of blood, so that the employment of Maas' method or the insertion of rubber tissue into the incision wound is quite sufficient.

In operating upon joints which are flexed, it is best to straighten them as much as possible before operating. In this way one avoids removing too much bone and at the same time removes enough, so that the tissues in the popliteal space are not too much stretched. This stretching tends to displace the fragments, and by closing the vessels tends to produce gangrene of the foot and leg.

The author's method of dressing these cases has been most satisfactory. It consists in applying an even and not lumpy dressing of gauze from the ankle to the upper third of the thigh. Upon the outer side of this gauze dressing eight to twelve thin bass or white wood splints, cut in strips 2 to 3 cm. wide and boiled until they are not only aseptic but perfectly pliable, are applied over the joint and are bandaged quite loosely in position. Over this is placed a sufficient cotton dressing which is fixed with plaster-of-Paris bandages. This plaster of Paris is not thick; it is scarcely more than two bandages thick, except where it covers the knee. It extends from the toes to the upper third of the thigh. The limb is now placed in a Volkmann's splint, which can be suspended or raised in bed to the required height. No dressing nor splint which I have seen used holds the knee so firmly and without undue pressure as does this combination. The

wood splints or strips, applied directly over an evenly applied gauze dressing, can be trusted, when they harden, to render slipping of the bone surfaces impossible. The plaster of Paris applied outside of the cotton and from the toes to the middle of the thigh holds the foot, leg, and thigh immovable, and exerts an even pressure upon all these parts. The Volkmann's splint protects and sustains the plaster-of-Paris dressing, which on this account need not consist of more than two thicknesses of bandage. This suffices for the immediate dressing, but fixation must be continued for a varying period after operation. Some have placed the period when ankylosis becomes complete at two months (Riedel, Deut. Zeits. für Chir., Bd. xv.), others at from six to eight months (Volkmann's klin. Vorträge, 51), and still others at one year (Hoffa, Arch. für klin. Chir., Bd. xxxii.). During this period the limb must be kept perfectly straight, and for this purpose plaster-of-Paris dressing is still used with perfect satisfaction. Windows can be made where necessary and the wound kept clean and healthy. There seem to me to be no advantages in the Howse or Hodgson splints which are not found in the above plaster-of-Paris dressing. Almost all the splints employed have the disadvantage of being complex and difficult to adjust. After splints have been removed, a leather support is usually applied. In children a support should be worn for from two to three years.

Results.—The age of the patient is important. The results are best, for either injury or disease, between five and fourteen years. Esmarch ("Beiträge zur Statistik der Kniegelenksresectionen," Kiel, 1883) had no deaths in 30 cases, Volkmann (Verhandl. der deutschen Gesell. f. Chir., xiii.) no deaths in 20 cases. Hahn, Maas, and Schede have had similar results. In 1898 Napalkow reported 26 cases operated upon between seventeen and twenty-five years old, with no deaths ("Chirurgie," 1898, p. 345). These statistics for tuberculosis bring the mortality very low. The general mortality for all cases and under all conditions is at present about ten per cent. (Bothe, Beitr. z. klin. Chir., vi., p. 282). The former high mortality of 7 per cent. for gunshot wounds, 40 per cent. for injury, and 30 per cent. for disease is being gradually reduced by a better selection of cases and an improved technique.

The final results of resections in children up to the fourteenth year show (Hoffa, Archiv f. klin. Chir., xxxii., p. 763) that 6 per cent. of failures occur, most of which require amputation; that 7 per cent. die of tuberculosis in other organs at a subsequent period; that 58.47 per cent. have an ankylosis in the straight position, with neither genu valgum nor genu varum; that 41.53 per cent. have a flexion contracture due to a faulty position of the leg and thigh at the time of operation, (2) to contracture of the flexors and atrophy of the quadriceps femoris, and (3) to the weight transmitted through the limb in faulty position. All of these conditions are avoided by obtaining a bony ankylosis in the extended position before the limb is used. Eighty-seven per cent. of the cases were permanent cures (54 per cent. without subsequent fistulæ, 33 per cent. with fistulæ requiring from one to twenty-one months to cure). One hundred per cent. of the cases show some interference in the growth of the limb, yet in 92 per cent. this is not greater in the intra-epiphyseal resections than in the conservatively treated cases (loc. cit., p. 794). In 8 per cent. of the cases measured by Bothe (Beiträge zur klin. Chir., vi., p. 208) lengthening had taken place. The final results in resections in which the subjects are older and in which the operation is either intra- or extra-epiphyseal, in so far as the bone section is concerned, are as follows:

In operations for tuberculous disease (443 cases) (Bothe, l. c.). Healed and useful limbs, 67.4 per cent.; incompletely healed, 13.7 per cent.; amputated, 8.8 per cent.; useless, 17 per cent.; mortality, 10.1 per cent.

In operations for gunshot wounds. Useful, 60 per cent.; required amputation, 24 per cent.; unknown, 16 per cent.

In operations for relief of deformity. Perfect, 19.5 per cent.; useful, 68 per cent.; unknown, 13.5 per cent.

The Atypical Resection.—By this is meant the method

employed by Wright under the name of erasion and by Volkmann under the name of arthrectomy. It is an operation in which the synovial membrane and bursæ are removed entire and in which the bone foci are gouged out, scraped out, or chiselled out, while all that is healthy is left intact. An operation of this kind in more favorable cases consists of a synovial extirpation with the goug-
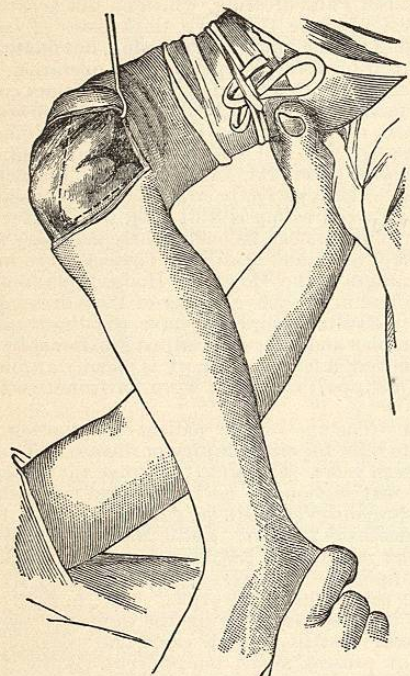

FIG. 4087.

ing out of one or more small osseous foci; in the more extensive cases it consists of a nearly complete removal of the articular cartilage, i.e., of an almost typical resection.

The operative technique is usually carried out by a transverse incision through the skin, subcutaneous tissue, lateral ligaments and fibrous capsule, down to the synovial membrane; reflection of this flap upward; and extirpation of the synovial membrane as recommended by Kocher for typical resections. It is now my custom, after the crucial ligaments are divided and the menisci removed, to examine the bones carefully, in order to determine from the beginning whether I can be content with a limited destruction of the articular cartilage, or whether this must be removed in greater part. It is at this stage that I determine whether my operation is to be the erasion or the intra-epiphyseal resection. Provided the former is the selection, the foci in the bones are removed by a gouge or chisel, and as much of the articular cartilage is saved as is possible. If two-thirds of the articular surface is intact, I then attempt to obtain a movable joint (eighteen per cent. in seventy cases, Maudry), and after dissecting away the posterior synovial membrane and the bursæ I suture carefully the capsule, the ligamentum patellæ, and the skin. I treat the joint subsequently as in a fractured patella, with absolute rest for from four to six weeks. If one-half to two-thirds is removed by the gouge or chisel, I remove the remaining articular cartilage by sawing intra-epiphyseally and I attempt to obtain an immediate bony union in the extended position. In my opinion the atypical and the typical intra-epiphyseal operations should be combined in this manner to obtain the best possible result of each method. Kocher, in order to avoid the cutting of the quadriceps tendon, makes the usual curved anterior incision, dividing the skin, subcutaneous tissue, and the fasciæ of the vasti muscles. He then makes upon each

side of the quadriceps tendon two vertical incisions, which, meeting the incision in the fascia of the vasti, form two right-angled flaps which are retracted outward (Fig. 4087). The capsule and synovial membrane are now cleared as in the typical resection, and are removed together with the menisci and ligamenta alaria (Kocher). The crucial ligaments have been previously separated at the tibial eminence, the femur is dislocated outward or inward in order that the posterior and postero-lateral portions of the capsule be rendered accessible for removal. The condyles are now examined, and if necessary foci are removed. The patella is at last turned completely upon itself and cleared of all tuberculous or diseased tissue.

Either of these methods of exposure may be selected. For myself, I prefer the former method, dissecting out the synovial membrane in the manner recommended by Kocher for the typical resection.

RESECTION OF THE HIP-JOINT.—This operation was first performed by Whyte for deformity in 1818, for disease by Hewson in 1822 or by Brodie in 1836, and for gunshot injury by Oppenheim in 1829. The resections are classed as complete when the acetabulum is partially removed together with the femur, as partial when only the femur or the acetabulum is removed. They are typical or atypical, according to the modifications in the method of approach and the manner of attacking osseous tissue.

The indications for the operation are:
1. Gunshot wounds, where partial and atypical resections rather than typical and complete methods are undoubtedly indicated. With the new projectiles, conservative methods rather than operative should be employed unless the operative interference is confined to a correction tending to production of better wound healing.
2. Tuberculosis, where operative procedure is not to be delayed, but earlier interference recommended.
3. Deformities from injury or disease. Here partial or complete resections are alone indicated when osteotomy cannot correct.
4. Old dislocations from disease or traumatism, where partial operations are quite sufficient.
5. Intracapsular fracture of the neck of the femur followed by disability and pain. Here the partial resection confined to the femur is beneficial.
6. In dislocation of the head and fracture of the neck of the femur. Here removal of the dislocated head is sufficient.
7. Congenital dislocation in adults which have failed of reduction by manipulation. (Lorenz and Hoffa.)
8. In acute infectious arthritis. Here arthrotomy rather than resection will be found to be more beneficial.

Results.—The mortality of resections for gunshot wounds is, according to Culbertson, 89.07 per cent., while according to Gurlt it is 88.23 per cent. Gurlt classifies this mortality as follows: 92.68 per cent. for primary resections; 94 per cent. for intermediary resections; 89.39 per cent. for secondary resections; 60 per cent. for late resections. Otis gives a mortality of 90.9 per cent. in the primary resections, while similar cases treated conservatively give 98.8 per cent., and by exarticulation 83.3 per cent.

The mortality for disease is low. Culbertson gives 44.8 per cent., of which 6.93 per cent. represented deaths from operation directly, leaving 37.89 per cent. for deaths from the disease and its complications. Grosch (Centralblatt für Chir., 1882, p. 228) gives a mortality, in 120 cases of tuberculosis treated antiseptically and observed to the end, of 36.7 per cent., which, compared with the results of Culbertson in pre-antiseptic times, shows that the cases dying from operation have been excluded by the present methods of operation, but that the deaths from the disease have not been diminished. It can but be said that the time of after-treatment is shortened, nor is the functional result better. These statistics include only cases operated upon late in the disease. The results of the operative treatment are better in proportion as the operation is early performed, and better in children than in adults. The mortality in the first stage, i.e., in the

stage in which the changes in the joint are slight and in which sinuses have not formed, is 0 per cent. The mortality in the second stage, i.e., in the stage in which fistulæ have formed and pus is present, is 24.1 per cent. The mortality in the third stage, i.e., in the stage in which the patients are already debilitated by long-standing suppuration and fistulæ, is 67.5 per cent. Two-thirds of the deaths following operation are due to general tuberculosis or tuberculosis of other organs; one-third is due to septic infection, suppuration, and amyloid degeneration (Bruns, Beiträge zur klin. Chir., xxii., 1894). The mortality at present is in the neighborhood of five per cent. (Wright, 3 : 100).

Functional Results.—Baehr reports 44 cases of resection which were able to walk: 8 with perfect motion =18 per cent.; 23 with restricted motion = 52 per cent.; 11 with ankylosis = 25 per cent.; 1 with a flail joint = 2.5 per cent. Baehr also found that resection of the head alone gave 0.9 cm. shortening; of the head and neck, 1.5 cm. Subtrochanteric section gave a shortening of 4 cm. His views substantiate Riedel's: namely, that the early resections give less shortening than the continuance of the disease will give, and that motion in the joint is equally good or better (Deut. Zeits. f. Chir., No. 30, p. 349). Mauninger (Deut. Zeits. f. Chir., No. 65, p. 1) gives the statistics of 41 cases carefully observed. The shortest time during which a patient was kept under observation after operation was one year and six months. The following are the classified results: 41.02 per cent. were healed without fistulæ; 17.07 per cent. were healed after treatment for fistulæ or after subsequent operations; 9.75 per cent. were healed, but now and then a fistula would open and close. The general health of these patients was good. In 67.84 per cent. the results were good. In 11.195 per cent. the health was bad, and the wounds suppurated profusely; 21.95 per cent. of the patients died. The results were bad in 33.143 per cent. of the cases. Of the deaths (21.95 per cent.), 1 was due to fat emboli in the lungs. 10 per cent. were due to a general miliary tuberculosis, which followed the operation in from one to three months, and the development of which was probably hastened by the operation. In another 10 per cent. of the cases death was due to tuberculosis of internal organs, the disease developing from one to ten years after the operation.

Functional results in these cases must be considered in reference to the condition of the extremity at the time of operation. In no case had the disease in the hip lasted less than two and three-fourths years, so that the operation had to do with (1) the shortening of the extremity due to an atrophy from inaction—4 to 8 cm.; (2) slipping upward of the head of the femur upon the ilium—2 to 3 cm.; (3) contracture of the soft parts (muscles, etc.), usually a flexion-contracture of thirty degrees and an adduction-contracture of twenty degrees; (4) atrophy of the musculature of the pelvis and femur. Yet, in spite of this condition of affairs, in 50 per cent. of the cases in which good results were obtained good motion was present; in 50 per cent. of these cases a cane with or without a high shoe was used in walking. With the exception of one case, all limped more or less; i.e., most patients walked from two to four hours without pain or special fatigue. All followed their vocations. In 50 per cent. their general health was good; in 50 per cent. it was very good. With the exception of one case in which multiple caries existed, no case was suspected of having tuberculosis in other organs. Mauninger collected, in addition to these cases, 304 cases which were operated in the aseptic period of surgery. Permanent healing took place in 65.8 per cent. The mortality was 17.4 per cent. The question to-day is whether conservative treatment will give as good or better results than the operation.

The statistics of Gibney, Waterman, and Reynolds, of 114 cases examined five years and upward after leaving the hospital, show that 107 were cured and able to follow an occupation without trouble; 7 cases were cured, but with considerable deformity, for which osteotomy or excision was done. About 14 per cent. showed perfect

motion, 20.5 per cent. good motion, 38 per cent. limited motion, and no motion in about 8 per cent. Shortening of the limb averaged 1.75 in. (i.e., 4 cm.) in all the cases except in 21 in which it was absent, i.e., 19.5 per cent. (Annals of Surgery, 1897, vol. ii.).

The statistics of Mauninger (loc. cit.), obtained for the conservatively treated cases, give the following results as regards the cures and deaths: purulent cases, 27.1 per cent. healed, 48.8 per cent. mortality; non-purulent cases, 74.2 per cent. healed, 16.5 per cent. mortality.

The results of conservative treatment are therefore, in reference to mortality, no better than those obtained by the operative method, for even if the cases of death due to operation alone or induced by the operation be included, still the operative cures present a mortality of only 17.4 per cent. as against 16.5 per cent. in the non-suppurative cases and 48.8 per cent. in the suppurative cases treated conservatively. If in this comparison cases be deducted in which the disease is attacked early before suppuration exists, the mortality ranges from 0 (Bruns) to 3 per cent. (Wright)—a result far superior to that shown by the statistics of the cases treated conservatively, and even better than the results obtained by Gibney—8.8 per cent.—or by Marsh—6 to 8 per cent.—("Diseases of Children") for the conservative treatment.

The functional results are quite as good—perfect motion being obtained in 18 per cent. of the operative cases (Baehr), in 14 per cent. of the conservative (Gibney, et al.). Even in the cases reported by Mauninger, operated after two and three-fourths years of the disease, 67 per cent. were good results; one-half of these patients had motion and one-half walked with a cane. All could follow their vocations. These excellent results obtained by both methods of treatment depend much upon two factors. In the first place, in the conservatively treated, some cases of restitutio ad integrum are due to the fact that the disease was non-tuberculous (Karewski). Again, in the cases treated by operation much will depend upon the time at which the operation is performed. Operations are not to be performed because conservative treatment has failed, but at an early stage when fistulæ and suppuration are not present, or, if they are present, only to a small extent (Wright, "Diseases of Children"; Barker, Lancet, 1900, vol. i., 1099).

The shortening in the limb is less by the operative treatment than by the conservative treatment. In the older cases the average shortening from operative procedures is not increased over that which is present at the time of operation and which is due to the atrophy of inaction, the slipping upward of the head of the femur, and the contracture of the limb. In the early cases, the statistics of Baehr show that shortening for any section made on a line situated higher up than below the trochanter is very slight (0.9 to 1.5 cm.), while average shortening in the conservative treatment is 4 cm., with 19 per cent. of the cases showing practically no shortening (Gibney), i.e., less than ½ in. or 1.25 cm. Our view is that operation should be carried out as soon as it is clear that conservative measures cannot prevent suppuration. A resection is indicated so soon as suppuration exists in the joint and before fistulæ are present (König, "Das Hüftgelenk," Berlin, 1902).

In the wealthy class, where long-continued mechanical treatment can be carried out and where iodoform injections can be made as indicated, suppuration can oftentimes be prevented and a result obtained which, as we have seen, gives perfect motion in fourteen per cent. of the cases. In the poorer class, who cannot afford or will not carry out this long-continued mechanical treatment, suppuration is more frequent, the deformity is greater, and the destruction of the bones is more marked than is the case in those who have been able to command mechanical treatment and have followed it faithfully. In these latter cases operative treatment is frequently indicated and will give results superior to those offered by the conservative treatment both in respect to function and in respect to mortality, when like degrees of disease are compared.

Anatomy.—The hip-joint is deeply placed and is immediately surrounded by the psoas and iliacus muscles; by the quadratus femoris, the obturator internus, the gemelli, and the pyriformis behind; by the gluteus medius, gluteus minimus, and rectus femoris externally; and finally by the pectineus and obturator externus internally. Beneath

FIG. 4068.

these muscles is the thick capsule, the auxiliary bands of which are the ilio-femoral, the pectineo-femoral, and the ischio-femoral, the border of which latter is known as the zona orbicularis. Between the ilio- and ischio-femoral bands the capsule is strong; opposite the lower and back part of the femoral neck and opposite the cotyloid notch it is thin. Within the joint is the ligamentum teres, a flat band extending from the acetabular notch to the depression in the head of the femur. The marginal fibro-cartilage and the transverse ligament complete the ligamentous structures. The synovial membrane lines the capsule and passes over the border of the acetabulum to cover the round ligament. The bursæ are numerous and of frequent occurrence; upon the outer and anterior surfaces there are five, while upon the posterior surface there are four.
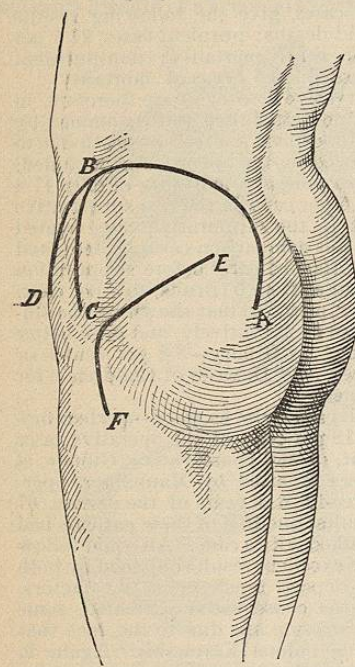
The bones consist of the innominate and the femur. The former contains the acetabulum, a hemispherical cavity which receives the femur. The latter consists of a rounded head and a neck, which latter is long and joins the shaft obliquely, *i.e.*, at an angle of one hundred and twenty-five degrees.

Ossification occurs in the head of the femur and in the greater and lesser trochanters, at the first, fourth, and thirteenth years. They join the shaft in the reverse order at the eighteenth, eighteenth and a half, and nineteenth years.

The acetabulum ossifies at the sixth year from the Y-shaped cartilage occupying its centre. At the fourteenth the ilium and ischium unite with the acetabulum. The pubis does so at the fifteenth year. Ossification is completed in the acetabulum at the seventeenth year.

Owing to the obliquity and the length of the neck of the femur, the muscular attachments to the bony prominences have great leverage and a wide range of motion is possible. When the head is removed these muscles tend to draw the femur upward unless the neck is engaged in the cotyloid cavity. If the neck is also removed, the abduction and rotation of the femur are lost. The pelvi-trochanteric and all muscles passing between the pelvis and the femur cause the femur to ascend, which ascension is limited only by the tension of the capsule. The shortening, then, in any resection will depend upon: (1) The loss of the epiphyseal cartilage. This is slight. (2) The amount of bone removed. (3) The muscular displacement of the femur. (4) The atrophy of the limb from disuse.

This shortening is partly corrected by the inclination of the pelvis on the side operated. The object to be acquired in a resection is a nearthrosis or a tight pseudarthrosis. They give the best results in walking. To obtain either, the neck must be retained in the acetabulum or in apposition with the bone at this level, and not allowed to ascend. Owing to the inclination of the pelvis after shortening, the femur must be retained slightly flexed and abducted upon the pelvis. The main points, then, are to preserve the greatest possible length, to obtain a solid, slightly mobile union with the acetabulum, and, lastly, to preserve the proper position in the limb.

Methods.—The hip-joint has been removed by several methods of incision.

1. By the external incision. First proposed by Charles White in 1769, and modified by Langenbeck in 1867 (*Langenbeck's Archiv*, No. 16, p. 24), by Sayre in 1874 (personal communication from son), and still later by Ollier ("Régénération des Os," t. ii., p. 384) and Kocher (*Correspondenzblatt f. Schweizer Aerzte*, 1887, Dumont).

2. By the anterior incisions. (*a*) The longitudinal (Schede, Verhandl. der deut. Gesell. f. Chir., i., p. 68, 1878; Lücke, *Centralblatt für Chir.*, 1878, p. 681; Hüter, 1878, "Chirurgische Operationslehre," Löbker; Parker, Transactions of the Clinical Society, vol. xiii., 1880; Barker, *British Med. Journal*, vol. i., p. 1326, 1888). (*b*) The transverse (Roser, "Chirurgisch-anatomisches Vademecum," 1870).

3. Posterior incisions, Hueter ("Die Gelenkserkrankungen," 1877); Guérin ("Manuel Opératoire" of Farabœuf); Bidder (*Langenbeck's Archiv*, No. 39).

4. Superior incisions, Bardenheuer (*Langenbeck's Archiv*, No. 41), H. Schmid (Verhandl. der deut. Gesell. f. Chir., 1891); Sprengel (*Festschrift Braunschweiger Aerzte*, 1898).

In addition to these, there are from fifteen to eighteen other modifications of these methods of approaching the joint ("Manuel Opératoire," Farabœuf). They are of little value. Of these methods of entering the joint three are selected: 1. The external incision. 2. The anterior longitudinal. 3. The superior incision.

1. *Operation by the External Incision.*—The patient lies upon his sound side with the thigh flexed upon the pelvis at an angle of forty-five degrees. It is also rotated inward. One assistant holds the limb with one hand upon the knee and the other upon the foot and produces the required positions during the operation. The operator stands behind the thigh and is usually aided by two assistants.

An incision is made which may correspond to that of Langenbeck, Sayre, Ollier, or Kocher. If Langenbeck's is selected, it passes from the posterior superior iliac spine over the great trochanter behind its centre and follows the axis of the femur. Two-thirds of this inci-
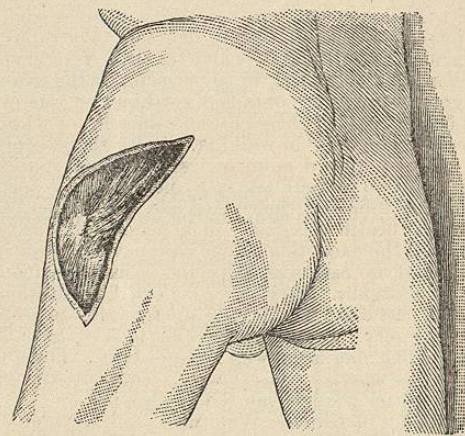

FIG. 4089.

sion is above the trochanter, one-third is below it. If Sayre's incision is selected, it passes from a point mid-

way between the anterior inferior spine and the trochanter across the top of the great trochanter behind the centre, and curves thence forward and inward. If Ollier's incision is selected, we flex the thigh on the pelvis at one hundred and thirty-five degrees. From a point four fingers' breadth behind the anterior superior spine
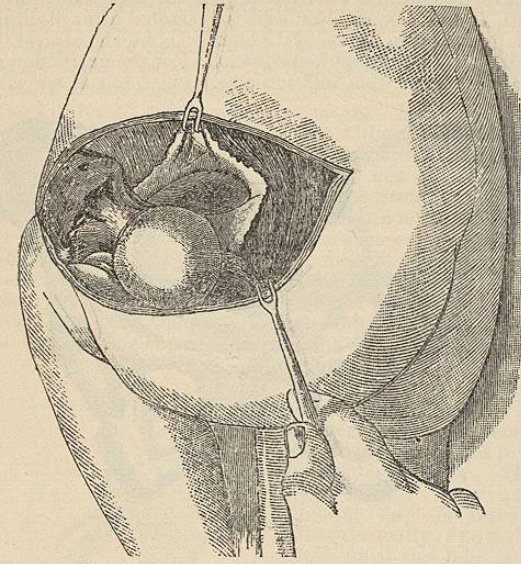

FIG. 4090.

and the same distance below the crest of the ilium, the incision passes downward and forward in the direction of the fibres of the gluteus medius to the trochanter, thence forward and downward in the axis of the femur. If Kocher's incision is selected, it commences at a point opposite the upper border of the great sciatic notch in a line connecting the posterior superior spine of the ilium and the centre of the trochanter major, and descends parallel to the fibres of the gluteus maximus to the trochanter major on its external surface. From this point it bends backward and downward. The upper limb of this curve is usually 8 cm. in length, the lower 6 to 8 cm. (Dumont, *Correspondenzblatt f. Schweizer Aerzte*, 1887).

Of these incisions I prefer Kocher's, because of the ready exposure of the parts which it affords, and the easy access which it gives to the joint through the muscular interstices, thereby avoiding the arterial and nerve supply of the muscles (Fig. 4088, *E F*).

Having selected the latter incision, the surgeon should divide the skin and deep fascia and thus expose the fibres of the gluteus maximus in the upper two-thirds of the cut. These are divided parallel to their length and in the line of the skin incision. Two or three branches of the gluteal artery are usually cut here in their middle. Two retractors are introduced, the gluteus medius and pyriformis are exposed beneath this muscle internally, while externally the trochanter is felt. The knife now divides the strong fascial attachment of the gluteus maximus, passing over the vastus externus and descending in the interstice between the vastus externus and the quadratus femoris (Fig. 4089). In this incision the tendon of the gluteus maximus is in part divided, and this division, by reason of the resulting retraction, exposes the muscles covering the joint behind and the trochanter in front. It is here that the external circumflex artery is sometimes cut. The interstice between the pyriformis behind and below, and the gluteus medius above and in front, is seen in the anterior part of the exposed area. Below this is seen the interstice between the pyriformis above and the gemelli and obturator internus below. It is between the latter muscles that the incision is deepened, since in the upper retracted flap will be the gluteus medius and pyriformis supplied by the superior gluteal nerve, while in the lower

retracted flap will be the obturator internus and gemelli supplied by the inferior gluteal artery. The joint capsule is now exposed throughout its length and should be divided by an incision which runs parallel to the axis of the neck of the femur, and at the same time divides the periosteum of the neck, and the orbicular zone of the ischio-femoral band, the capsule and the circumferential fibro-cartilage of the acetabulum. This incision is usually sufficient to allow dislocation of the head of the femur, but, if it does not suffice, a transverse incision may be added near the acetabular margin. The internal circumflex artery is usually cut here as it passes over the capsule. The incision in the periosteum of the neck is now continued over the trochanter major upon its posterior border, and the periosteum, together with the attachment of the gluteus medius above, the pyriformis internally, the gluteus minimus, the vastus externus, and the Y-ligament anteriorly, is separated with the rugine. This separation is greatly facilitated by flexion and rotation outward of the thigh. It is here that the external circumflex artery is often cut a second time. This flap can now be pulled forward over the trochanter. It contains within, if we exclude the small portion of the vastus externus, only those muscles which are supplied by the superior gluteal nerve. The thigh is now less flexed, adducted, and rotated inward. The tendons and the periosteum are separated with the rugine from the apex and posterior half of the trochanter as far as the origin of the quadratus femoris from the linea quadrati. These tendons, namely, the gemelli, the obturator internus and externus, and as much as is necessary of the quadratus femoris, are now retracted backward and downward with the capsule. These muscles are all supplied from the inferior gluteal or sciatic, whose branches are uninjured.

When these capsulo-periosteal flaps are freely retracted, the posterior surface of the head of the femur, its neck, and the trochanter are in view. The sciatic nerve is free from danger, being carried away from the joint when the obturator internus, the obturator externus, and the quadratus femoris are divided and retracted.

The thigh is now strongly flexed, adducted, and rotated inward. The round ligament is divided if intact and the head is luxated (Fig. 4090). The remaining periosteum and capsule upon the neck is separated with the rugine.

The head is now held firmly with the lion-toothed forceps, the soft parts are protected by the retractors, and the bone is sawn with the Gigli saw just below the level of disease or injury.

FIG. 4091.

The acetabulum is next removed with the gouge, chisel, or Volkmann's spoon, according to the indications. The synovial membrane and parts of the capsule are removed after the bones are cleared of disease. If sinuses are present they must be excised or curetted. Hemorrhage usually consists of oozing, and can be stopped by hot saline solution; if it is very troublesome the wound may be packed with gauze. Where no oozing is present and no sinuses exist the wound may be closed directly. If, however, abscesses, sinuses, or great oozing is present, it is best to pack with gauze, for a time at least.

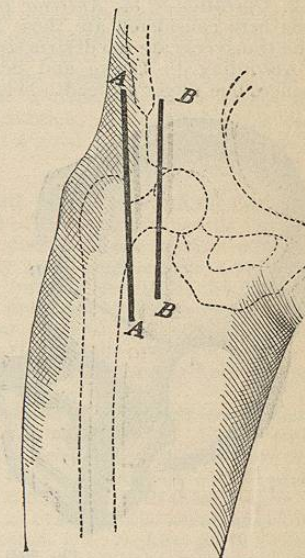The section in the bone should be made in the neck if

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possible; if not, through or beneath the trochanter major, because of the shortening which is liable to ensue.

A nearthrosis is best secured when the section passes through the neck near the head, yet subtrochanteric sections have given as good results in the restoration of the joint. Such cases are seen in the autopsy shown by J. Israel (German Surgical Congress, 1882) and in the collection made by Sach (*Deutsche Zeitschrift für Chir.*, xxxii.). In some of these cases a newly formed head covered with fibro-cartilage, a new trochanter, and synovial membrane were reproduced to a considerable extent. To obtain the best results, one must operate early in the disease, early in life (three to fifteen years), and subperiosteally, and must preserve as much of the bones as possible, so as to diminish the shortening.
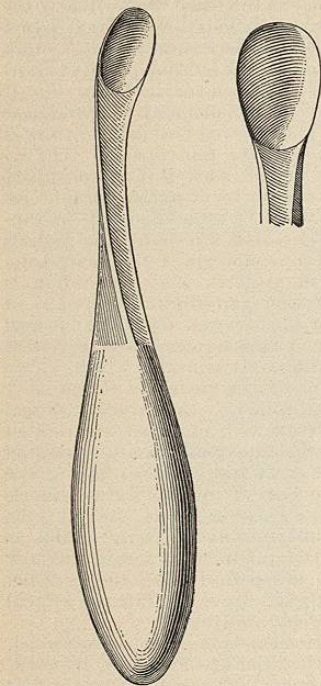

FIG. 4092.—Löbker's Spoon-Elevator. (About ⅓ natural size.)

When a nearthrosis is not attainable or is inadvisable, the after-treatment should secure the retention of the limb in abduction with the slightest flexion. This gives a very good and useful limb.

2. *Operation by the Anterior Incision.*—The only incisions here considered are those which are longitudinal. The transverse are too destructive of the soft parts.

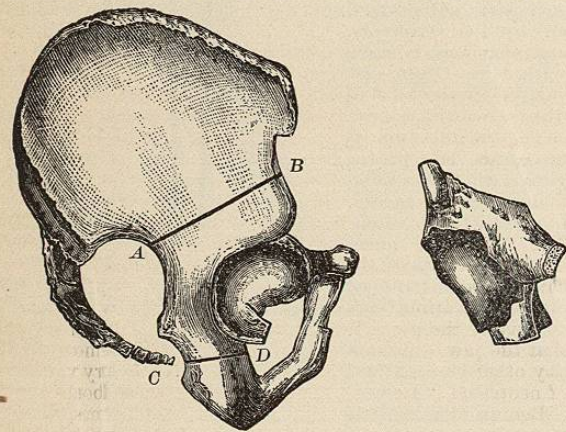According to Lücke and Schede, the incision commences one finger's breadth below and to the inner side

FIG. 4093.

of the anterior spine and descends in the long axis of the femur for a distance of 10 to 12 cm. (Fig. 4091, *BB*). As it is deepened it passes to the inner side of the sartorius and the rectus muscles and to the outer side of the iliopsoas muscle. The crural nerve and the external circumflex artery are avoided. The assistant flexes, abducts, and

rotates outward the thigh. The sartorius and rectus muscles are drawn outward, the ilio-psoas muscle and the crural nerve inward. The capsule of the joint is exposed and is divided by a crossed incision, the transverse portion parallel to the neck passing from the acetabulum over to the anterior intertrochanteric line, while the vertical portion crosses this line at a right angle. The neck is now sawn with a Gigli saw and the head is extracted after dividing the ligamentum teres by Löbker's spoon-elevator (Fig. 4092) or by a lion-toothed forceps. For the extraction of the head alone this incision may suffice, but if we wish
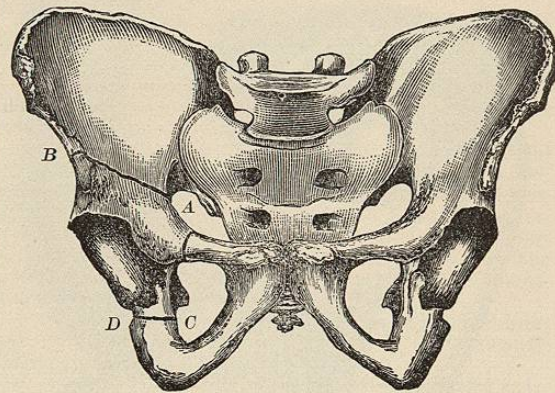

FIG. 4094.

to reach the trochanter in addition we must advocate the incision of Hueter which has been much used and strongly advocated by Barker. In this latter method, the patient rests supine with the thighs extended; the surgeon makes an incision which, according to Hueter, passes from the middle of a line drawn from the anterior superior iliac spine to the trochanter major, downward and slightly inward along the outer border of the sartorius. In children the incision is 6 to 8 cm., in adults 10 to 15 cm. in length. According to Barker, the incision commences in the anterior surface of the thigh, one-half inch below the anterior superior spine of the ilium, and runs downward and inward for three inches (Fig. 4091, *AA*). With either incision, the dissection is carried in the space between the sartorius, anteriorly, and the tensor vaginæ femoris and the gluteus medius behind. The incision is deepened to the bone and some fibres of the vastus externus are divided. In the lower angle of the wound is seen the external circumflex artery, which may be divided. These muscles are retracted, the joint capsule is seen and is incised by the same cross incision mentioned in the Schede-Lücke method. After this exposure of the head and neck, the spoon-elevator may be used and the trochanter freed of its muscles sufficiently to allow an easy exposure of the joint. The diseased head is now removed after encircling the neck and dividing it with the Gigli saw. The removal of the head is often difficult unless it be much diseased. With the lion-toothed forceps the removal is often very difficult and the soft parts and the head are often crushed. The easier method is to pry the head out of the acetabulum by introducing a strong, gently curved elevator or Löbker's spoon in the space between the head and the acetabulum, and after the ligamentum teres has been divided the head is then easily removed.

The bleeding by this anterior incision is small in amount if one avoids the anterior circumflex artery. Drainage of the wound will require not infrequently a posterior opening, but in many cases operated early all necessary drainage can be secured through the anterior incision.

In either of these methods by the anterior incision are muscles cut. Neither nerves nor vessels are injured. In both methods the route to the joint is a direct one. The advantage of the Hueter incision over the Lücke-Schede

incision is that the trochanter, as well as the head and neck, can be reached.

When the acetabulum is primarily involved, or the *x*-ray and the clinical symptoms show that the disease which affects it must be especially attacked, the methods introduced by Bardenheuer (*loc. cit.*) and Schmid (*loc. cit.*) give the best chances for radical cure. As usual methods, these procedures are considered at present too extensive. In Bardenheuer's hands, the mortality due to the operation alone was 4.3 per cent. In Schmid's hands, the recurrences were not lessened by the procedure, two of the four cases dying of continued tuberculosis. In the large majority of cases the Kocher incision will give sufficient exposure to enable us to chisel or gouge away the diseased acetabulum; and as this method is less extensive and more easily accomplished it should be preferred.

Operation by the Superior Incision.—In a few cases, Kocher's operation is not sufficient, and we recommend for these the suggestion of Sprengel ("Zur operativen Nachbehandlung alter Hüftresectionen," *Festschrift*, 1898), which consists in making an extensive incision along the crest of the ilium from the posterior superior spine of the ilium to the anterior superior spine of the same. This incision divides the muscles and the periosteum. At the border of the gluteus medius and the tensor vaginæ femoris this incision descends to the trochanter major. (Fig. 4088, *ABC*.) This quadrilateral flap is removed subperiostically from the ilium until the joint is opened and the head and neck of the femur are exposed. As the nerves and vessels are avoided by this, the muscular paralysis and hemorrhage are practically nil. If the disease is well forward in the acetabulum and pubis, especially if a flexion-contracture exists, the incision is made in front of the tensor vaginæ femoris, sartorius and rectus, and these muscles are separated with the rest (Fig. 4088, *ABD*). After exposing the head of the femur, it is rotated inward or outward, as occasion demands, and adducted strongly. If the acetabulum alone is to be removed, this can be easily accomplished with the chisel or gouge through the incision first recommended (*ABC*). If the disease requires a resection of the acetabulum and the surrounding bone, the second incision is used (*ABD*). In this latter case the outer surfaces of the ilium, the acetabulum, and the outer margin of the great sciatic notch are bared of their periosteum. In like manner the internal surface of the
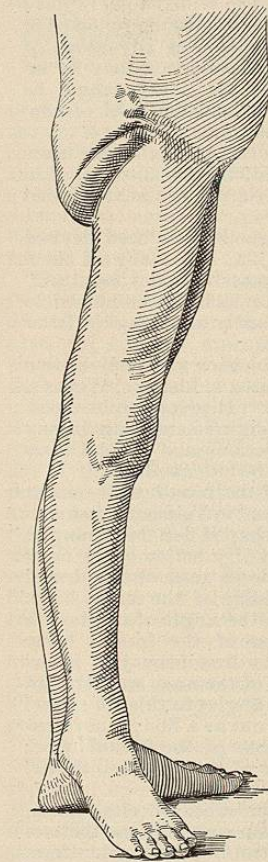

FIG. 4095.—A Patient Three and a Half Years After Removal of One-Half the Pelvis and the Head of the Femur. (Kocher.)

ilium, the iliac fossa, is freed from the pelvic fascia and muscles until the great sciatic notch is reached. A Gigli saw is then inserted through the sciatic notch beneath the iliac muscles and over the anterior inferior spine of the ilium and the bone is sawn (Figs. 4093 and 4094, *AB*). The horizontal ramus of the pubis is next cleared of its periosteum, carrying with it the vessels, which are displaced from 1 to 2 cm. internally. An aneurism

needle now carries a Gigli saw around the ramus and out of the obturator foramen (Fig. 4094, *CD*). The bone is sawn. As the bone is now cut upon two sides, it can be displaced outward somewhat. The periosteum is next removed from the descending ramus of the ischium from above downward with great care to avoid injuring the vessels and nerves as they pass out of the pelvis. The Gigli saw is again passed around this ramus at a point one finger's breadth beneath the acetabulum (Figs. 4093 and 4094, *EF*). The bone is sawn. The acetabulum and surrounding bone can now be quite easily removed with the heavy lion-toothed forceps. If the head of the femur is to be removed with the acetabulum, it is best removed before we attempt the resection of the acetabulum.

After the hemorrhage has been controlled the wound is closed with sutures except in some portion where the packing emerges. It is best in all cases to pack the large wounds for from twenty-four to forty-eight hours, in order to control hemorrhage completely. After this, that portion from which the gauze emerges can be left for drainage or it may be sutured at this time.

After-Treatment.—The after-treatment in resection of the hip is important. An aseptic dressing, equable compression and rest for the wound are the first desiderata. The position to be maintained is that of extension and abduction of the thigh, with the neck or the trochanter closely applied to the acetabulum or ilium. During the first three weeks, since these wounds are packed with gauze and require secondary suture or dressings, a Buck's or Volkmann's extension apparatus with plaster-of-Paris spica passing to the knee is most frequently used. After this period, when the packing is removed or the wound is healed in great part, a Thomas splint or the plaster-of-Paris dressing may be used for the next three weeks. If the patient is up and about upon crutches (children), a Thomas splint is very inexpensive and satisfactory. If the patient is confined to bed, a plaster-of-Paris splint which can be readily removed for the active exercise of the joint is the more useful form of splint. During this period of three weeks, active exercise in the new joint is made every two or three days.

During the following three to six weeks patients are allowed to walk with their splints, and during this time the Taylor hip splint or some modification of it is substituted for the former apparatus. These splints allow flexion, extension, and abduction when applied, and the surgeon must continue the extension and abduction of the limb for a long time to overcome the constant tendency to flexion and adduction. It is only by this careful after-treatment that a good functional result can be obtained.   *Frank Hartley.*

RESECTION OF THE SUPERIOR MAXILLA.—HISTORY.—Partial removal of the superior maxilla for alveolar growths, necrosis, disease of the antrum of Highmore, etc., has probably been practised for a very long time, but the complete, formal resection of this bone appears to have been first proposed by Lizars in 1826.

In the following year Gensoul, quite independently of Lizars's suggestion, performed the operation, and therefore seems entitled to the credit of having first executed this procedure.

The indication for resection of the upper jaw is almost invariably the presence of a new growth. Hueter states that the jaws are more frequently the seat of tumors than any other bones of the skeleton. Almost every variety of neoplasm is found in connection with these bones.

Benign tumors such as cysts, epulis, adenomas, fibromas, chondromas, osteomas, etc., require partial resections only; merely enough of the bone being removed to give access to the tumor or to effect the complete removal of the latter.

Complete resection of the superior maxilla is usually done for malignant growths, *i.e.*, carcinomas and sarcomas, affecting the bone. They occur with about equal frequency. The majority of the former begin in the alveolus.