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Rickets, Its Treatment by Osteotomy.

A Clinical Lecture Delivered at Bellevue Hospital

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Gentlemen: In the clinic to-day I propose to discuss a subject which at present occupies a good deal of attention among hospital surgeons. It is a subject, I may add, that is not considered in detail in any of our standard text-books upon surgery. A mere reference to the operation is found in the recent surgical works. The description of the operation and the results are to be found only in medical journals or in special monographs, devoted to a consideration of the subject. I have here in this clinic to-day a number of cases to illustrate the varieties of rachitic deformity for which osteotomy is performed, and I shall avail myself of this opportunity to discuss the subject in all of its details. Rachitis is a developmental disease, which impairs the nutrition of the body. Every organ and every viscus is affected by it. Rickets is a disease essentially of childhood; but in rare cases the deformity of rickets is manifested in the adult. Without entering upon an argument as to whether it is possible for rickets to occur in the adult, I shall ask you to accept this statement, as pathologists have not as yet given us any description of a disease with the characteristic features of rickets to explain the deformity in the bones of the adult.

Until a disease is described to account for the few rare cases of rachitic deformity which occur in adults, it is better to assume that rachitis, or at least a disease closely allied to it, exists in adults and that this disease is the common factor in producing the deformity in the young and the old. The word rachitis is derived from a Saxon word

meaning a hump, and the derivation of this word has also been traced to a Greek origin meaning a spinal disease; because it was supposed in early times that it was the spinal marrow which was the seat of the disease and consequently the cause of the deformity. The fallacy of this pathological doctrine has been proved, and it is now accepted by pathologists that the disease is one of a constitutional nature, depending upon malnutrition and having a local manifestation in the osseous system and the joints. The disease is congenital as a rule; but some writers have attempted to prove that it may develop in utero.

In an analysis of over twenty-three thousand fœtuses born dead at the Maternité only two cases of rachitic deformity were found by Chaussier.

In Guerin's tables comprising three hundred and forty-six fœtuses, examined with reference to this point, three cases only were discovered where tho characteristic deformity existed. These exceptions are interesting as throwing light upon the etiology of the disease, but for practical purposes rachitis may be considered as a disease during the first few years of life. In a very large number of cases which have been sent to me for operation, I have found the average at which the disease may be considered at its height to be about three years. This is the period when these rachitic children manifest the greatest deformity, because they experience the ill results of bearing the weight of the body upon bones which yield to pressure. These children walk late in comparison with healthy children and attain considerable size and weight, which aids greatly in causing the deformity, for the relief of which they are brought to the surgeon. The etiology of rickets is referred to hygienic conditions. The disease is one found among the children of the poorer classes, who live in dwellings which are ill ventilated and improperly drained, and where sun-light and fresh air have no admittance. Impure air seems to have the most important influence upon the development of this disease. Children brought up in the country rarely are afflicted with rickets and the disease may be said to be practically restricted to city children. In addition to hygienic causes may be mentioned also the feeding of infancy as a potent factor in developing the disease. Improper feeding leads to indigestion and to a want of proper assimilation, and hence a child suffers from malnutrition. It is a remarkable fact that rickets seldom is seen in a child who has nursed from a healthy mother's breast. I have treated a number of children for rachitic deformity where the mother would not nurse the infant on account of the flippant exactions of a fashionable society life.

These children were nourished upon artificially prepared food, and, at the time when they began to walk, their bones were soft and yielding, and lateral curvature of the tibiæ was the result. There is no equivalent for healthy mother's milk, and any substitute for this food has its serious objections.

Among the constitutional symptoms of rachitis may be cited diarrhœa from undigested food, diaphoresis, which is peculiar in that the upper part of the body seems to be most effected while the lower extremities are dry and hot, dentition, which is retarded, and when the teeth appear they are black and soon decay.

During my year's service in the children's hospital upon Randall's Island I saw a child with rachitis, and at eighteen months from birth not a single tooth had appeared, and with cranio-tabes most marked.

Another constitutional symptom is to be found in the condition of the muscular system. If the muscles be examined they will be found to be flabby, and if the skin is observed it is found to be pale and unhealthy. Irritability of temper is another symptom, and if the child is disturbed he is fretful and has a desire to be left alone, as lifting seems to cause pain. Open fontanelles are also characteristic of rickets, and as a result of this condition the head begins to assume somewhat the shape of the hydrocephalic skull. The chin appears pointed from an arrest of normal development, and it likewise appears more prominent, owing to the peculiar shape of the skull. Outbursts of crying may also be mentioned, and the child often cries for a long period, and at times it is impossible to appease him or her. It is not the cry of acute pain nor the hydrocephalic cry, but it is a moaning and continuous cry, which is different from the usual cry of an infant.

Before dismissing the cerebral symptoms I would like to call attention to the shape of the skull.

If measurements of the normal skull be taken, it will be found that the diameter of the base is about one-fifth less than that of the diameter of the cranium. For example, if you place one leg of a compass upon the glabella, and the other leg upon a point just beneath the external occipital protuberance, the distance between the two points placed on a ruler marked with a scale will give the diameter of the base. If now the same test is made by the instrument by placing one leg of the compass upon the most prominent part of the frontal bone, and the other leg upon the most prominent part of the occipital bone, the distance between the two points will give the diameter of the cranium. This Dr. Gee, of London, has demonstrated to be about a fifth greater

in the normal head. If now a skull is examined which is abnormally large, the measurements just described should be made; and if the head is simply large and round it is called a cyclocephalic skull, and thus it is indicative of tuberculosis, which is associated with dropsy of the ventricles; but if the head is abnormally long in its antero-posterior diameter, it is called a dolichocephalic skull, and this shape is characteristic of rachitis.

Having now considered the constitutional signs and symptoms of rachitis, it is pertinent to consider the local signs of rachitis, which subject embraces a study of the special manifestations of rickets as they appear in the bones and joints. The first thing which is noted in the changes in the bone as a result of rickets is the absence of solidity to the shaft.

Absorption of the compact structure of the bone takes place, and this loss is substituted by layers of soft cartilaginous tissue, which permits the bones to bend. The bones of the upper extremity are not affected to so great a degree as the bones of the lower extremity. The bones of the skull are also affected. Besides these changes of absorption of the compact tissue in the shaft, and the increase in the organic constituents of the bone, the epiphyseal extremities are also altered in shape and consistency. The epiphyses are enlarged, and are often distorted by forces acting upon the softened and yielding diaphysis. The cartilaginous cells of the epiphysis, instead of becoming calcified as a result of proper assimilation and appropriation of the earthy salts, become pathologically transformed into a soft medullary tissue. Still further, in addition to the changes observed in the diaphysis and epiphyses of the bone, the ligamentous structures also undergo changes. The ligaments become lax and altered in their histological formation, and thus they permit of a free lateral movement in a joint where, under conditions of health, such mobility is not found. Besides laxity of a ligament, shortening may occur as a result of contraction, which is seen in genu-valgum, where the external lateral ligaments of the knee-joint are found to be very taut. Langenbeck placed much importance upon this change, and I have seen him divide the external lateral ligaments with a tentome, with a view to overcoming the obstacles which prevented the straightening of the leg. This was a plan Langenbeck resorted to very frequently before osteotomy became a recognized operation for relief in these deformities. The local changes which have thus been briefly described in the shaft, the extremity, and the ligamentous structures, may be divided into two well recognized stages. The first stage is when the

bones are soft and pliable, and the second stage is when the bones are hard and unyielding in their deformed position. This clinical fact will be again referred to under treatment. The cause of the curvature in bones during the first stage has been erroneously assigned to muscular action. The anterior curvature of the tibia has been explained by a contraction of the tendo-achillis. The genu-valgum deformity has been ascribed to the contraction of the biceps. The bending of the humerus has been demonstrated to be the result of the action of the deltoid. Recent investigations have proved that muscular action is not the cause of the curvature in these cases, because the muscles themselves are flabby and weak, and if found contracted, it has been a result of the curvature rather than the cause. A corroboration of this statement is found in the fact that precisely those bones which support the weight of the body are those which are bent. In the few remaining bones which have no part in supporting the body, and which are found curved—as, for example, the curvature of the humerus—the curvature has been shown to be caused by nurses carrying the child by its arm. A still better proof lies in the fact that in children who are kept in bed no deformity exists, and the curvatures soon appear after attempts to creep or to walk. Before discussing the different varieties of curvature for the relief of which osteotomy is performed, a few words in regard to the history of the operation would not be inappropriate. The word osteotomy means literally a section of the bone.

From 1815 to 1875 a few osteotomies were performed. A saw was used in the majority of the cases, and the chisel was first employed in 1868 by Little, of London, and nearly all of these operations were treated by the intervention of an open wound. During 1875 the operation was first performed under antiseptic principles by Volkmann, a few weeks later by McEwen and by Ogston, and from that date the operation has been considered a recognized one in surgery. I will omit a list of the many instruments which have been recommended for the performance of an osteotomy, and mention only those requisite for the operation as it is performed at the present time. It was my privilege as a member of the German Congress of Surgeons, held in Berlin in 1877, to be present at the time Ogston read his paper on osteotomy, and it was subsequent to this meeting that Volkmann began his work in this department of surgery. The osteotome should be of steel, with good temper and bevelled upon both sides. The entire instrument should be of one solid piece of steel. The cutting edge should be sharp, and

one of the sides marked in half inch scale to enable the surgeon to accurately determine the depth to which the instrument has penetrated the bone. The handle should be octagonal, so that it can be firmly held by the operator, and a good head upon top of the handle against which the mallet can impinge with firmness and without danger of slipping. I have been in the habit of using McEwen's chisels, and have found them, as a rule, satisfactory. There should be at least two osteotomes, one smaller than the other, and in this way the accident of breaking the osteotome may be avoided. The larger chisel can be first used, and toward the end of the operation the second or smaller one can be employed. As the smaller one is narrower than the larger there is no danger of cutting the tissues and structures adjacent to the bone. The mallet should be of lignum vitæ, or of rawhide, which seems to answer best the purposes. A sand-bag, six inches square and covered with India rubber, is essential to a complete outfit for osteotomy. Beside the sand-bag upon which this bone is to rest during the section of it, there should be placed on either side of the child's limb two sand-bags, at least two feet in length, and equal in circumference to the thigh of a child. These long sand-bags are to be placed under the rubber, which is split in the centre so as to protect the limb to be operated upon from coming in contact with the opposite limb. These two long sand-bags lying on each side of the limb thus form, with the rubber cloth over them, a complete trough; and if the head of the table is elevated about six inches and a large pail placed at the foot of the table, every facility is provided for carrying away the irrigation fluid. The child the night previous to the operation should have a mild laxative and a warm bath. The limb to be operated upon should be carefully scrubbed with a nail-brush and hot water and soap. This removes from the leg all the fatty and oily excretions of the skin. After this ablution a saturated solution of ether and napthaline, or iodoform and ether, should be poured over the leg, and then a clean antiseptic bandage should be wrapped around the entire limb. At the time of the operation, the following day, free irrigation over the part will render it perfectly aseptic for the operation. The child should now be placed under the influence of ether, provided that no food has been taken a few hours previous to the time for the operation, and when fully anæsthetized osteotomy can be performed. The application of Esmarch's bandage is unnecessary, as there is seldom any hemorrhage sufficient to counterbalance the objections to its use. Wet towels, wrung out of a (1-2000) bichloride solution, should be placed about the limb above and below, and around the part upon which the operation is to

be performed. The technique of the operation itself may be divided, for convenience of description, into four stages, and a description of it will include the application of the permanent dressing to the wound. The *first stage* consists of the incision through the skin down to the bone. The *second stage* includes the section and fracture of the bone. The *third stage* comprises the correction of the deformity and the dressing of the wound. The *fourth stage* embraces the application of a permanent dressing. In the first stage the incision should be made by pushing the point of the scalpel straight down to the bone and cutting the skin, which should be firmly held between the thumb and index finger of the surgeon. The skin incision should be longitudinal and only sufficient to permit the chisel to be placed upon the bone, and any incision larger than this only adds a danger, by more fully exposing the seat of fracture. The incision should be squarely upon the centre of the shaft at the point where the bone is to be fractured. No vessels are wounded, and care should be exercised lest a tendon be injured or the knife slip off the bone.

The second stage now begins, and consists of placing the osteotome upon the bone and through the small skin incision. The edge of the osteotome must not overlap the side of the bone, and the direction of it must be away from the main artery lying in close juxtaposition to the bone. The handle of the osteotome must be held tightly, and the mallet should strike firm blows upon the head of the osteotome. When the chisel has traversed about half the diameter of the bone it should be removed, and the smaller chisel should be inserted into the centre of the track of the first chisel, and the instrument can be safely hammered, as the blade can not come in contact with any soft structures, because the blade of the second chisel is narrower than the first chisel, and the sides of the bone itself prevents any accident. This can divide the bone still further, and then the chisel should be removed and a clean, small, antiseptic sponge placed over the wound while the surgeon attempts to break the bone. There is great protection in the use of the second and smaller osteotome; because, otherwise the first chisel is tightly held in the bone, and in extracting it the cutting edge of the chisel may break off and be left in the bone. This accident has occurred to me twice in badly tempered chisels; but in both cases no harm arose, though a good sized piece of steel was left imbedded in the bone, and could not be removed. This accident will not occur if the second chisel is used in the manner described. The bone should not be entirely cut through with the chisel, but only three-fourths of its diameter, and then it will fracture without splintering. It is not well, on the other hand, to attempt by violence to fracture the bone if the chisel has not tra-

versed at least three-fourths of it. If a fracture is produced under these circumstances, the solution may be oblique, and a fragment with a sharp point may result, and give rise to serious difficulty.

With a green stick fracture of the lower fourth of the bone, and a clean transverse fracture of the upper three-fourths of the bone, there is no danger of any spiculæ of bone wounding a vessel at the time of the operation or later on by ulceration. If the bone is broken properly no danger follows, but it is only in those cases where there has been an improper use of the chisel or where too great mechanical violence has been employed that an osteotomy has been followed by suppuration and even death.

The third stage of the operation is now entered upon.

If, after the fracture, the limb cannot be placed in a normal position owing to the contraction of certain tendons, they should be subcutaneously divided, and this removes any obstacles to complete reduction. I have many times performed tenotomy on the tendo-achillis in cases of anterior curvature of the tibia. The physiological rest thus secured has a most salutary effect on the rapid repair of the fracture.

The lips of the small incision should now be pressed together and its edges pared of the subcutaneous fatty connective tissue by scissors curved upon the flat, and between the lips of the small wound and down to the bone a few strands of aseptic catgut should be introduced by means of Sir Joseph Lister's drainage tube forceps.

This method of drainage by capillarity was introduced by Mr. John Chiene, of Edinburgh, and in this variety of wounds it is one of the best methods for drainage.

The catgut relieves any tension in the wound, and the dressings need not be removed to withdraw the strands of catgut, as they become absorbed and give rise to no harm. The lips of the wound should now be brought in exact apposition and sewed by fine catgut, and iodoform should be dusted over the wound, and a small piece of antiseptic gauze placed over the wound and around the limb at this point. The continuous irrigation can now be dispensed with, and the rubber sand bag upon which the leg rested during the operation can be removed, together with the wet towels which were placed about the limb and over the rubber cloth. A clean wet towel which has been standing in a (1-2000) bichloride solution should now be wrung out as dry as possible and placed over the rubber cloth and under the limb so that the dressings which are to be applied will not become stained with the blood and bichloride solution in the trough. The surgeon should rinse his hands and then dip them into a bowl of bichloride (1-2000), and everything

is now in readiness for the application of the permanent antiseptic dressings, which brings us to the fourth stage of the operation.

The thin piece of iodoform gauze is now covered by a bandage wet in a warm solution of bichloride of mercury, and after fixing the iodoform gauze over the wound with the bandage, a piece of combined dressing should be made to envelop the entire limb and foot. The combined dressing consists of a layer of absorbent cotton placed between two layers of Von Brun's hospital gauze, which has been previously disinfected and prepared. This dressing is now fixed by a roller of antiseptic bandage, and then a plaster of Paris bandage can now be applied over the bandage which retains the combined dressing. I have found perforated strips of tin or sheet iron very useful to add strength to the splint, which makes it unnecessary to apply a very thick layer of plaster Paris. The child can now be placed in a bed and the nurse should steady the splint until the plaster is firmly set, and after the child has come out from under the influence of ether, the presence of the splint on the limb should give rise to no inconvenience or discomfort. This dressing can remain until it is time to remove it permanently, unless there is some local cause for changing it. I have pointed out the dangers of allowing plaster Paris splints to remain on a limb too long in cases of compound fractures; but the osteotomy wound is so small that it is not likely to give trouble. Still the fact must not be lost sight of that even the osteotomy wound is capable of giving rise to suppuration, septicæmia, and death. The day following the operation the child can sit up and its ordinary diet be allowed, and, as a rule, there is nothing in the operation to in any way disturb the happiness of the child. I have found in some cases, however, some complications a reference to which might not be amiss. Retention of urine has occurred in one case, and this lasted for nearly a week despite everything that could be done. Fat embolism has been observed in several cases, and this would be attended by a sudden rise of temperature, a quick pulse, rapid respirations and such general symptoms as would naturally awaken anxiety on the part of the surgeon. Diphtheria has occurred once as a complication, but the wound remained aseptic and union had taken place. The child became very ill and symptoms of impending suffocation rendered tracheotomy necessary; but to no avail, as the child succumbed, after a few days, from exhaustion. Measles has occurred in quite a number of cases during an epidemic. These children were transferred from Bellevue to the Island, and one case died from the disease, but with no trouble with the leg.

The cases which were returned to Bellevue after convalescence

were examined, and the fractures were found firm, the deformities corrected, and there seemed to be no ill-effects from the measles during the repair of the fractures. Bichloride irritation has followed in several cases where the skin was hypersensitive, and a small superficial ulcer followed, which involved only the outer layer of the skin.

In none of the many cases, amounting to more than a hundred, have I seen suppuration, or non-union, or anchylosis ; but in every case the deformity was corrected ; but not always by one operation ; for it was necessary in some cases to resort to many osteotomies in the leg, thigh, and forearm. In certain cases when the deformity was nearly corrected the parents would be satisfied with the great improvement and remove the child from the hospital before a final operation was performed. In a careful analysis of a large number of cases occurring in the practice of other surgeons as well as those occurring in this city, there is every reason to believe that under proper precautions the operation is attended with little risk, and that the correction of this deformity is now entirely under the control of the surgeon. Osteotomy not only can overcome the rachitic deformity, but it offers an opportunity to correct a deformity arising from a badly united fracture, or an irregular contraction, due to a diseased joint. Osteotomy opens up a new field for surgical interference, and cases of bow-legs, knock-knees, and deformities of upper extremity can now be safely corrected, which but a few years since were supposed to be entirely beyond the control of the surgeon to remedy.