THE ORIGIN OF ORTHOPAEDIC SURGERY.

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THERE was a work, in two volumes, entitled, "*Orthopaedia; or, The Art of Correcting and Preventing Deformities in Children*"; translated from the French of M. Andry, Professor of Medicine in the Royal College, and Senior Dean of the Faculty of Physick at Paris." It was printed by A. Millar at Buchanan's Head in London in 1743. M. Andry explains his choice of the term as follows:

As it is not within the reach of every Reader to understand the Title of Orthopaedia, which is affixed to this Book, I shall begin with explaining it: after which I shall give an Account of the Book itself. But in the first place I must take notice of two Pieces which have been published upon a subject akin to this, though they differ a good deal from it; the first in the year 1584, by Scèvele de Saint-Marthe, and the second in the year 1656 by Claude Quillet. As to the Title, I have formed it of two Greek Words—namely, *ὀρθός*, which signifies straight, free from Deformity, and *παῖδιον*, a child. Out of these two Words I have compounded that of Orthopaedia, to express in one Term the Design I propose, which is to teach the different Methods of preventing and correcting the Deformities of Children.

The expression seemed to me the more allowable, that the two celebrated Authors above cited, have made use of Terms of the same kind: the first in giving the Title of Paedotrophia to a Treatise upon the Manner of suckling Infants; and the second that of Callipaedia, to a Poem upon the Method of getting beautiful Children: both which Titles are likewise taken from the Greek: the first from *παῖς*, an Infant, and *τροφή*, Nourishment; and the second from *καλός*, beautiful, and *παῖδιον*, a Child.

In a supplement at the end of the second volume mention is made of a series of critical articles, published weekly, by the Abbé Desfontaines, under the title of "Observations upon Modern Writings," and Andry says that, "In this particular one of October 14th, 1741, he (Desfontaines) confines himself to my Orthopaedia." The term "orthopaedia" was, therefore, probably used for the first time in 1741, a view corroborated by William Adams, who states that Andry published his book in Paris in that year.

Hippocrates used bandages for the cure of varus, and the only advance on this method, for centuries, was the employment of mechanical appliances. Orthopaedic surgery can only be said to have really begun with the introduction of tenotomy. The first record of tendon cutting was that performed by Lorenz, on the advice of Thilenius, in 1784. He cut the tendo Achillis through an open wound for talipes equino-varus. The first account of subcutaneous tenotomy is by Petit in 1799, who cut the tendo Achillis for a retraction of the heel after Chopart's operation. In 1816 Delpech, of Montpellier, conceived the idea of treating talipes equinus by cutting the tendo Achillis subcutaneously after first transfixing the leg just in front of the tendon. Owing to a mishap in his first case he did not pursue the operation, although in his work, *De l'Orthomorphie* (Paris, 1829) he lays down very sound rules for the operation and subsequent treatment. Stromeyer, who greatly benefited by Delpech's rules, divided the tendo Achillis by subcutaneous puncture in 1831, and by a series of successful cases established the division of tendons on a secure basis, and ensured its reception as a standard operation in surgery.

Stromeyer published his results in his book on operative orthopaedic surgery (Hanover, 1838). A young English physician in London, W. J. Little, who had talipes equino-varus following infantile paralysis in early childhood, had consulted Sir Astley Cooper and most of the approved surgical authorities in London, but from none did he receive the slightest prospect of cure. In June, 1836, he went to Hanover, and his tendo Achillis was divided by Stromeyer, who later afforded Little the opportunity of practising the operation himself. Going afterwards to Berlin, he taught the operation to Dieffenbach, and treated upwards of thirty patients in that city; Little was therefore the first to introduce subcutaneous surgery into the Prussian capital. Through Johannes Müller's kindness he was also allowed to dissect numerous deformed fetuses contained in the Berlin Museum. In Stromeyer's own words, Little became "the apostle of subcutaneous surgery," for until the conversion of Dieffenbach the German universities regarded the operation with dis-

favour, although afterwards Stromeyer himself was elected professor of surgery at Erlangen.

On his return home Little at once introduced the operation, performing his first tenotomy in London on February 20th, 1837, and a few weeks later attended a discussion at the Royal Medical and Chirurgical Society on this new surgical procedure. The following year he was instrumental in founding the Royal Orthopaedic Hospital, the first public meeting of which was held in 1840 with the Earl of Eldon in the chair. This was the beginning of orthopaedic surgery in this country. In 1839 Little, who was now assistant physician and lecturer on comparative anatomy at the London Hospital, published the first English book on this branch of surgery, *A Treatise on the Nature of Club Foot and Analogous Distortions*, and dedicated it to Sir Astley Cooper, who had displayed a warm interest in what Little had been able to demonstrate. Little continued to write much, and in 1853 published another important work, *On the Nature and Treatment of the Deformities of the Human Frame*. His description of spastic diplegia in infants reveals his power as a clinician, this affection being often referred to as Little's disease.

Of the many workers who have appeared in this field since Little, two stand out prominently—William Adams and Hugh Owen Thomas. William Adams followed closely in Little's steps, and did as much as pre-antiseptic days would permit to advance the subject. He joined the Royal Orthopaedic Hospital as assistant surgeon in 1851, and did much good pathological work. His book, *Club Foot: its Causes, Pathology, and Treatment*, based on his Jacksonian Prize Essay of 1864, was published in 1866. He devised operations for ankylosis at the hip-joint, and for Dupuytren's contraction, and introduced several ingenious corrective appliances. Among other works published by him was one on *The Reparative Process in Human Tendons*, based on post-mortem examinations and experiments on rabbits. John Hunter and Paget had previously studied tendon repair in animals, the former, it will be remembered, being induced to do so through rupturing his tendo Achillis when dancing.

Hugh Owen Thomas of Liverpool was practically a contemporary of Adams. He was a man of extraordinary originality of view. In 1869 he published a well-illustrated monograph on *A New Method in Applying the Wire Ligature in Compound Fractures of the Lower Jaw*, in which he anticipated much of the present day method of dealing with this lesion. His now famous hip and knee splints were figured for the first time in *Diseases of the Hip, Knee, and Ankle* (1875). In this book Thomas adopted the great principle of mechanical and physiological rest, in the treatment of surgical diseases, laid down by John Hilton in his famous lectures at the Royal College of Surgeons, 1860-1862. Hilton very successfully applied his principle to diseases of the hip-joint by means of a splint, which consisted of a leather case from the pelvis to below the knee, with a posterior steel extension and foot-piece to fix the rest of the limb. The Thomas splint was an improvement on this, in that it was simpler and could be variously modified for correction purposes in cases with flexion.

It took many years, however, for Hilton and Thomas to change surgical opinion upon the treatment of joint tuberculosis. Thomas was the first to point out the cardinal principle of relaxing paralysed muscles, and thus preventing over-stretching; he carried it out in practice with his metal splint for dorsiflexion at the wrist, and with his caliper for maintaining extension at the knee.

THE USE AND ABUSE OF BONE GRAFTS.

BY

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THE operation of bone grafting for non-union of fractures is by no means a new one, and it is one which has undergone many alterations since its inception.

The first bone-grafting operation was done in 1809, when Mercer obtained successful healing of bone plates in the skull after a trephine operation.

A great number of substances, such as solidified milk,

have at various times been suggested which should replace bone tissue and act as a scaffolding for the formation of new bone, but all of them have fallen into disrepute, as the great majority were either quietly discharged as foreign bodies or else led to sepsis being started or restarted.

In 1881 Macewen wrote a paper explaining his method of bone grafting in a case of ununited fracture. In this case he used wedges of bone removed from rachitic tibiae broken up into very fine pieces and placed between the freshly chiselled ends of the broken bone; thus new bone was formed.

The modern technique follows that of Albee, and aims at obtaining a long solid unbroken graft consisting of periosteum, compact bone, and marrow which will unite on each side with the two fractured ends, and which will increase in size until it is as large as the receiving bone.

The causes of non-union are many and varied, and unfortunately some or all are present in a large majority of the cases of fracture now reaching the military hospitals.

The first and in all probability the most common cause of non-union is want of fixation of the fracture. This is usually due to the fact that the splints are so placed that they control the region of the fracture alone, and do not extend so as to control the joints on either side. Without this there can be no proper fixation.

The second cause is the presence of foreign bodies, either metal or cloth, or pieces of tissue such as muscle or fascia between the fractured ends, or the occurrence of virulent suppuration, which inevitably causes a localized sclerosing osteomyelitis, and so shuts off the medullary cavity with its powerful osteogenetic function.

The third local cause of non-union is loss of bone tissue, either due to the destruction and loss of bone tissue caused by the missile, or else to the removal by operation of apparently loose pieces of bone which, if left *in situ*, would in the large majority of cases unite firmly in position, and so form a sound thickened bone.

Delayed Union and Non-union.

The first question in regard to fractures which have not united is to distinguish between delayed union and non-union. A large number of cases are met with in which, for some cause other than the interposition of tissue between the fractured ends, there is delay in the union of a fracture. The cause may be local, such as we have just mentioned, or it may be some general debilitating process, and if this is treated and cured the fracture will unite readily. Apart from these, however, there are a number of cases in which no local or general cause can be found for the want of union. It would almost seem as if there was a definite idiosyncrasy on the part of the patient, or, indeed, on the part of the particular bone, so that one fracture may not unite, whilst another in the same patient at the same time may unite firmly and rapidly.

There is no time limit beyond which it can definitely be said that a fracture which has not united has passed the stage of delayed union and is in a state of non-union. That a fracture is ununited can only be said when it has undergone proper treatment by fixation, venous congestion, and the administration of thyroid extract for a period of at least three months without the occurrence of union at the site of fracture.

If non-union of a fracture has definitely occurred one must then decide, "How long should the interval be between the cessation of all discharge and the time of operation?"

It has been found by experience that if the intervening period is less than six months many of the cases operated on will become septic even when the wound has remained soundly healed without any signs of infection for some time before the operation, and where the strictest asepsis has been carried out at the operation.

This recurrence of sepsis has been attributed to a change in the condition of the blood, which, instead of being, as it normally is, a germicide, becomes instead a culture medium for bacteria, but the most probable explanation is that in shell or bullet wounds, especially in those which have produced a fracture, a large amount of fibrous tissue is formed owing to the extensive wounding and opening up of the neighbouring tissues and the spreading of the sepsis along the fascial planes.

As healing takes place small localized patches of sepsis are found which are completely surrounded by their fibrous

tissue wall, and are thus to all intents and purposes completely shut off from the blood and lymph stream; these foci are opened up during the course of the operation, and lead to a recurrence of the sepsis. This I have found to be the case in several patients in whom small pieces of metal were present apparently perfectly aseptic; when cut down upon they were found to be localized in a fibrous capsule, in which they lay bathed in pus.

In one case on which I operated recently, intending to do transplantation of bone, a small abscess was found in the centre of one of the broken ends; it was only after opening into the shaft of the bone that the abscess with its central sequestrum was seen. This case had remained soundly healed without any discharge and with no sign of redness or inflammation for a period of four months.

The fixing of the interval at six months is due to the fact that in the eighteen cases of bone grafting which I have done and in which this interval had been left there has been no instance of a recurrence, but in the first cases operated on without this interval there were two cases of recurrence of sepsis.

The operation of bone grafting should, then, be performed after the proper interval has elapsed since the cessation of all discharge. There are certain principles about the graft which should be rigidly adhered to.

1. The Graft should be Autogenous.

In one case which came under my care a piece of rabbit's bone was transplanted into an ununited ulna. There can, however, be no advantage from these exogenous grafts; they complicate the operation to a very marked degree, and lead to great increase in the risk of sepsis at the time of operation.

In this particular case there was no possibility of success owing to the fact that the operation was performed and the exogenous graft implanted whilst the wound was still actively discharging, and that the bone transplanted had an outer covering of compact bone on all sides which left no possibility of expansion of the transplant to the size of the receiving bone; lastly, the transplant had been fixed in position by means of wires which caused marked loss of bone tissue.

2. Situation from which Graft is Removed.

The graft may be removed from one of two positions: (a) Either from the subcutaneous surface of the tibia, which on account of its extent and its accessibility is the site usually preferred, or (b) from the upper or lower ununited fragment, by what is known as the sliding graft.

In all cases in which the patient has no objection to what may be called the double operation the graft should be taken from the tibia. This is not because the grafts may be removed from the tibia much more easily and of much larger size than from any other bone, but also because in the case of every ununited fracture there is a condition of osteo-sclerosis at the ends of both the fragments, which is greatly increased in the case of an actively suppurating compound fracture such as a gunshot fracture. If sections of the ends of the fragments are made the medullary cavity will be found to be lost for a space of half an inch or an inch on either side of the fracture, and the density of the bone is greatly increased, so that it here becomes very much harder than normal, and frequently it is almost impossible to use an ordinary chisel. Thus any bone graft removed in this region will have to extend so as to pass beyond these thickened portions and reach the healthy bone on either fragment.

3. The Graft should Consist of Periosteum, Compact Bone and Marrow.

In several cases in which the graft has been used without periosteum, the graft has united firmly, showing that this membrane is not essential. Periosteum stripped from the bone in its course, but attached at the two ends, can throw down a layer of new bone on its inner surface, so that the structure raised from the surface of a bone by means of an elevator, whether it is periosteum alone or periosteum and attached bone-cell, can undoubtedly form bone.

Union of a bone graft consisting of compact bone and medulla can undoubtedly occur, and has done so on many occasions, thus showing that the periosteum has at best

only a subsidiary part in bone formation, but a graft consisting of compact bone and periosteum alone will in the large majority of cases not unite, thus proving the great importance of marrow.

One case of non-union of the radius which I had under my care illustrated this point. A graft of bone had been taken from the subcutaneous border of the tibia consisting of compact bone and periosteum alone without marrow. This graft remained in position in the arm for three months without any sign of union, and was then quietly discharged through the skin.

4. *Size of Graft.*

The graft should be at least two inches longer than the space between the fractured ends which it is going to fill. The older method of bone transplanting or grafting as used by Macewen aimed at freshening up the fractured ununited ends of the bone and filling up the space between them with the chopped up pieces of bone which naturally consisted chiefly of compact bone, and which lay in contact with each other and with the freshened bone ends. But the chief power of union in a bone graft comes from the presence of the bone marrow and the adjacent more porous bone which is completely absent from the fractured ends for a distance of half an inch to an inch, owing to the obliteration of the medullary cavity; therefore the transplanted bone fragments came into contact only with the sclerosed ends of the bone in which the blood supply is markedly diminished; and the osteogenetic power almost absent. Any bone graft which is taken should be long enough to extend beyond this sclerosed area on both fragments.

5. *Preparation of Graft.*

The graft may be obtained from the tibia or from the fractured bone itself at a higher level in two ways.

(a) By means of a circular saw, with either one or two parallel blades, driven either by a small motor or by hand by means of a large wheel turned by an assistant at some distance from the table. With this the bone is sawn down to the medulla for the required distance, and then transferred to the site of the operation.

(b) The other method is by means of chisels and a bone drill. If an attempt is made to remove a bone graft by means of a chisel alone it will be found that the bone becomes splintered and almost useless for the purpose in view. If, however, the bone is first drilled down to the medulla along the line of the proposed bone graft, then the subsequent use of the chisel is without danger, as the bone breaks between the drill holes.

When the graft of sufficient length has been obtained a bed should be made for its reception in the two fragments at the site of fracture by removing from these broken ends a wedge of bone equal in breadth to the graft and so placed that the graft lies on either fragment for a distance of at least $1\frac{1}{2}$ in. When the graft has been placed in the bed prepared for it, it should be anchored there by means of catgut or small bone pegs. No metal, such as plates or wires, should ever be used in its fixation, owing to the fact that metal of any description placed in a bone acts as a foreign body and leads to atrophy of the bone round the site of the metal, thus hindering bone formation which would otherwise occur between the fragments.

It has been shown that in a plated fracture bone is thrown out on all sides except at the site of the plate or screws. There is atrophy of bone which can frequently be seen in the *x*-ray photograph as a light area round each of the screws.

The osteogenetic action of the bone graft should not be opposed by the inhibitory action of the screws. As regards the after-treatment the newly implanted bone graft should be kept in position without any stress or strain for a period of at least two months.

Many forms of splints may be used for this purpose, but the most efficient method of fixation is to apply a plaster-of-Paris case to the whole limb, so that all the joints which by their movements could in any way act on the transplant are completely fixed. This case should be put on immediately after the operation. It is not at all necessary to leave its application over until the stitches are taken out, as they can be easily removed through an opening made in the plaster directly over them. This is a marked advantage, as the surgeon has in his mind at the

time the exact position of the limb in which the graft lies most snugly in its bed.

When the plaster has been removed after two or three months the transplant will probably be found to be firmly united, but in case the union is not firm the limb should be immediately replaced in plaster or splints and treated by fixation and venous congestion, with the administration of thyroid extract, which undoubtedly tends to promote the deposit of callus and so to hasten the union.

The failures of bone-grafting operations which I have seen have been due to (1) want of proper interval since the cessation of discharge, (2) insufficient length of the graft, (3) inefficient fixation, (4) the use of the sliding graft.

A POSSIBLE ELECTRO-CARDIOGRAPHIC SIGN OF MYOCARDIAL CHANGE.

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DURING the last few years the attention of those interested in diseases of the heart has been increasingly directed towards the signs and symptoms by which impairment of the myocardium can be diagnosed. The importance of the heart muscle in the prognosis of cardiac disease is no new discovery; the pioneers of cardiology fully realized that grave valvular lesions could be compensated for by efficient heart muscle, but while their methods of examination permitted surprisingly accurate diagnosis of valvular defects, there was by no means the same precision in their means for determining the state of the heart muscle.

Though modern methods of investigation have somewhat increased our knowledge in this direction, it is not possible, as yet, to say that we can as accurately visualize in any individual case the condition of the myocardium as we can, for instance, that of the aortic valves. Any method of investigation, therefore, which tends to throw light on this problem is worthy of serious consideration.

Numerous attempts have been made to arrive at a just estimate of the condition of the myocardium in regularly acting hearts, such as the careful consideration of the subjective symptoms, the response of the heart to exercise, the relative intensity of the first apical and the aortic second sounds, the length of the A.V. or P.R. interval, and the inversion of the second ventricular or T wave of the electro-cardiogram in at least two of the usually employed leads. No doubt all of these methods have their uses.

We have had during the last few years the opportunity of examining several thousand cardiac cases and of comparing the clinical findings, and in a large proportion the subsequent histories as well, with the electro-cardiograms. As a result of these observations we have become increasingly convinced that the height of the second ventricular or T wave affords some indication of the efficiency with which the ventricles are functioning.

The second ventricular wave marks the end of systole, and it is generally agreed that it is produced by some portion of the base remaining in a state of contraction after the contraction of the apex has ceased. There is not, however, the same agreement as to the exact site of this residual contraction. Sherrington considers it to be the aortic base; other observers are not disposed to localize it so definitely. From the point of view under discussion this is immaterial; the essential question is whether very low or absent T waves in an electro-cardiogram indicate myocardial impairment or not.

With a view to bringing our opinion in some measure to the proof, it seemed to us that if we could get cases in which there was clinical evidence of myocardial change, and in which the electro-cardiogram showed small or absent second ventricular waves, and if on treatment these waves increased or reappeared in electro-cardiograms concurrently with an improvement in the clinical condition, it would, to a certain extent, support our contention.