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SYMPOSIUM: AAOS 75TH ANNIVERSARY TRIBUTE TO PAST PRESIDENTS

The Classic

Two Hundred Cases of Paralytic Foot Stabilization after the Method of Hoke*

O. L. Miller MD (1887–1970)
The 10th President of the AAOS 1941

Dr. Oscar Lee Miller was born on a farm in Franklin County, in northeast Georgia [6]. He obtained a teachers' certificate and taught school several years after high school before he attended the University of Georgia and then graduated from the Atlanta College of Physicians and Surgeons (now Emory University School of Medicine) in 1912. He took postgraduate training in Atlanta, working with Dr. Michael Hoke (whose name is associated with hindfoot arthrodesis). He entered military service in 1917, then returned to private practice after the armistice. As with other first Presidents of the AAOS, foreign experience was important, and in 1921 he visited Sir Robert Jones and other British surgeons. Upon returning he moved to Gastonia, North Carolina and helped develop the North Carolina Orthopaedic Hospital, an institution focusing on crippled children. In 1923, he opened an office which eventually became the Miller Clinic in nearby Charlotte. (The Miller Clinic and Charlotte Orthopedic Specialists merged in 2005 to create OrthoCarolina.)

Dr. Miller was active in the AOA as well as the AAOS, and was a member of the Argentine Surgical Association. He became President of the AAOS in January, 1942, only days after the bombing of Pearl Harbor. In his Presidential address he emphasized the importance of the care of crippled children and urged a strong relationship with the Latin American orthopaedic community [1]. He served as Chair of a committee that created the Inter-American Orthopaedic Fellowship Program, for Latin American surgeons to visit training centers in the US. He also urged the AAOS to develop a library "as a repository for all pertinent records." The Executive Committee outlined a program in June, 1941, to present a "motion picture exhibit," a feature of the meeting which subsequently became the Instructional Course Lecture [2]. Under his leadership at that meeting, the AAOS passed a resolution regarding support of the country during the war years: "It is the desire of the American Academy of Orthopaedic Surgeons to offer its wholehearted support to our Country in this serious emergency." A telegram with the resolution was sent to the President of the United States.

Miller had a lasting interest in foot surgery, undoubtedly influenced by Hoke. We reprint here Miller's report of Hoke's triple arthrodesis for paralytic feet [3]. Astonishingly, Miller states this was the only operation performed for paralytic feet in his clinic over a three-year period, yet he reported 200 cases in this short time; obviously the number of polio patients at the time was devastating. Among these 200 cases, 121 were of the "clubfoot type," 62 had pes cavus (on which he wrote in 1927 [4]), and 17

Oscar Lee Miller, MD is shown. Photograph is reproduced with permission and ©American Academy of Orthopaedic Surgeons. *Fifty Years of Progress*, 1983.

pes calcaneus (on which he wrote in 1936 [5]). Miller reports eight cases of flail feet (although it is unclear whether these are additional cases, or fall within one of the three categories since the numbers of those categories add to 200). His focus is to describe the basic operations with indications for supplemental procedures including tendon transfers. As was often common practice in describing procedures at the time, he did not report the followup results and did not provide references [3].

Richard A. Brand MD

References

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In the minutes of the Bone and Joint Section of the American Medical Association in session at New Orleans, May, 1920, the following discussion is credited, in substance, to the writer, in connection with a paper presented by DeForest Willard, of Philadelphia, on the Davis Subastragaloid Arthrodesis Operation for Paralytic Feet:

"The foot stabilization operation has developed to be the greatest single procedure thus far contributed to the surgical treatment of infantile paralysis. If a committee from the American Orthopedic Association were to collect, summarize, and condense all the work now being done on infantile paralysis, including the foot stabilization operation of Hoke, it seems that we should now have at our command sufficient effective procedures to make these cases reach their maximum recovery in the minimum time."

Since 1920, with the opportunity for more experience with the Hoke operation, we are more forcibly convinced of its entire efficacy in meeting the defects and deformities of paralytic feet. It is definitely established that an understanding application of this operation, together with the proper tendon transplantation and skeletal alignment, will meet all the surgical needs of the paralytic foot more nearly, more lastingly, and with more natural preservation of the function and appearance of the foot than any procedure yet devised.

In October, 1921, a comprehensive presentation of this operation was published by Hoke himself. Since that time a number of clinics here and there have tried out the procedure. In the clinic of the North Carolina Orthopedic Hospital, for the past three years, no other type of operation has been used for stabilizing paralytic feet, and this report is offered in review of the cases.

In this series of cases the involvement of the thigh muscles and the deformities of the hip and knee have been treated and braces applied when needed, but the fact is only mentioned and no detailed description is offered. Where surgical measures have been resorted to above or about the knee, mention of the operation will be made in a summary, together with the type of brace, where a brace was used. One ambition of the Clinic where this foot stabilization operation originated was the elimination, so far as possible, of artificial apparatus. In this group of cases no braces were applied for primary foot conditions.

As in all surgical or medical cases an accurate diagnosis lends itself to intelligent application of a known therapy, so, in handling paralytic limbs does an accurate diagnosis of all factors entering into their instability become necessary to insure stability, with a given method of treatment.

It has been observed in many cases, really most cases, of paralytic involvement of the lower extremity, that the limb assumes a generally outwardly rotated position. The rotation may be only in the leg or it may be in the leg and thigh. In consequence of this, the osseous structures acquire a torsion in the length of their shafts, and not to recognize this nor attack it in the course of treatment of a case is to invite an improper alignment, a tendency to relapse of possibly other good work, and a disappointing result in the end. Since we are dealing here with the skeletal structure of the foot, reference to the thigh will not be made further than to say that the alignment of the femur must be obtained, and maintained, either by operation or by brace,

before expecting well designed work on the leg and foot to hold.

In the shaft of the tibia of the paralytic leg pathological torsion is seen most frequently and to the greatest degree. The rotation is always outward and is frequently associated with a knock-knee deformity. The torsion occurs in amounts varying from 5 to 10 degrees, which may be inconsequential if left alone, to as much as 90 degrees, which places the tarsus at a right angle to the normal line of the leg. However good an operation one may be able to do on a foot, the maximum improvement will not be attained unless an osteotomy of the tibia is done and this torsion corrected when it is present to a crippling degree.

One must say that the work of Lovett and his students has contributed most to the detailed study and understanding of paralytic muscles. It is necessary to know the normal muscles about the foot and leg, the approximate and comparative degree of their involvement after poliomyelitic infection, and what disposition to make of any one, or group, contributing to deformity. It is needless to say at this time that the most skilled maneuvering of tendons will not meet the entire needs of paralytic feet, and tendon transplantation in this series of cases is done only as an associated procedure in developing a foot by stabilization. Like the torsion in the bone shafts, however, unless careful disposition is made of unbalancing tendons they will contribute to an unsatisfactory result or to a relapse.

With the use of this operation on the foot, one finds tendon transplantation not so universally necessary for those muscles which have a fair degree of power left, but which would be sufficient to unbalance the average unoperated foot. The arthrodesed foot will hold its balance against a considerable pull from any of the muscles passing about the ankle. One then develops his own relative rule, usually by experience, as to whether, in a case of foot deformity, he will transplant a tendon or whether he will control the foot by stabilization alone. In this series of cases an error was made twice. Once a tendon was transferred to a new insertion in connection with stabilization, and overcorrected a foot; again, a tendon was not transferred to a new insertion and caused a relapse in a foot after operation.

In a given case after analyzing and dealing with, or planning to deal with, the factors of bone torsion and the disposition of unbalancing tendons, if any, one should classify the foot deformity. Each type of foot deformity is met by this operation in a definite way peculiar to that particular deformity. And here is where detailed and specific knowledge of foot anatomy and structural pathology must be exercised if the ideal end-result is obtained.

In addition to the general classifications of foot deformities, there are variations within each classification. A calcaneus foot (the classification) may be in extreme cavus also, or valgus, or both, or neither. Then all of these must be noted and met in the rearrangement of the bones of the tarsus at operation and a later manipulation. Precision must be practiced in sectioning the neck of the astragalus, in replacing the astragalar head, in sectioning the under surface of the astragalus and upper surface of the os calcis, and in securing their eventual resting relation. There is a refinedness of minute position and relation to be obtained between the astragalus, os calcis, scaphoid and cuboid bones particularly, and the bones of the whole foot in general, throughout all the classifications and variations of paralytic foot deformities.

The general classifications of club foot, flat foot, calcaneus foot, and flail foot will be used in presenting these cases, and only such reference will be made to the variations within the classifications as to make clear the reason for this or that technique in a procedure.

The operative approach for the foot stabilization is through the outer side of the ankle over the subastragaloid fossa. The incision reaches from a point near the dorsum of the foot, backward to beneath the outer malleolus where the peroneal tendons pass. The approach is the same for all types of feet.

Club Foot

Under the heading of club foot is included all those feet in varus, in equinus, equino-cavus, or any combination of these deformities. Applying the foot stabilization operation to these types calls in all for sectioning the under surface of the astragalus, freely clearing away the cartilage with a broad chisel; the same to the upper surface of the os calcis, so that when the two bones approach one another at the finish the broadest possible contact of raw surface may be had.

In the foot with varus deformity there is always more or less bony hypertrophy of the antero-external aspect of the os calcis, the cuboid bone, and the head and neck of the astragalus. The physiologic interception to their antero-external development is displaced inward, hence their overgrowth. The head of the astragalus is external or superior to the median line of the foot, and the metatarsal shafts pitch inward, downward, and usually with some rotation.

The foot with simple equinus does not develop so much fullness about the antero-external aspect of the tarsus, but more noticeably an overgrowth downward and forward of the head and neck of the astragalus in the median line, causing decided blocking to dorsiflexion of the forefoot even when the heel cord is lengthened. In the simple equino-cavus foot the latter pathology is a little more emphasized, together with a very taut plantar fascia and downward pitching of the metatarsals.

Fig. 1 Case No. 692. A case of extreme paralytic club-foot.

Fig. 2 Case No. 692. Afterstabilizing the foot, lengthening the heel cord, transplanting the anterior tibial tendon to the centre of the tarsus and correcting the tibial torsion.

Fig. 3 Case No. 505. Paralytic club-foot with equinus and associated outward torsion of the tibia.

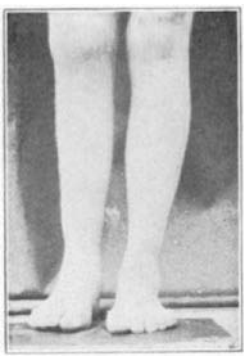

Fig. 4 Case No. 505. After aligning the tibia, lengthening the heel cord, stabilizing the foot, and transplantation of the anterior tibial tendon to the centre of the tarsus.

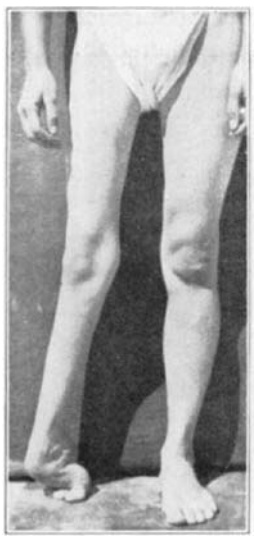

Fig. 5 Case No. 347. Paralytic club-foot with extreme equines and caves. Moderate knock-knee and torsion of the tibia.

Fig. 6 Case No. 347. After osteotomy of tibia, heel cord lengthening, plantar fasciotomy, and club-foot and equinus type of stabilization.

When the neck of the astragalus is sectioned, it is shortened and the hypertrophy of the os calcis and cuboid is relieved by a section from their outer side, including their adjacent articulations. The head of the astragalus is removed from its bed, denuded of its cartilage together with the opposing cartilage of the scaphoid, and the head reshaped and transplanted back, somewhat reduced in size,

Fig. 7 Case No. 669. A case of ugly knock-knee and tibial torsion with a paralytic club-foot.

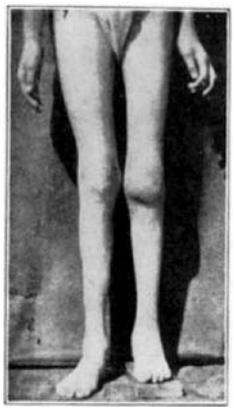

Fig. 8 Case No. 669. Corrected by high osteotomy of tibia, section of ilio-tibial band and foot stabilization.

and placed more nearly in its normal position. In a varus deformity the head will best be placed a little to the inner side of the median line of the foot; in an equinus and cavus foot the head is reduced in size and transplanted deep centrally on the end of the os calcis and as near as possible in its normal line. The alignment of the metatarsals may be disregarded at this time. The corrected position of the head of the astragalus is the secret of normal-looking, stable, well-balanced feet in this operation.

At the time of operation it may be impossible to place the head of the astragalus in perfect position and hold it there, so it is done approximately and more attention given to shifting the foot slightly backward beneath the malleoli. In about five to six weeks after operative work has been done on the foot, a refining manipulation is given it. By this time there has taken place moderate union throughout the area of the fusion, but not so much union that one can not, with the thumb, force the astragalar head a few millimetres one way or the other until correct alignment is given it. At this time, also, from the structures having atrophied and softened in cast, the entire forefoot may be molded in the hands of the operator to a corrected or overcorrected alignment, if desired. At the sitting for the foot stabilization operation, or at a different sitting within an interval of a few weeks, tendon transplantation or osteotomy of the tibia may be done if indicated.

Below is summarized the associated fasciotomies, tenotomies, osteotomies and tendon transplantations done in connection with the club foot cases.

Of the two hundred cases reported, one hundred and twenty-one cases are of the club foot type. The right foot was involved sixty-five times, the left fifty-six. Heel cord tenotomy was done alone in twenty-two cases, plantar fasciotomy alone in three cases, and heel cord tenotomy and plantar fasciotomy were done together in seventy-one cases. Osteotomy of the tibia was done ten times for pathologic torsion alone, one time for knock-knee alone, and forty-six times for knock-knee and torsion combined. In all, fifty-seven osteotomies of the tibia were done.

The anterior tibial tendon was transplanted to the centre of the tarsus in thirty-one club feet. The extensor proprius hallucis was transplanted into the head of the first metatarsal bone in six cases. The external hamstring was transplanted to the patella in three cases to reinforce a weak quadriceps muscle.

Soutter's operation, shearing off contracted structures from the anterior superior spine and side of the ilium, was done in two cases. A femur-turning operation was done in one case. Thirteen cases were furnished light leg braces to support weak thigh muscles.

Averaging about five and one-half weeks after operation, one hundred and seventeen feet had refining manipulation.

One foot in this classification relapsed after correction. This relapse was due to failure to estimate the strength of an anterior tibial tendon at time of stabilization. Later reworking the foot and transplanting the anterior tibial tendon to the centre of the tarsus gave a satisfactory result.

Flat Foot

The paralytic flat foot is one of the most uncomely deformities seen. It is not so disabling as some, but the weight of the body thrown for a number of years upon the arch of the foot stretches the restraining ligaments and so distorts the bone relations that to reconstruct them into improved position, with stability and comfort, has been a test of surgical mechanics.

The deformity in this type of foot is met by approaching the tarsus as in the club foot operation, but recognizing that the structural pathology is opposite. The hypertrophy of the head and neck of the astragalus is directed much to the inner side of the normal foot line. The medio-tarsus and metatarsals are in valgus and abduction to varying degrees.

At operation the sections from the under surface of the body of the astragalus and upper surface of the os calcis are

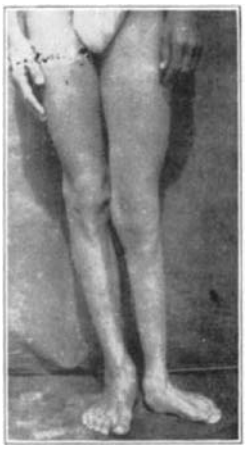

Fig. 9 Case No. 657. Severe paralytic flatfoot with hypertrophy and displacement of the inner aspect of the mediotarsus.

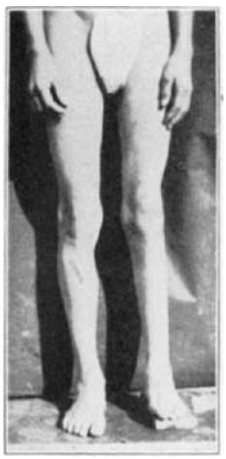

Fig. 10 Case No. 657. Corrected by flat foot-type of stabilization and transplantation of the peroneuslongus tendon into the heel cord.

made to get good broad bony contact. Here a point should be emphasized, and that is, taking off a substantial plane from the upper surface of the outer external angle of the os calcis to provide a raw resting place for the head of the astragalus to be transplanted. The subastragaloid fossa should be cleared of fat, and the periosteum raised away from the bones (astragalus and os calcis). Any chips of raw bone saved from working out the operation should be chinked in here to broaden the base and strengthen the fusion.

The neck of the astragalus is sectioned, shaped, and shortened to suit. The head is raised from its deep bed on the inner side of the foot and cleared of its cartilage, with the cartilage from the scaphoid articulation. Corrective reconstruction of the flat foot now hinges on fashioning and fitting the head of the astragalus back to its neck with its base resting on the raw surface over the antero-external angle of the os calcis referred to above. The head should now be well away from its original bed and even external to the median line of the foot, so that the new weight thrust will be corrective rather than deforming. The forefoot is held in as much adduction as possible, the wound closed, and a well fitting plaster cast applied. Five to six weeks later a refining manipulation is practically always necessary here to improve the adduction and somewhat overcorrect the foot. The flat feet do better when allowed to stay in cast for ten days longer than the average feet. The firm fusing in the new position means permanency, if the skeleton above has been lined up and necessary tenotomies and transplantations done.

In this series sixty-two cases of paralytic flat foot are reported, operated after the method described. The right foot was involved twenty-seven times and the left thirty-five. The heel cord was lengthened in eight cases. Osteotomy of the tibia was done twice for pathologic torsion alone, five times for knock-knee alone, and twelve times for knock-knee and torsion combined. In all, the tibia was sectioned nineteen times.

In eighteen cases the extensor proprius hallucis tendon was transplanted alone to reënforce the anterior tibial tendon. In two cases the extensor proprius hallucis and peroneus longus were transplanted together to reënforce the anterior tibial tendon. In three cases the extensor proprius hallucis, the peroneus longus, and the second, third, and fourth toe extensors were all transplanted together to reënforce the anterior tibial tendon. In eleven cases the peroneus longus and brevis were transplanted together into the heel cord and in three cases the peroneus longus was transplanted alone.

At the end of six weeks after operation a refining manipulation was done on fifty-eight feet.

Two cases had a Soutter operation to relieve hip flexion. A femur turning operation was done on four cases. A light leg brace was applied for weak thigh muscles in thirteen cases.

There was one case of over-correction. The flat foot type of stabilization was done together with the transplantation of the extensor proprius hallucis to the anterior tibial tendon. In this case the stabilization alone would have held the foot, and transferring the extensor proprius hallucis to the anterior tibial tendon overbalanced it. A second operation placing the extensor proprius hallucis tendon into the middle of the tarsus left the foot balanced.

Calcaneus Foot

The calcaneus type of paralytic foot deformity has been in the past one of the most discouraging to correct, and hold, by surgical measures. The difficulty in controlling the calcaneus foot has probably given impetus to the development of the various operations for stabilizing feet. When the structural pathology of the skeleton in the calcaneus foot is analyzed and this stabilization procedure applied to it, together with the shifting of the foot backward on the

leg, permanent correction and stability can be had, and a foot which is quite normal in appearance both in and out of a shoe.

In the calcaneus foot the Achilles tendon is weak or paralyzed. This structure in a normal foot is part of the physiologic control to the superior inferior growth of the bodies of the astragalus and os calcis. In the calcaneus foot the physiologic control of the growth of these bones is lost. Their superior-inferior diameters are decidedly increased, thrusting the heel downward and the forefoot forward and upward. The unequal muscle pull adds to the deformity. Some of the feet in this classification are simple calcaneus feet, some are in position of calcaneo-valgus, while some are in calcaneo-varus. In describing the application of the operation here the subastragaloid sectioning is emphasized.

The incision exposes the heel bone with a prolongation of the upper aspect of its body toward the astragalus and the astragalus has an unusual depth toward the os calcis. It is easy to see the increased depths of the superior-inferior diameters of the opposing bones. With a broad chisel a deep section is lifted from the astragalus and os calcis at this site. The sum of the depths of these two fragments in the bad cases will approach an inch. Removing these sections properly represents the secret of the success of this operation with this type of foot. When the foot is shifted backward, which can easily be done here, the raw bony surfaces of the os calcis and astragalus impact broadly and solidly together. The heel cord is relaxed by this shortening, put at rest, and allowed to recover tone and strength. In fact, it has been noticed that after such an operation and rest in plaster a gastrocnemius soleus group which appeared to be completely paralyzed before operation, after operation shows a helpful degree of power.

If the calcaneus foot has associated a valgus or cavus forefoot, this associated deformity is met by placing the head of the astragalus in a new position, as was brought out with some detail above in connection with describing the treatment of the valgus and cavus type of foot deformity.

In dressing these cases after operation care should be exercised to shift the foot backward and upward until the space created by the subastragaloid sectioning is dissipated, and the two bones firmly face to face. The plantar fascia is sectioned, if indicated, and any tendons calling for transplantation are disposed of. Plaster dressing is applied with the foot in equinus and the knee slightly flexed.

Six weeks later the foot is manipulated. When this is done an assistant holds the heel well up and the forefoot is molded to alignment, against this protection. After manipulation it is well to allow the foot another ten days to two weeks in plaster, when it is ready for massage, a shoe, and the test of walking.

Fig. 11 Case No. 313. Paralytic calcaneus foot.

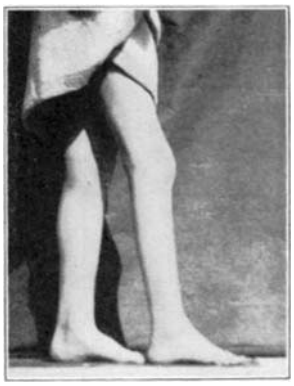

Fig. 12 Case No. 313. Corrected by calcaneus type of foot stabilization.

Seventeen calcaneus feet are included in this series. Eleven occurred in the right foot and six in the left. There was one osteotomy of the tibia done to correct pathologic torsion and knock-knee.

The peroneus longus and brevis tendons were transplanted into the heel cord in three cases. The external hamstring was transplanted into the patella in one case of associated quadriceps weakness.

Two cases were furnished light leg braces for weak thigh muscles. Seventeen cases had final manipulation, and so far no cases of relapse have been seen.

Flail Foot

In treating the flail foot, particularly good fusion is sought between the astragalus and os calcis, and this operation gives satisfaction in this connection. In our classification of paralytic feet not a great many deformities are called by the term "flail foot." Our flail feet are usually in a mild drop-foot position. As has been noticed, a great many really flail feet will assume a varus or valgus deformity. These cases get the club foot or flat foot type of stabilization, and are so classified.

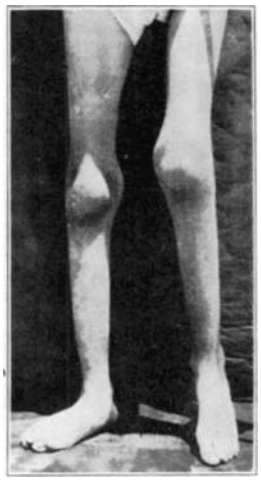

Fig. 13 Case No. 582. Left paralytic flail foot—drop or dangle foot.

Fig. 14 Case No. 582. After shifting the foot backward with a simple stabilization.

Fig. 15 Case No. 538. A case which was being treated by braces on these lines.

Fig. 16 Case No. 538. Prepared for braces by lining up the feet and legs.

Fig. 17 Case No. 538. In braces.

The cartilage is freely removed from the head of the astragalus in the flail feet and from the opposing surface of the scaphoid. When these structures fuse together, with the foot shifted slightly backward and the forefoot manipulated to alignment, the foot is stable, has no tripping toe-drop and reaches its maximum of recoverable function.

Eight flail feet, as such, are reported here. Two are in the right foot and six in the left. In four cases, osteotomy of the tibia was done to correct pathologic torsion and knock-knee.

A Soutter procedure for flexed hips was done on three cases. All the feet had refining manipulation at the end of six weeks, and six cases were furnished light leg braces for weak thigh muscles.

A notation of several follow-up observations has been made in the records from the out-patient department of the hospital on each of these cases.

The average age of the patients at the time of operation was eleven years. The youngest patient operated upon was four years, the oldest thirty-five years. The ideal age is eight years, after which there is no age limit to the possible application of the procedure.