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SYMPOSIUM: AAOS 75TH ANNIVERSARY TRIBUTE TO PAST PRESIDENTS

The Classic

Arthrodesing Operations on the Feet

Edwin W. Ryerson MD
(1872–1961) The 1st President of the AAOS 1932

Dr. Edwin Warner Ryerson was born in New York City, graduated from Harvard, then trained at Boston Children's Hospital [1]. After visiting centers in Berlin and Vienna he moved to Chicago in 1899, where he accepted a post at Rush Medical College. In 1916 he was named professor and head of orthopaedics at the University of Illinois College of Medicine. Owing to WWI he entered military service in 1918–1919. Afterward he became head of orthopaedics at Northwestern University until his retirement from the university in 1935. He continued in private practice until 1947, when he retired to Florida.

Dr. Ryerson maintained a lifelong interest in teaching and service to the orthopaedic community. He became a member of the American Orthopaedic Association in 1905 and was President in 1925. Dr. Ryerson was active in the Clinical Orthopaedic Society, which also had a role in forming American Academy of Orthopaedic Surgeons [4]. In the archives of the AAOS, he was described as "a forensic and parliamentary expert" [6]. He was a founding member of the American Board of Orthopaedic Surgery in 1934, became its vice President in 1935, and served on the Board until 1940 [11].

The article reproduced here describes the triple arthrodesis [9]. Ryerson modified a technique earlier described by Hoke which advocated fusing the subtalar and talo-navicular joints [7]. According to Campbell [5] Ryerson popularized the name "triple arthrodesis." Hoke had not mentioned fusion of the calcaneo-cuboid joint, although Gill, in a discussion following Hoke's description states, "an additional arthrodesis os calcis and cuboid is unnecessary." Thus, it is possible Ryerson introduced the third fusion of the triple arthrodesis, although the record is not clear on this point. Ryerson's operation, however, was commonly used to stabilize the hindfoot in polio patients, and continues to be used less commonly today for other indications. It is likely Ryerson met Adolf Lorenz (1854–1946), the Professor of Orthopaedics at the University of Vienna at the time of his visit [8, 10]. Lorenz, in turn, had trained with Eduard Albert (1841–1900) who conceived the idea of arthrodesis for paralyzed extremities [2, 3]. As with most surgeons of the time, Ryerson wrote on a wide variety of topics related to spine surgery, infection, and congenital anomalies, although he seemed to have a particular interest in foot surgery.

Edwin W. Ryerson, MD is shown. Photograph is reproduced with permission and ©American Academy of Orthopaedic Surgeons. *Fifty Years of Progress*, 1983.

Richard A. Brand MD

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Deformities and disabilities of the feet, due to infantile paralysis or other causes, have received a great deal of attention from the orthopaedic surgeons for many years. Certain fundamental principles have been developed which are well worth following. The essential aim of this kind of reconstruction surgery is the improvement of the function of the foot. The damage done by the attack of poliomyelitis, or the traumatism to nerves or muscles by war wound or civil injury, has produced a distorted or unstable mechanism upon which the individual must walk with a degree of difficulty corresponding to the degree of disability. In the early days of surgery, little attempt was made to change the shape of the deformed foot. The shoemaker did his best to supply a covering which fitted the foot, but his efforts ended there. The unfortunate patient walked upon the point of the heel, or the ends of the metatarsal bones, or the side of the cuboid bone, with no prospect or possibility of improvement. In later years, tenotomy and forcible correction offered much hope, but little fulfillment, except in the cases of congenital club foot. It soon became evident that simple correction, or even overcorrection, of paralytic talipes never produced a permanent cure of the deformity. Slowly, but surely, the distortions recurred, in spite of the most carefully designed braces and apparatus. Then came the brilliant tendon-transplantations, ingenious and fascinating. It is simple and easy to convert flexors into extensors; abductors in adductors, etc.; they will functionate, they will obey the mind's commands, but they will not prevent or cure deformity in the feet. The most successful results seen in a large number of carefully performed tendon transplantations recently reviewed by the writer were observed in cases where extensive cuneiform osteotomies had been done simultaneously for the relief of bony deformities. By reason of these osteotomies, some of the joints of the foot, usually the medio-tarsal, had been obliterated, and an ankylosis or arthrodesis had resulted. In practically all other instances, although the tendon transfers were technically successful, deformity had recurred, sometimes in its original form, sometimes in a different form, but always deformity. The causes of this lack of practical success were, in general, due to three main factors. First, lack of power on account of (a) disparity in size between the transplanted muscle and the one which it was desired to replace; (b) adhesions limiting the range of contractility of the transplanted muscle (much less frequent under the later technique of Biesalski and Mayer); (c) mechanical difficulties resulting from change in direction or function, as in transferring a peroneus longus to act as a tibialis anticus, or making a flexor serve as an extensor; also, failure to suture the tendon under exactly the proper amount of tension. Second, the difficulty in securing an exact balance of power when more than one set of motors were paralyzed, as, for example, combined paralysis of tibialis anticus and posticus, or triceps surae and tibialis posticus, etc. When two groups are paralyzed, the problem of reconstruction is usually too complicated for simple tendon transplantation. Third, the fact that the foot is not a rigid lever, but is made up of many joints which are capable of independent motion, whose mobility cannot be controlled completely by the ordinary tendon transplantations. Under the severe strains of locomotion and weight-bearing, these imperfectly controlled joints become

FIG. I. F. M.

FIG. II. F.M.

FIG. III. F. M.

Fig. 1 Paralytic equino-valgus. Triple arthrodesis. Peroneus longus transplanted into tibialis anticus. Operation Nov. 1, 1921. The last two pictures were taken March 13th, 1922.

distorted, and deformities soon make their appearance. The subastragaloid and mediotarsal joints are the most frequent offenders, followed by the tarsometatarsal joints.

It is a common experience to find that a tendon transplantation which for many months seems to be a brilliant success gradually becomes less and less efficient, and at the end of two or three years is found to be wholly unsatisfactory from its inability to control the lateral deforming influences. The best results of tendon-transplantation seen by the writer have been where the extensor proprius hallucis was made to act as a tibialis anticus, and where the semitendinosus and the long head of the biceps femoris were transplanted forward into the patella. Although the upper extremity is not included in this paper, it should be mentioned that the results of transplantation in the arm and forearm are much more uniformly satisfactory than in the lower extremity.

One of the most disappointing operations has been the attempt to control varus deformity in the foot by the transplantation of the tibialis anticus as a whole, or in part, to the outer border of the foot. This operation at first seems to be successful, but is always followed by a return of the varus, because the medio-tarsal joint is not properly controlled by the muscle insertion, which has been made at a point distal to this joint. This operation should be abandoned, in favor of a medio-tarsal arthrodesis.

Next in order came the useful and practical operation devised by Royal Whitman, astragalectomy and backward displacement of the foot. It was designed for the relief of calcaneus and calcaneo-valgus deformities, and has

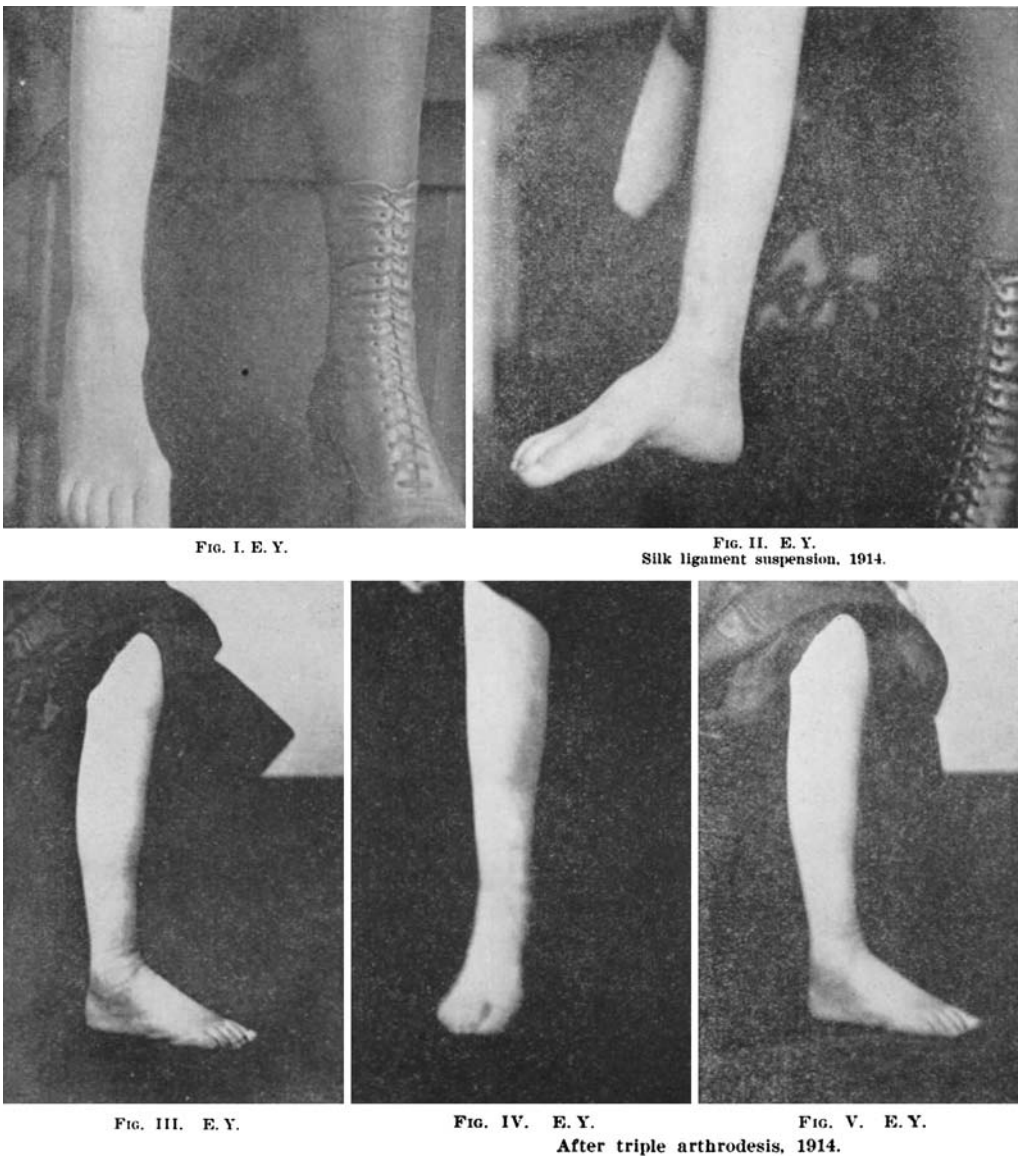

Fig. 2 Silk ligament suspension, March, 1914. In 1922 foot began to turn in to varus. Triple arthrodesis performed July 5, 1922. The last three pictures were taken six months after the arthrodesis.

unqestionably been the most generally successful method in use at the present time in the treatment of this particular deformity. Many operators, however, have used it in cases of equinovarus, and the results have been almost uniformly unsatisfactory. The reason for this is not difficult to understand. The removal of the astragalus leaves a large gap or defect in the bony continuity of the inner border of the foot, and although the tibia partly fills this gap, it fails to prevent the recurrence of the varus deformity. In the opinion of the writer of this paper, therefore, astragalectomy should not be performed in any cases of varus deformity where it can be avoided. In a very few cases of great severity (usually neglected cases of considerable age), it may be impossible to obtain sufficient correction unless the astragalus be removed and in such cases the operation should be supplemented by the lateral arthrodesis to be later described.

Silk ligaments, and the implantation of tendons into the tibia and fibula to control varus and valgus deformity have not stood the test of time. They have an inherent mechanical defect, in that they act simply as guy ropes from the leg bones, and they do not prevent motion in the subastragaloid and medio-tarsal joints. They often act admirably to check plantar flexion in "drop-foot," but they do not control rotation and lateral deformity. Implantation or tenodesis of the tibialis anticus or the tendo Achillis by Gallie's method is often useful as an adjuvant to other operations.

FIG. I. S. O.

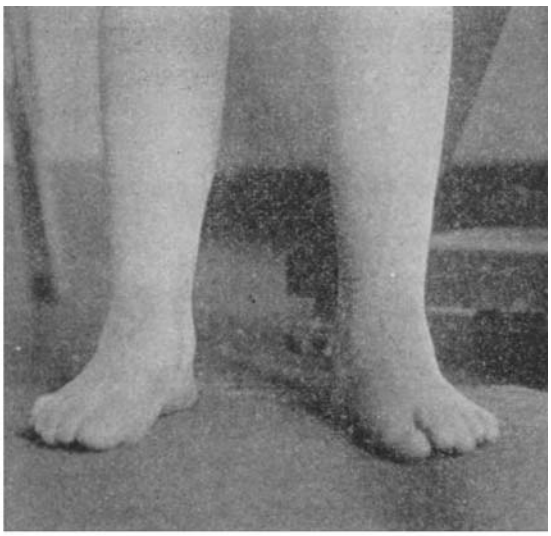

FIG. III. S. O.

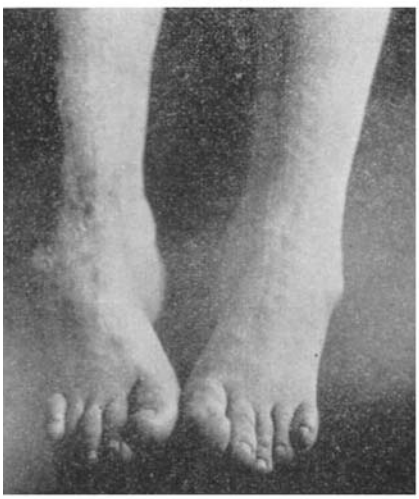

FIG. II. S. O.

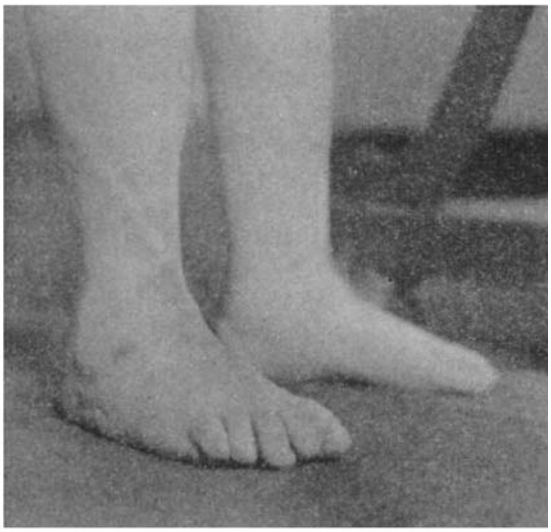

FIG. IV. S. O.

Fig. 3 Paralytic equino varus. Right foot—Steindler stripping of os calcis. Tendo Achillis lengthened. Hoke's remodelling of head of astragalus. Piece of cuboid inserted into astragaloscaphoid joint. Ext. Prop. Hall. inserted into first metatarsal. Calcaneo-cuboid arthrodesis, also subastragaloid. Left foot—No subastragaloid arthrodesis, otherwise same operation. Last two pictures taken eight months after operation.

Careful analysis of the cases studied in the series previously referred to has led to the conclusion that the chief cause of complaint and disability is the development of lateral deformity in the feet. Calcaneus deformity can be relieved by Whitman's operation. Drop-foot can be relieved by braces or by Gallie's tendon implantation. Lateral deformity, varus or valgus, cannot uniformly be relieved by either method. Some one has observed, and correctly observed, that a person with an artificial leg and foot walks much better than most persons with infantile paralysis. One of the chief reasons is that the ankle joint and foot in an artificial leg are capable of motion only in flexion and extension, the most important motions, and the only really necessary motions, in ordinary walking. There are no deformities in the artificial foot, no painful projections of bone, no calluses or bursae, no lateral instabilities. Why should we not, then, so stabilize the tarsus and metatarsus that these lateral deformities and disabilities cannot occur? The astragalus is held with sufficient firmness by the malleoli, in most cases, to prevent lateral motion of this bone. If, now, we fasten all of the other important bones of the foot to the astragalus, we ought to obtain a foot which is incapable of lateral deviation. Gwilym Davis was probably the first operator to see this proposition clearly, and he devised the horizonal section of the foot, cutting through the joint between the astragalus and calcaneus and then forward in a horizontal plane through the head of the astragalus and the upper part of the scaphoid. No bone or cartilage is removed, but the adjoining surfaces of the astragalus and calcaneus are thoroughly dug up and the chips allowed to remain. The soft tissues having been freely detached, and the chisel-gouge having been freely thrust through from one side of the tarsus to the other, a complete horizontal transverse

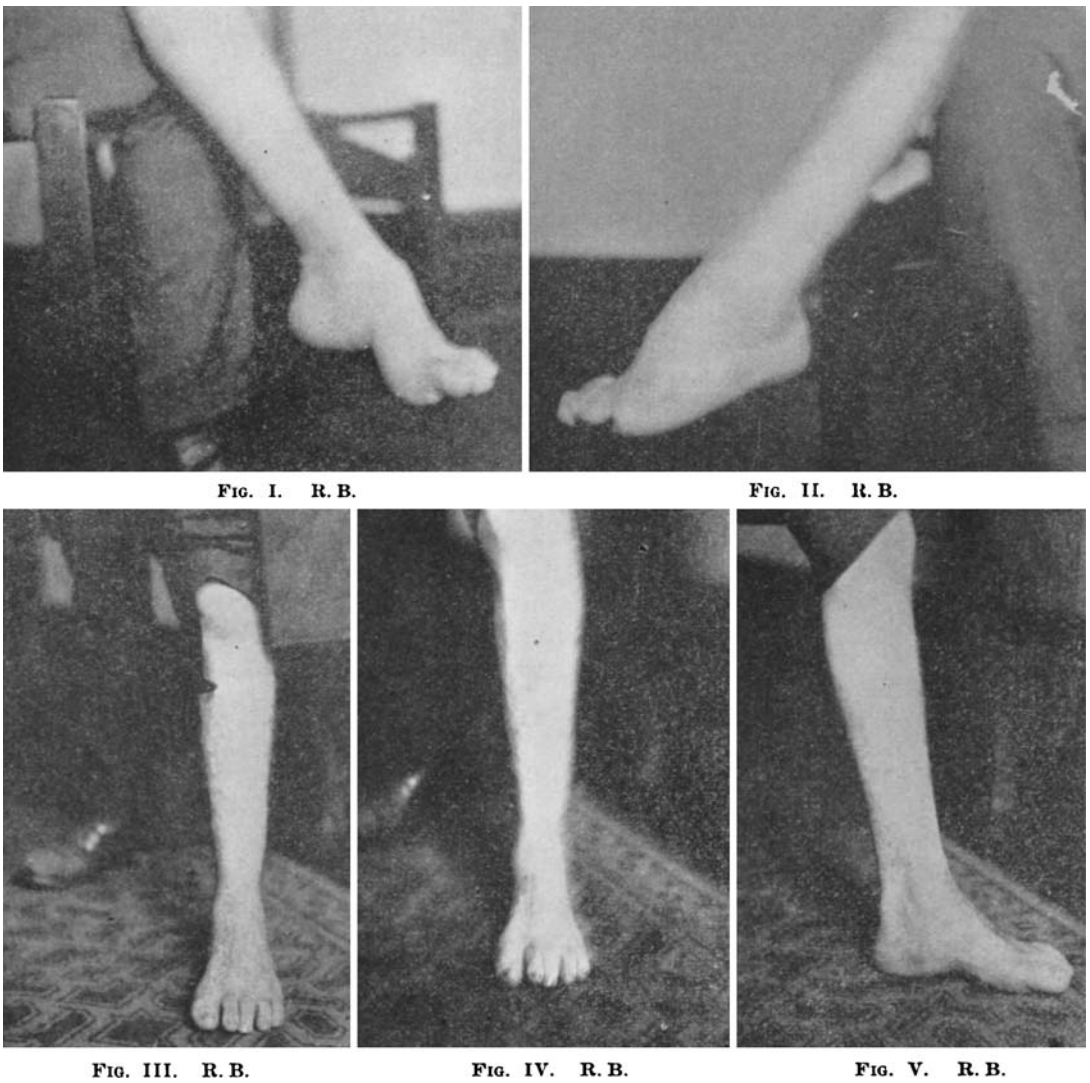

Fig. 4 Hollow claw foot, with varus. Steindler stripping of os calcis. Wedge from dorsum of foot, including astragalo-scaphoid and calcaneo-cuboid joints. Subastragaloid joint curetted. Operation July 7th, 1921. Last three pictures taken Dec. 19, 1921.

section of the foot, just below the malleoli, has been made. The foot is then forcibly thrust backward about 2 cm., the two incisions sutured, and a plaster of Paris dressing applied with the foot in slight equinus and with no lateral deviation in either direction. This produces an ankylosis of the subastragaloid and the mediotarsal joints, and very effectually checks all lateral distortion which might occur by reason of motion in these particular joints. Davis' operation has apparently been very infrequently used, to judge by the literature, and yet it was brilliantly conceived and is of great practical value. Like Whitman's operation of astragalectomy and backward displacement, it was designed for the deformity of calcaneocavus, but it prevents lateral deformity in a much more certain and satisfactory manner than does Whitman's operation. It also has the advantage of producing no shortening of the total length of the leg from knee to sole. It does not produce so much stability in cases where the astragalus fits loosely between the malleoli, but in such cases the external malleolus can be cut obliquely and bent into closer contact with the astragalus.

There are some cases, however, where well-marked lateral deformity exists beyond the medio-tarsal joint, usually a varus position, rarely a valgus. In such cases, besides fusing the medio-tarsal joint, it is desirable and practicable to cause a fusion of, first, and most important, the joint between the cuboid and the base of the fifth metatarsal bone, and, next, the joints between the scaphoid, the internal cuneiform, and the first metatarsal bones. This operation has been performed by the writer in a small series of cases, and with results which seem to be satisfactory. An interesting fact has been noted in one case, which may prove to be of considerable importance.

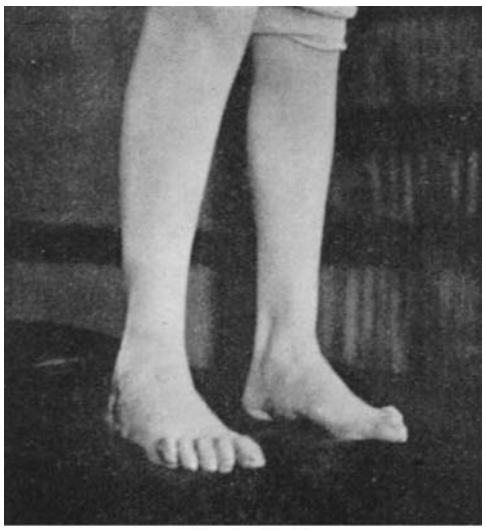

FIG. I. R. M.

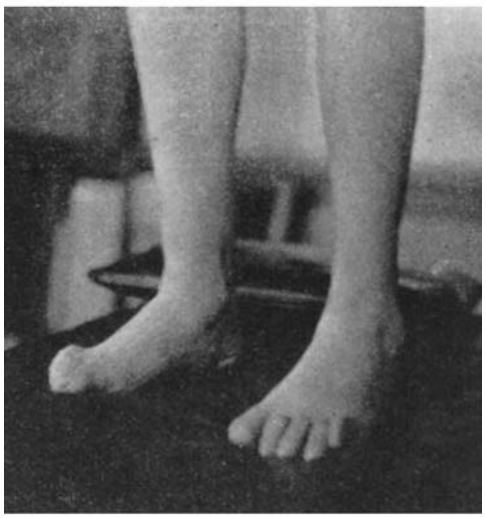

FIG. II. R. M.

Fig. 5 Severe hollow claw feet. Cuneiform osteotomy with subastragaloid arthrodesis. July 11, 1922. Also, Steindler stripping of os calcis. These pictures taken seven months after operation.

A boy of 7½ years was operated upon in 1920 for a rather severe varus with slight equinus. The cartilage was carefully cut away from the astragalo-scaphoid, the calcaneo-cuboid, and the cubo-fifth metatarsal joints, and the subastragaloid joint was curetted and gouged. The foot was kept in a plaster of Paris splint for three months. Examination in January, 1923, showed a stable, straight, and useful foot, with none of the former tendency to varus deformity. There was, however, no fusion whatever in the astragalo-scaphoid joint. This joint was as freely movable as before, except that its lateral excursions could not be carried out on account of a very complete fusion of the bones on the outer side of the foot. The result, then, is practically as satisfactory as if the astragalo-scaphoid joint were also ankylosed, and there is, in addition, slightly more flexibility of the foot. Whether or not this "lateral arthrodesis" will be sufficient to maintain a correct position of the foot in other cases, remains to be seen. The operation is much easier and more accurate.than the astragalo-scaphoid arthrodesis, since the two joints are nearly plane surfaces and the cartilage can be cut off with a few strokes of the chisel. It can probably be performed with success in younger children than can the astragalo-scaphoid arthrodesis, because the layers of cartilage are thinner than in the head of the astragalus, at equal ages, and it is therefore easier to obtain approximation and union of the denuded surfaces. The combined operation should always be performed, however, except possibly in cases of severe varus deformity where it is not desirable to shorten the inner border of the foot.

The purpose of this paper is to advance the following proposition:

1. Lateral deformities of the feet, especially those due to paralysis, are the source of considerable disability.
2. They have not been so successfully provided for as have the deformities of calcaneo-cavus and talipes equinus.
3. They can be effectually treated by arthrodesis of the subastragaloid, the medio-tarsal, and the first and fifth tarso-metatarsal joints.
4. No radical operations should be performed until at least two years have elapsed since the acute attack, nor until careful trial has been made of non-operative treatment, such as muscle training and protection of weakened muscles by apparatus. These operations are much more successful in children over 12 years of age than in younger children.

Muscle training has its distinct limitations. It cannot restore life to dead nerve-cells, but it *can* help weak muscles to hypertrophy, and can train some individuals to use weakened muscles to better advantage. When muscle-training has reached its limit, and this limit falls short of the minimum power necessary for successful locomotion or the prevention of deformity, then the patient must choose between operation or a life time of brace-wearing. Even this statement must be qualified, for there are a few unfortunates in every large community who cannot be made to walk either by operation or by braces. Fortunately, these cases are very rare. Braces are unsightly, cumbersome, and annoying, and do not control lateral deformity.

Technique of triple and lateral arthrodesis: the "triple arthrodesis" is indicated where most of the weakness and deformity occur in the subastragaloid and medio-tarsal joints. Mid-tarsal valgus and varus, and the severe hollow claw foot are good examples. The operation is most easily and accurately performed by two incisions, one on the inner and one on the outer side of the foot. A Martin bandage (broad, thin, flat rubber, three inches wide and five

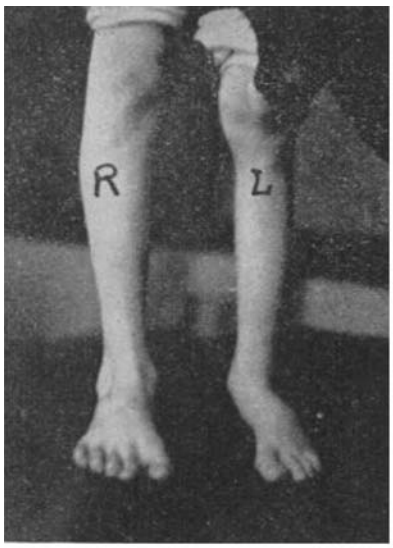

FIG. I. R. H.

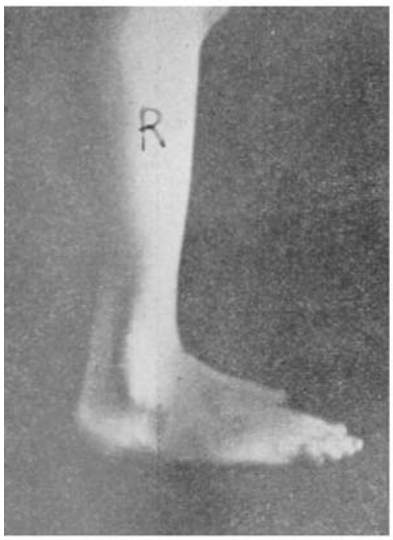

FIG. II. R. H.

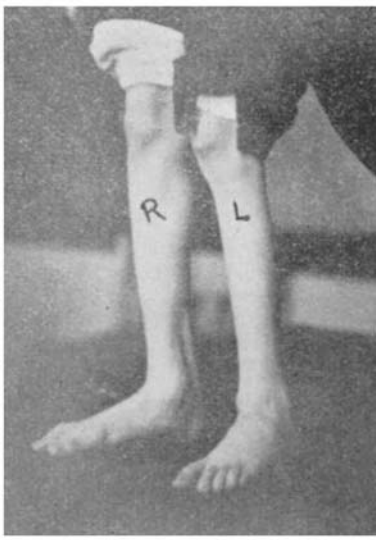

FIG. III. R. H.

Fig. 6 Operated at 7½ years of age, Feb. 20th, 1920. Triple arthrodesis *right* foot. Astragalo-scaphoid joint did not ankylose, but remains perfectly free. Foot is held perfectly by the calcaneo cuboid fusion. These pictures taken 2¾ years after operation. Left foot has never been operated upon.

or six feet long) is applied from the toes to the knee, the turns barely overlapping each other. It should be wound on snugly, and on reaching the top of the calf just below the knee-joint it should be secured by several turns. The end at the foot is then unwound as far as the knee, and tied or clamped to the upper end. This gives a bloodless field and greatly facilitates the difficult dissection. An incision is now made from just posterior to the inner malleolus, and immediately below it, through the skin only, and carried directly over the astragaloscaphoid articulation and to about the middle of the first metatarsal bone. Below the malleolus the tendon of the tibialis posticus is identified, its sheath is opened, and the tendon is retracted upward. This exposes the joint at the sustentaculum tali, between the astragalus and calcaneum, and further retraction backward will show the posterior part of the substragaloid joint. A narrow chisel, or preferably a Davis flat gouge, can be used to cut loose the articular cartilage, and a very small, strong curette is used to complete the denudation, going as far toward the outer side of the joint as possible.

Next, the astragalo-scaphoid joint is exposed, and opened by cutting the capsule. The attachments of the capsule and ligaments can be peeled away with a chisel, and the cartilage is then cut loose and curetted out. This joint is extensive, and the denudation must be very thorough. In small children, 6 or 7 years of age, the cartilage on the head of the astragalus is nearly one-quarter of an inch thick, and by the time the bleeding bone of the ossification center is reached, there is practically no possibility of bony contact between it and the denuded concave surface of the scaphoid. This is one of the chief reasons for not operating on young children, and is the most frequent cause of non-fusion in this joint. In children of 10 years or more, the cartilage is thinner and the results are proportionately better

FIG. I. E. H.

FIG. II. E. H.

Fig. 7 Arthrodesis all tarsal bones on inner side of foot. Ext. Prop. Hallucis transplanted into tibialis anticus. Tendo Achillis lengthened. Operation, March 2, 1921. These pictures taken Nov. 2, 1921.

with each additional year up to 12 or 13. It is especially necessary to denude the lateral (outer) aspect of this joint with great care, so that, when the calcaneo-cuboid joint is correspondingly denuded, there will be a complete transverse section through the entire foot, the medio-tarsal joint thus being entirely denuded. If any marked degree of varus or valgus be present, a wedge shaped piece can be removed from the outer or inner section of the medio-tarsal joint sufficient to correct the deformity. If the condition be one of pes cavus or hollow claw foot or calcaneus, the base of the wedge should be upward.

The joints between the scaphoid, internal cuneiform, and base of the first metatarsal can be similarly denuded if deformity beyond the mediotarsal joint be present or be likely to occur. This part of the operation may not often be required, but should be used especially in severe cases of hollow claw foot.

An incision, similar to the first one, is now made on the outer (lateral) border of the foot, beginning just posterior to and below the external malleolus and extending distally to or beyond the base of the fifth metatarsal bone. The sheath of the peroneus tendons is opened and the tendons displaced and retracted upward, exposing the lateral portion of the subastragaloid joint. This is rather short, and slants upward and backward. It can usually be completely denuded with chisel and small curette, without cutting the external lateral ligamentous structures. The subastragaloid joint, with its two or three subdivisions, is by far the most difficult of all of the joints of the foot to expose and clean out in a proper surgical manner. After this has been done, the calcaneo-cuboid joint is denuded, and made continuous with the astragalo-scaphoid joints, so that the foot is completely mobilized and freed up through the whole extent of the medio-tarsal region. Next, the cubo-metatarsal articulation is attacked and the cartilage cleaned out. The foot as a whole is then viewed as to the complete correction of any pre-existing deformity, and whatever remodelling may be necessary is then done. If, now, there seems to be too great laxness or instability, chromic catgut may be used to bind the bones together, by passing it through drill-holes. This precaution has been very seldom used by the writer, most often, perhaps, in cases of hollow claw foot where a very large wedge has been removed. The wounds are then sutured with interrupted or occasionally-interrupted stitches, after the tourniquet has been removed. The bleeding, very fresh at first, usually becomes inconsiderable after a few minutes, but a few large skin veins may require tying. The work has been largely in the joints and under the periosteum, and the main vessels are not likely to be injured. After suturing, it is wise to insert a few strands of silkworm gut in spaces between sutures, in both outer and inner wounds. These drains prevent accumulation of blood in the tissues, and greatly reduce the post-operative pain and swelling. Sterile vaseline is smeared over the wounds, and dressings, folded long and narrow, are placed over the line of sutures. Sterile sheet wadding is wound thickly over the foot and leg, bandaged snugly, and covered with a light layer of plaster of Paris, reinforced on back of leg and bottom of foot with a 2-inch moulded plaster “rope” or splint. If only one foot has been operated upon, it is well to carry the plaster far up on the thigh, with the knee straight, and to suspend the whole leg by straps or frame, as advised by Whitman after astragalectomy. The whole plaster splint should be cut on each side from top to toes, so as to make anterior and posterior halves, and this cut should include the cloth or gauze bandage down to the sheet wadding. If all of these rules be followed, constriction will be avoided

and the pain after the operation will be very slight. The cuts in the cast must be made low enough so that when the anterior or dorsal half is lifted off, the two incisions, low down on the two sides of the foot, will be exposed for inspection and dressing, and removal of drains and sutures. The silkworm drains are left in place for 48 hours. It might seem to those who have had no experience with this form of operation that it was unnecessarily extensive, or severe, or dangerous, but this is not the case. The transverse section through the medio-tarsal joint, cuneiform or otherwise, has been done by the writer in a large number of cases, and with the addition of the subastragaloid and other joints in more than fifty. In some of these cases, where the details of drainage and proper splitting of the cast were not carried out, there was severe post-operative pain for several days. In most other instances, there was less pain than after such simpler operations as forcible correction with tenotomies.

The results are extremely satisfactory, so far as observed, and the procedure is recommended as safe and logical. It is believed that it furnishes better stabilization and more central correction than osteotomies in the continuity of the bones. When a partially paralyzed foot has been stabilized in this way, tendon transplantations can be done to provide flexion and extension, with the certainty that disabling lateral deformity will not occur. It is in such cases that transplantation finds its true field of usefulness.

In conclusion, attention may again be directed to the essential instability of the imperfectly controlled medio-tarsal and sub-astragaloid joints as one of the most frequent causes of deformity and disability in paralysis of the leg.