PRINCIPLES INVOLVED IN THE TREATMENT OF CONGENITAL CLUB-FOOT *

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The purpose of this paper is to make a plea for conservative treatment of congenital club-foot and to call attention to certain mechanical and pathological principles involved. It is the author's experience that most club feet can be successfully corrected by a series of plaster casts and wedgings, without the use of anaesthetics, forcible manipulations, or operative procedures, and with far better results.

Before the era of modern surgery, numerous machines were devised for the forcible correction of club feet, and a variety of braces were worn. *With the advent of aseptic surgery there were described in rapid succession* a large number of operations, first on the fascia and tendons, and a little later on the bones and joints of the foot. It seems that the chief object of these operative methods was a rapid anatomical correction of the club-foot deformity, without giving much thought to the future function of the foot.

It must be admitted that most club feet are improved somewhat in appearance by forcible manipulations and operations, and occasionally a foot is restored to almost normal appearance with very little functional impairment. However, when a series of these cases, in which operations had been performed by the author and by others, were followed for a number of years and studied critically, it was found that there were many relapses, and that many patients had stiff, rigid feet, a few of which were more disabling than the original deformity.

After reviewing the literature and studying a series of operative cases, it seemed that if progress were to be made in the treatment of club-foot, it would not be made by devising a new operation, or by doing more accurately the operations which had already been devised, but that it would be *by a method which did no harm to the foot, and which caused no adhesions* in the many joints of the foot.

Inspired by a clearer understanding of the mechanics of the foot as taught by Dr. Michael Hoke, as well as by his meticulous attention to details in the application and molding of the cast, the writer followed the principles which Dr. Hoke recommended, and finally obtained a good correction of a club foot, without resorting to any operative procedures. The treatment extended over a long period of time, but the surprisingly good functional result repaid for the additional time and effort. During the past fifteen years the author has personally treated over 400 patients

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with club feet. The observations made here are based on a study of this group.

The writer has previously shown roentgenograms of cases where all

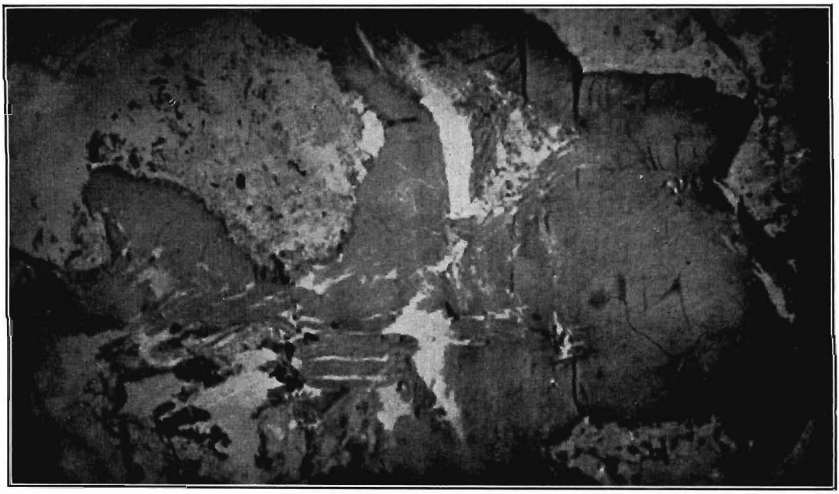

FIG. 1

Section of a joint removed from a recurrent club foot which had had several forcible manipulations previously. Fibrous and bony adhesions can be seen crossing from the cartilage of one bone to the other, causing an ankylosis of the joint and preventing further correction by the non-operative method.

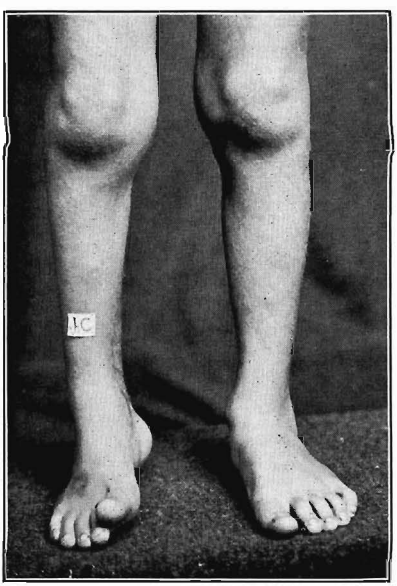

FIG. 2-A

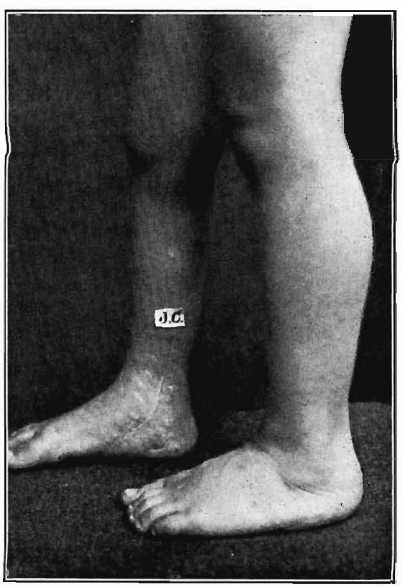

FIG. 2-B

This patient has had two operations on the medial side of the right ankle for the correction of club-foot deformity. The tibial epiphysis was injured, and has fused, causing the foot to be turned inward in a varus position.

the bones in the posterior foot had fused to each other and to the tibia, following forcible manual manipulations under an anaesthetic. Such extensive ankylosis is not the rule. However, when any force is used in manipulating a foot, some injury is done to the joints in the foot. The cartilage is often cracked, and the bones are partially crushed, forcing bone cells into the joint spaces. When the foot is held for a month or two in plaster casts following the manipulation, it is not surprising that fibrous ankylosis, or often bony ankylosis, occurs.

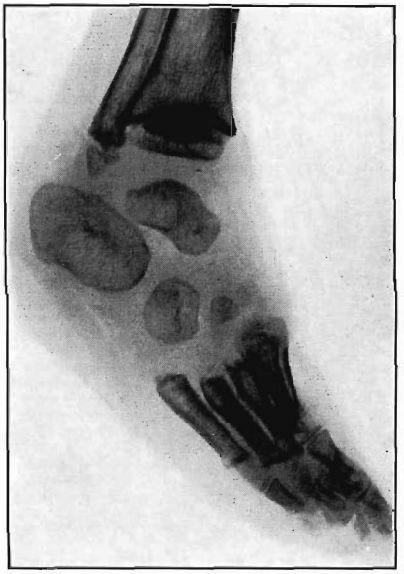

FIG. 3

Roentgenogram of the patient in Figs. 2-A and 2-B, taken at the age of four years, showing fusion of the distal epiphysis of the tibia. Notice the shortening of the tibia, as compared with the fibula.

A microscopic study of some of these joints following forcible manipulations of the feet has been made by Dr. Everett L. Bishop. These joints were removed when operation was done later for correction of the deformity. (See Figure 1.) He states: "This condition may be described as a chronic, non-infectious, inflammatory reaction due to pressure, with organization of the tissue and fusion of the bones—first by fibrous connective tissue, later by some new ossification—the bones finally becoming fused together into a fibro-osseous mass."

Another type of injury which may follow operative treatment is illustrated by a patient under treatment at the present time. This boy had had an operation on the medial side of the ankle and foot when he was a year old. When he was two and a half years old the deformity had recurred, and another surgeon did a similar operation at the same point. The distal tib-

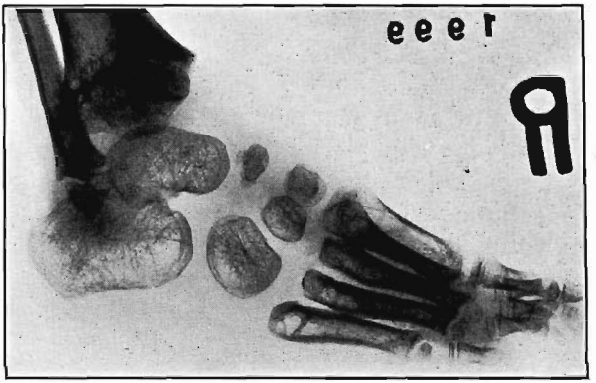

FIG. 4

Roentgenogram of patient shown in Figs. 2-A, 2-B, and 3, taken at age of five and one-half years. Notice the increased shortening of the tibia as compared with the fibula. The cessation of growth in the tibia causes the foot to be turned inward, in an inverted position. This shows the harm done by one type of operation.

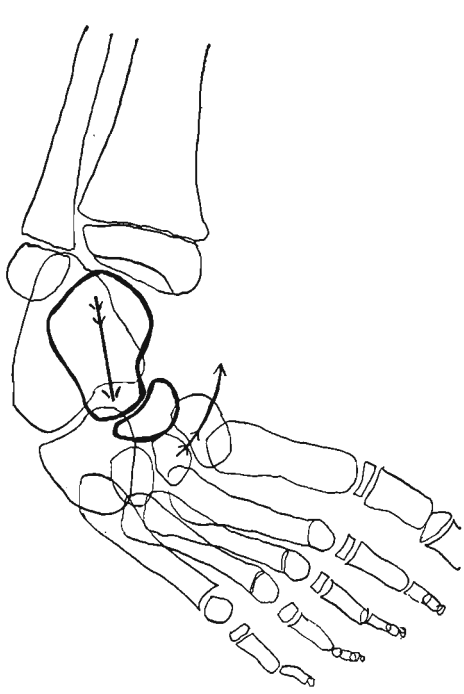

FIG. 5-A

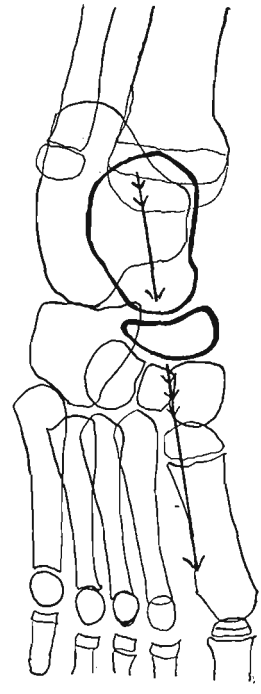

FIG. 5-B

Tracings made from roentgenograms of the right foot of a seven-year-old girl, before and after correction of club-foot deformity by plaster casts and wedgings. The roentgenogram made before treatment shows that the weight thrust of the body coming down the tibia is transmitted forward through the astragalus, strikes obliquely on the side of the navicular, and pushes the forefoot around in adduction. When the adduction deformity of the forefoot has been completely corrected, this weight thrust is transmitted straight forward from the astragalus through the navicular to the toes, as shown in the tracing of the roentgenogram made after correction of the forefoot adduction. If the wedging of the forefoot in abduction is stopped before the navicular is directly in front of the head of the astragalus, the deformity will recur when weight-bearing is permitted, because the weight thrust will fall obliquely on the navicular.

ial epiphysis was injured and later it fused. (See Figures 2-A and 2-B.) Roentgenograms made at the ages of four (Fig. 3) and five and a half years (Fig. 4) show that the fibula has continued to grow, while growth has ceased in the lower end of the tibia. The foot is being forced around in varus, and the deformity is increasing with time.

Space does not permit a long summary of the harm that may come to a foot following operative procedures, but many examples can be found in the relapsed cases brought to any club-foot clinic.

Club-foot deformity may be divided into three parts: adduction, inversion, and equinus deformities. The forefoot is *adducted* when compared with the posterior foot. The os calcis is rotated inward under the astragalus, causing the entire foot to assume an *inverted* position. The *equinus* deformity may be divided into two parts: the forefoot is plantar-flexed when compared to the posterior foot, giving "forefoot

equinus"; the entire foot is plantar-flexed in the ankle joint, giving "ankle equinus". Each of these three deformities must be completely corrected, and in the order mentioned.

When the forefoot *adduction* is corrected, the navicular, which was medial to the head of the astragalus, is drawn around in front of the head of the astragalus (Fig. 5-B). The weight thrust down the tibia is transmitted through the astragalus to the navicular and straight forward to the toes. If an attempt is made to dorsiflex the foot before the navicular is in the proper position, the latter will be forced up on the medial side of the head of the astragalus. If much force is used, the navicular may become fixed on the medial side of the head, and later it will be found very difficult to move. If the navicular is still on the medial side of the head, when the treatment is discontinued and the child is allowed to walk, the weight thrust will fall obliquely on the side of the navicular, and push the forefoot back into the adducted position. Figure 5-A shows the mechanics of this, and explains why forefoot adduction recurs when it has not been completely corrected. If the forefoot is carried outward too far, the navicular may be drawn around lateral to the head of the astragalus into a flat-foot position, which is undesirable. Care should be exercised to correct the adduction deformity completely without overcorrecting it.

Correction of the *inversion* deformity is of sufficient importance to justify a more detailed discussion. The value of thoroughly correcting this deformity was not fully appreciated until about five years ago, when a study was being made of a series of cases of recurrent club-foot. The original photographs and roentgenograms in these recurrent cases showed no unusual inherent deformity that might account for the relapse. The importance of the correction of the inversion deformity was realized during the treatment of the following two cases.

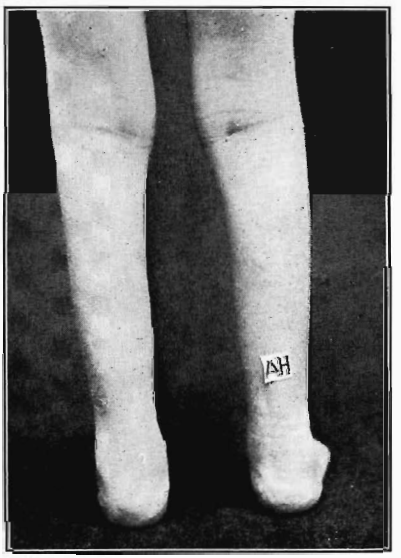

FIG. 6

Posterior view of feet of a five-year-old girl whose club feet were corrected by the non-operative method. The heels seem to be straight under the mid-line of the tibia. Clinically, the inversion deformity has been corrected.

A five-year-old girl with bilateral club-foot, the correction of which had previously been attempted elsewhere, was treated with a series of plaster casts and wedgings. The feet appeared to be well corrected when she was dismissed (Fig. 6). A few months later she returned, walking on the lateral border of each foot. Roentgenograms made on dismissal (Fig. 7) were thought at that time to have shown a satisfactory correction. It was later realized that the author's

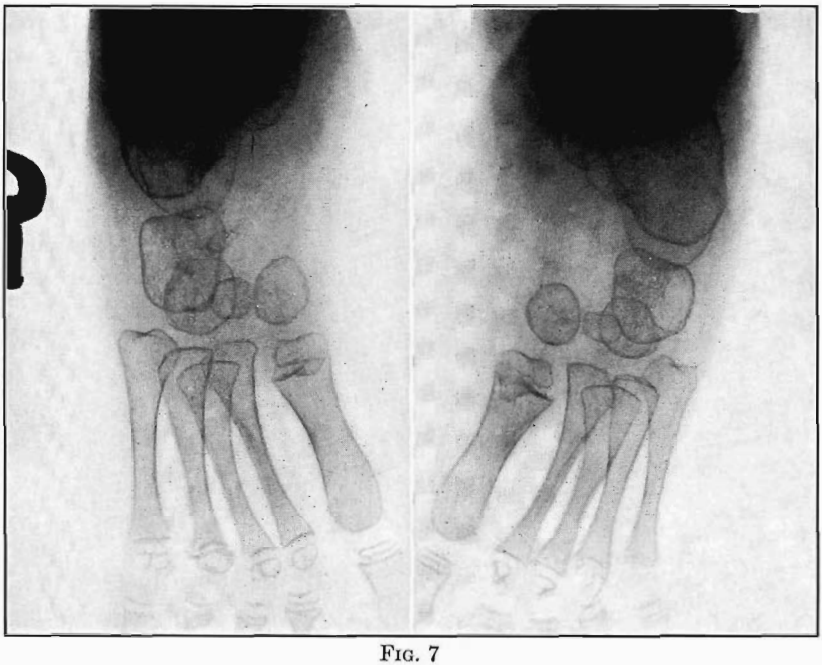

FIG. 7

Roentgenograms of feet shown in Fig. 6, taken after correction of the club-foot deformity. The inversion deformity has not been corrected, because the anterior end of the os calcis is still rolled in under the head of the astragalus. The shadows of the anterior ends of these two bones are superimposed instead of being separated normally.

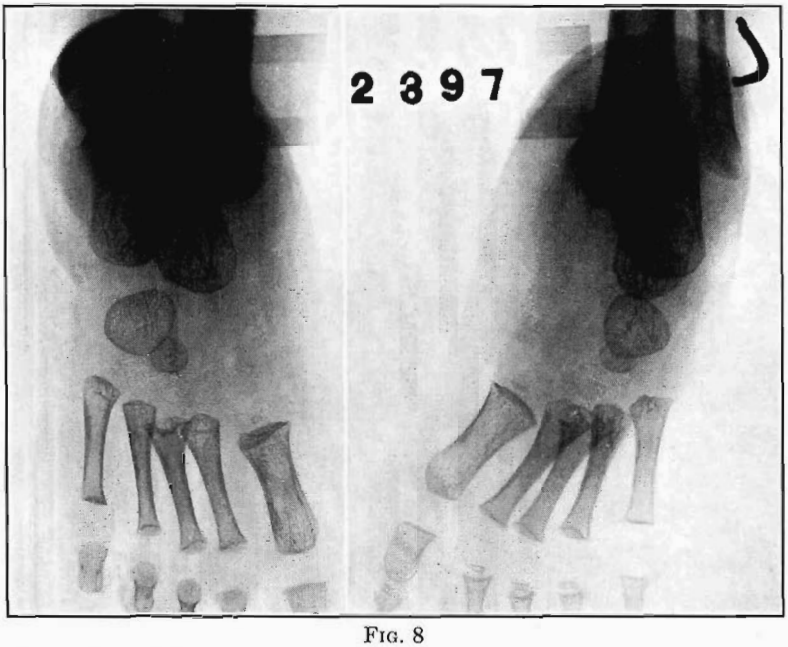

FIG. 8

Originally both feet were clubbed, and the deformity was corrected by the non-operative method. The correction was maintained in the right foot; in the left,

Fig. 8 (*continued*)

the deformity recurred. This roentgenogram shows the reason for the recurrence. The anterior end of the os calcis is under the head of the astragalus, while on the right the two shadows are separated in the normal manner. There is still an inversion deformity of the posterior foot on the left. (*Courtesy of Surgery, Gynecology and Obstetrics.*)

interpretation was in error and that the roentgenograms really showed that the inversion deformity had not been corrected.

At about this same time, another girl with bilateral club-foot, who had been treated with casts and wedgings, returned for observation. She placed the right foot in the normal position, but walked on the lateral border of the left foot. The anteroposterior roentgenogram (Fig. 8) showed that the inversion deformity of the posterior foot had been corrected on the right, but that it had not been corrected on the left.

The inversion deformity is recognized in the anteroposterior roentgenogram by the fact that the os calcis is rolled in under the astragalus, so that the shadow of the anterior end of the os calcis is directly under the shadow of the head of the astragalus. When the inversion deformity is corrected, the os calcis is rolled outward to its normal position, so that the anterior ends of the two bones are separated. The mid-line of the astraga-

FIG. 9

Roentgenograms of feet shown in Fig. 8 a few weeks later after the inversion deformity had been corrected on the left. This is determined by the fact that the shadows of the anterior end of the os calcis and the head of the astragalus are separated in the normal manner. The equinus deformity was then easily corrected, and the correction has been maintained for more than five years. (*Courtesy of Surgery, Gynecology and Obstetrics.*)

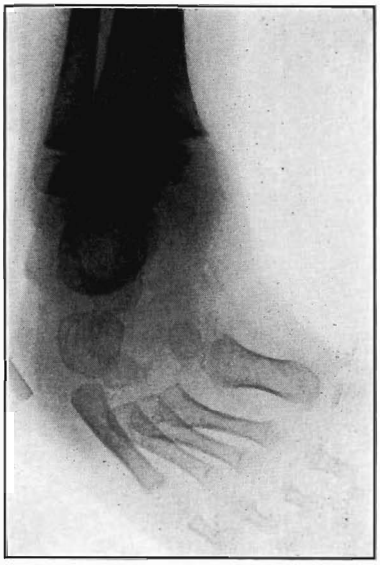

FIG. 10-A

FIG. 10-B

FIG. 10-C

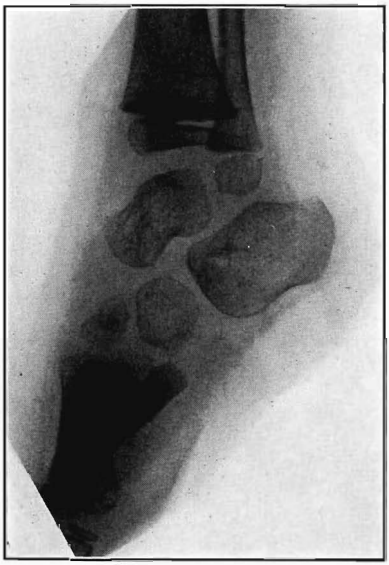

FIG. 10-D

Roentgenograms of a girl, three and a half years old, taken on admission. The patient had had a previous course of treatment elsewhere. The roentgenograms show that the deformity is about the same on the two sides.

lus then points toward the first and second toes, and that of the os calcis toward the fourth and fifth toes.

The left foot of the second patient mentioned was wedged in eversion until the inversion deformity had been corrected (Fig. 9), and then the foot was easily brought into dorsiflexion. The patient was seen recently,

FIG. 11-A

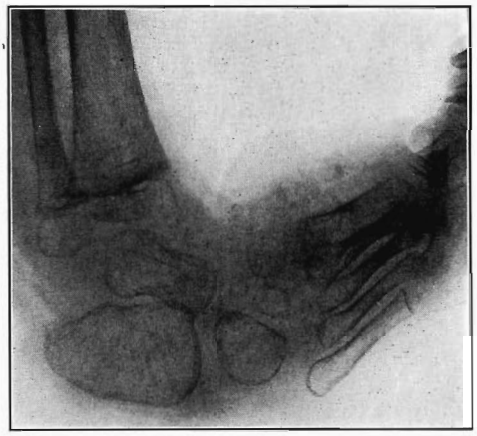

FIG. 11-B

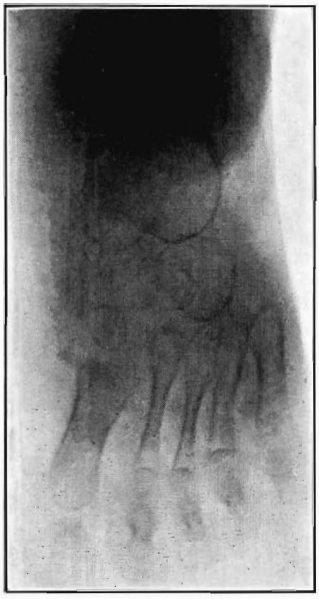

FIG. 11-C

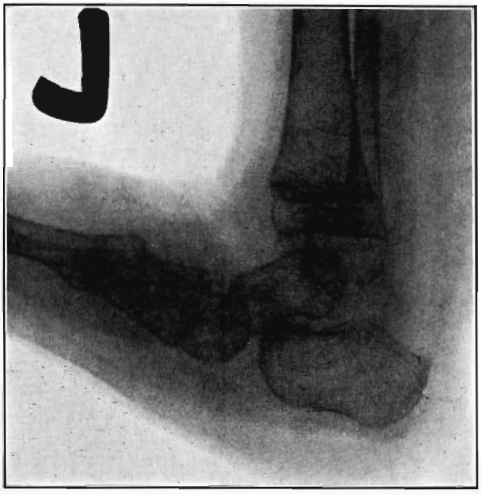

FIG. 11-D

Roentgenograms of patient shown in Figs. 10-A, 10-B, 10-C, 10-D, after the feet had been wedged in dorsiflexion. The right foot yielded in the mid-tarsal joint, giving a "rocker bottom" to the foot, while the left foot came into position without breaking in this joint. The antero-posterior roentgenograms show that the shadows of the anterior end of the os calcis and head of the astragalus on the right are superimposed, while on the left they are separated in the normal manner. The inversion deformity has not been corrected on the right, which accounts for the difficulty in bringing the foot into dorsiflexion.

some five years after the last treatment, and the correction of the deformity is well maintained.

There was another child under treatment at the same time, who had bilateral club-foot. When the feet were wedged in dorsiflexion, the right

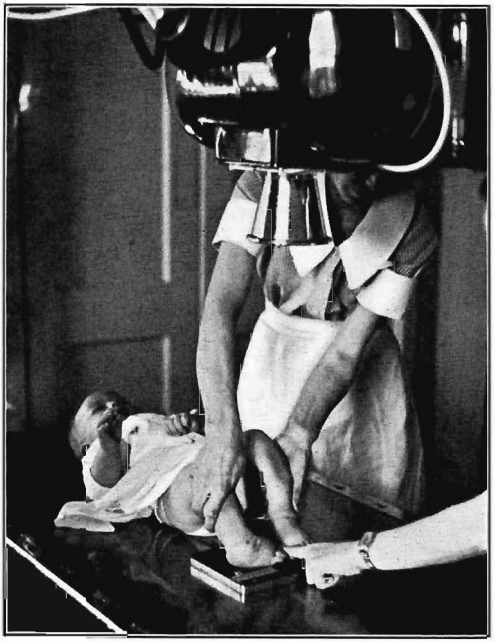

FIG. 12

Fig. 12

In taking a roentgenogram of club feet the central ray is directed straight down. The knees are held together and must be straight up, and not allowed to tilt to either side. The feet are held flat on the film by the great toes, as this does not cover up the part of the foot which is to be examined. The holding of the feet should always be done by the parents, so that no one individual will get too much exposure to the x-rays. In making the exposure the kilovolts should be increased, so that the exposure is a quarter of a second or less. It is difficult to keep crying babies still for a longer time. A five by seven film is large enough.

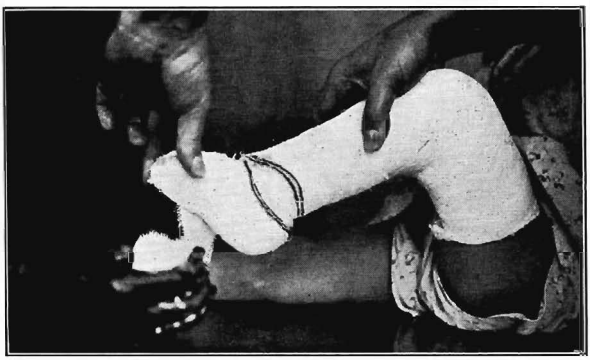

FIG. 13-A

FIG. 13-B

Figs. 13-A and 13-B

Method of wedging the foot in eversion. A wedge-shaped portion of plaster is removed about the level of the lateral malleolus; the cut in the plaster is carried all the way around the ankle, freeing the two segments. The base of the wedge is on the lateral border. A plaster bandage is started on the medial side of the lower leg, about halfway between the knee and ankle, and brought around under the heel and up the lateral border of the leg. The foot is everted, and tension on the bandage holds the foot in eversion. The bandage is then carried around the leg in circular turns to hold the first turns to the cast, and to fill in the area where the wedge has been removed.

foot was very difficult to bring into this position, and a "rocker bottom" developed in spite of the use of great care in applying and wedging the casts. The left foot came into dorsiflexion without difficulty, and without breaking in the mid-tarsal joint. Figure 10 shows no great difference in the appearance of the feet at the beginning of the treatment. Figure 11 shows the roentgenograms at the time when difficulty was experienced in bringing the right foot into dorsiflexion. The anteroposterior view of the resistant right foot shows that the inversion deformity has not been corrected. The inversion deformity has been corrected on the left, and this foot could be brought into dorsiflexion with little difficulty. The right foot was plantarflexed, as this is necessary to relax the subastragalar joint, and then wedged in eversion. Later it came into dorsiflexion without difficulty, and without producing a "rocker bottom", and the correction has been maintained in both feet for more than five years.

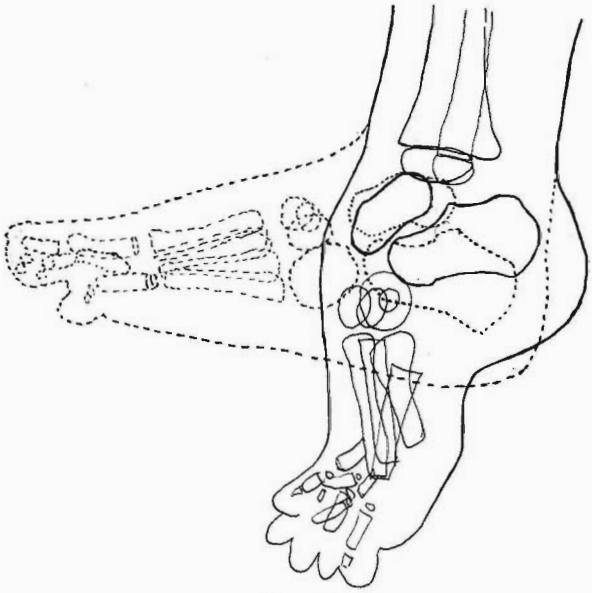

FIG. 14

Tracings of superimposed roentgenograms of the foot of a four-year-old boy, before and after correction by plaster casts and wedgings. The astragalus has been forced back under the tibia, and the os calcis has been drawn forward under the astragalus. The forefoot equinus and ankle equinus have both been corrected.

For the last five years it has been the author's custom to take anteroposterior roentgenograms of all feet after the forefoot adduction and the inversion deformity appear to be corrected. (See Figure 12.) If the anterior ends of the astragalus and os calcis are separated, the foot is ready to be brought into dorsiflexion. If they are still superimposed, the heel should be wedged in eversion as shown in Figures 13-A and 13-B.

The *equinus* deformity is corrected by gradually bringing the foot into dorsiflexion. The anatomists tell us that the chief motion in the subastragalar joint is rotation,—that is, in eversion and inversion. When a club foot is brought into dorsiflexion, there seems to be a gliding forward motion also in the subastragalar joint. The os calcis is drawn forward, as shown in Figure 14. Lateral roentgenograms before treatment frequently show the astragalus extending forward over the os calcis by half the length of the astragalus, while, at the completion of the treatment,

the anterior ends of the two bones are on the same level. At the same time the body of the astragalus is pushed backward under the tibia, restoring the normal relationship between the bones.

Pressure upward on the forefoot, with the heel in inversion, only binds together more tightly the os calcis and the astragalus, so that the deformity can never correct itself spontaneously. When more pressure is used and the treatment is continued, the transverse tarsal joint yields, and continued force fails to correct the inversion and equinus deformities of the posterior foot. If the condition is not recognized, and if the foot is held for a long period in dorsiflexion with the os calcis in inversion, adhesions form between the os calcis and the astragalus, binding the two bones together so tightly that they cannot later be rotated to the normal position without operation. In such cases, at the time of operation, it is difficult to introduce a periosteal elevator into the subastragalar joint, because of the adhesions.

A study of these feet seems to substantiate the following statements: When continued pressure is made on the bones forming a joint, in such a direction that the joint can move, little harm is done to the joint. When the direction of the force is such that the joint cannot move, or that the motion is blocked, the pressure causes atrophy, and, if the pressure is continued, the trauma will produce adhesions in the joint. Later, if force is applied correctly, the deformity frequently cannot be corrected, because of the adhesions which bind the bones together. It is for this reason that recurrent club-foot is often more difficult to correct than untreated club-foot. For the same reason we should be sure that the adduction and inversion deformities are thoroughly corrected before beginning dorsiflexion.

The details of the application of the casts and the method of wedging the casts have been published, so they need not be repeated here. Ninety per cent. of all cases of club-foot which the author has treated have been corrected by plaster casts and wedgings. The remaining 10 per cent., composed chiefly of older children and patients who had been treated previously by operative procedures, were corrected by a Hoke club-foot stabilization. The non-operative method is recommended, because it does no harm to the foot, preserves function, and restores the foot to a normal appearance.

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