

1962

Congenital talipes equinovarus : a review of the current methods of management

Frank Ted Herhahn
University of Nebraska Medical Center

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CONGENITAL TALIPES EQUINOVARUS;
A Review of the Current Methods of Management

Frank Ted Herhahn

Submitted in Partial Fulfillment for the Degree
of Doctor of Medicine

College of Medicine, University of Nebraska

March 22, 1962

Omaha, Nebraska

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I. INTRODUCTION

Management of the patient with congenital talipes equinovarus has presented a problem since earliest times. There have been far swings in the pendulum of treatment ranging from simple shoe splints through formidable wrenchings with a Thomas wrench under anesthesia to a multitude of radical operative procedures. The one point of congenital clubfoot that renders thorough management so necessary is the tendency towards recurrence of deformity. As J. H. Kite has stated, "No other condition presents so large a series of incomplete cures, recurrences, and failures as congenital clubfoot." (29) Essentially management consists of (a) correction of deformity, (b) maintenance of correction and, (c) careful follow-up. If any of one of these aspects of management are slighted, recurrence is practically inevitable.

The purpose of this paper is to review the management of clubfoot; the methods with their indications and contraindications, advantages and disadvantages, complications and prognosis. A general concept of each method will be presented but the details of the technical procedure is outside the scope of this paper. In addition, a brief review of the various etiologic concepts, pathologic anatomy, and diagnosis will be presented.

II. ETIOLOGY

The etiology of congenital clubfoot has remained an enigma to investigators since it was first described by Hippocrates. Many hypotheses have been put forth but none have been proved; in fact it appears that one can find more evidence to disprove the various hypotheses than to support them. To date the causative factor of congenital clubfoot is unknown. Seventy-five percent of congenital clubfeet are of the equinovarus deformity. The incidence of congenital clubfoot has been reported to be between one in 1000 to one in 1500 births (10, 13,39). It is more common in males at a ratio of two or three to one with the higher ratio usually reported in those studies relating to pure surgical treatment (39,13,33,30,38,26,29). It has been reported to be bilateral in from forty to sixty percent of the cases (13,26,29,33,38,39). When bilateral one side is usually twenty percent more severe than the other side. It appears to be associated with other congenital anomalies; surveys report an occurrence in six to twelve percent of the cases (26,29,33). Four to forty-five percent of the cases have a positive family history of clubfoot (10,23,26,29,33,39).

The theory of a mechanical cause was advocated very early and was supported by Denis Browne (7,9). He describes clubfoot

as the result of malposition with the legs in a crossed position. However, the questions of the many normal feet in cases of multiple births and hydramnios make accurate descriptions and predictions questionable with this theory. In 1928 Max Bohm["] carefully studied the fetal position of the feet at two, three, three and one-half, and four months and concluded that the deformities of congenital talipes equinovarus by the analysis of fetuses in their three chief deformities; plantar flexion, adduction, and supination, are in all of the stages of early embryonic development. He stated that a severe clubfoot resembled an embryonic foot at the beginning of the second month. He concluded "the best explanation for the great majority of cases of congenital clubfoot is the theory of a primary endogenous disturbance of the embryo, an arrest of development"(4). In 1882 Berg introduced the theory of dysplasia of muscles, muscle tendons, and ligaments. The theory has been supported by more recent investigators (2, 14, 17, 23, 43). They have found shorter muscle bellies with decreased diameter along with a corresponding increase in tendon lengths in many dissections. However, they have been unable to note any constant significant change from the normal side microscopically. The questions arises as to whether these changes are primary or secondary and further evidence would be necessary to substantiate this theory. The theory of anomalous tendon insertions has been supported by

various investigators. Most dissections have shown a definite but variable degree of anomalous tendon insertions usually in the tendo Achilles, anterior tibial, and posterior tibial tendons. Stewart (1951) stressed this finding as a possible cause of congenital clubfoot (39). Fried (1959) has found a tibialis posterior tendon which is thickened and fibrous with hypertrophic attachments in fifty-six cases of recurrent clubfoot at the time of surgery (19). Brockman (1937) thought it due to congenital dislocation of the head of the astragalus secondary to an atresia of the socket into which the head of the astragalus normally fits (6). Duraiswami (1952) injected insulin into the yolk sac of fertilized hen's eggs on the third day of incubation and consistently produced foot defects in the chick (16). This along with other studies suggest that there may be some sort of metabolic defect as the underlying cause of congenital talipes equinovarus.

Congenital clubfoot due to more obvious causes, for example spina bifida, arthrogryposis multiple congenita, are not included in the usual discussions of this condition. Their position as a starting point in discovering the cause of the usual congenital clubfoot should not be denied. As with any other condition the best solution to the clubfoot deformity is correction or removal of the basic cause; therefore, we should strive to find the basic lesion of this condition.

III. PATHOLOGIC ANATOMY

The pathologic anatomy of congenital equinovarus has been described by many investigators with considerable emphasis being placed on the various findings of each. Scarpa gave the first accurate description of the pathology of clubfoot in 1803. The deformity may be divided into three separate parts; adduction, inversion, and equinus. The primary pathology is thought to exist in the muscles, tendons, and ligaments with secondary changes occurring in the bones, only after a certain time. Thus, at birth the bones are normal in shape but altered in position. With time the bones undergo considerable morphologic and structural change. The chief abnormalities in the morphology are centered in the astragalus, calcaneus, scaphoid, and cuboid bones (36). Raybuck (1959) found that the internal structure of the tarsal bones show an arrangement of trabeculae suitable to provide strength against shearing stress rather than bending stress (36). He concludes that in clubfoot the bones are structurally adapted to their mechanical function. The degree of bone deformity varies in direct proportion to the severity and duration of the deformity. Once significant boney deformity has occurred major correction is practically impossible using conservative measures or soft tissue release operations.

The findings in the soft tissue are numerous and variable. Usually the calf muscles are poorly developed and the tendo Achilles passes downward and medial to its insertion into the calcaneus. The posterior joint capsule is tight. The tibialis posterior tendon has been described as fibrous and hypertrophic with its insertions to the plantar structures broadened and with accessory sites added to the normal sites of attachment (19). The ligaments and associated structures on the medial aspect of the foot are thickened and contracted with a variable amount of compression dysplasia of the medial structures. The peronei are usually weak and inert; this could be due to intrauterine compression of the peroneal nerve. The anterior tibial muscle and tendon are usually shortened and a few investigators have described abnormal insertion of its tendon. Furlong (1960) states that the shortened tibialis anticus aids in maintaining the clubfoot deformity (22). Most of the muscle involved in the deformity have a shortened muscle belly with a decreased diameter associated with longer than normal tendons. Repeated microscopic examination of these muscles and nerves have failed to reveal any constant pathologic picture (17). Electromyographic studies have also failed to disclose any lower motor neuron lesions as evidenced by fibrillary discharges (35).

The adduction deformity takes place chiefly in the astragalo-scapoid and calcaneocuboid joints. In this deformity the

forefoot is drawn inward in relation to the posterior foot. This position is maintained by the tight anterior and posterior muscles.

The inversion deformity occurs chiefly in the astragalo-calcaneus point and to a lesser degree in the astragaloscaphoid joint. Here the entire foot is turned in under the astragalus; however, there is no turning in of the astragalus because of its position in the ankle mortise formed by the tibia and fibula. This position is maintained by the tight medial structures and the medial displacement of the heel cord.

The equinus deformity is divided into two parts, forefoot equinus and ankle equinus. The forefoot equinus occurs in the astragaloscaphoid and the calcaneocuboid joints. Here the forefoot is almost at right angles to the posterior foot. The ankle equinus occurs in the calcaneus and astragalus and has no characteristic joint involvement. The ankle equinus is recognized by comparing the posterior foot to the lower leg. Here the heel is drawn upward and the anterior end of the calcaneus is pitched downward, in the reverse position from normal.

Occasionally talipes equinovarus is found in association with other congenital defects and here the pathologic anatomy is related to the basic process. Thus in arthrogryposis multiplex

congenita the aplastic muscles have many fibers replaced by fibrofatty tissue. The joints are usually fixed in a position of flexion, adduction, and inversion with marked limitation of motion and rigidity. In spina bifida the muscles are usually underdeveloped and weak. One should obtain roentgenograms of the vertebral column in suspicious cases for spina bifida may not be clinically evident. Clubfoot may also be associated with congenital constriction bands and Friedrich's ataxia. Occasionally the deformity is aggravated by a varying degree of tibial torsion.

IV. DIAGNOSIS

The diagnosis of talipes equinovarus is usually no problem. The diagnosis can be made at birth or shortly thereafter and can best be evaluated by dividing it into its three components. The equinus is characterized by a forefoot which is dropped plantarward. Examination reveals a tight heel cord and tight plantar structures at the mid-tarsal area. The varus is characterized by inversion at the ankle. Examination reveals a tight medially inserted heel cord and medially contracted ligaments which resist correction. The adduction is characterized by a tight anterior tibial muscle. In addition one may find a contracted plantar aponeurosis, dorsal and lateral boney

prominence of the astragalus, atrophic appearing leg muscles, and varying degrees of loss of flexibility.

Roentgenographically the scaphoid is displaced medially and inferiorly to the head of the astragalus, carrying the cuneiform and the metatarsals with it. The anterior end of the calcaneus is displaced medially and overlaps the astragalar head. Roentgenographic follow up is very important in treatment and will be discussed under the principles of treatment.

In the differential diagnosis of congenital talipes equinovarus the frequently assumed inverted position of young infants can be differentiated from true clubfoot by its easy correctability on gentle manipulation. It is much more important to differentiate clubfoot from "Z" foot which consists of metatarsus adductus and a relaxed valgus of the rear foot because, if it is treated as a clubfoot the scaphoid will be displaced further laterally to the astragalus with a resultant severe flatfoot.

V. MANAGEMENT

A. History

The history of the treatment of talipes equinovarus began in the time of Hippocrates who recognized the several components of the deformity and all of the essential features of treatment. He stressed the correction by conservative means. Arcaeus in

1658 described essentially the same method plus a mechanical contrivance (21). In the sixteenth century Ambrose Paré introduced an era of apparatus treatment which continued up to the nineteenth century (21). In 1803 Scarpa emphasized that all soft parts are capable of considerable stretching without pain when the corrective force is applied in a gradually increasing manner. Guerin in 1836 was the first to use plaster casts (21). During the nineteenth century therapy became progressively more radical with manipulative maneuvers and retention devices giving way to surgery by the middle of the century. Stromeyer in 1831 first advocated subcutaneous tenotomy of the heel cord (32). Toward the end of the nineteenth century, not only were multiple tenotomies being done, but also radical soft tissue procedures and osteotomies. Solly in 1857 did the first osteotomy with removal of the cuboid; this operation gave poor results and did not gain wide favor (21). By the end of the century therapeutic procedures became more conservative once again. Tubbs urged conservative treatment with therapy divided into three stages; correction, retention, and supervision (21). He also stated that the ultimate outcome depended on the thoroughness of the third stage.

During the early twentieth century conservative measures were vigorously supported by Denis Browne in England and J. H. Kite in the United States. Early operative correction and

forcible manipulations under anesthesia declined significantly. Denis Browne (1937) emphasized the importance of function as well as structure in evaluating the final result (9). He felt that correction should be obtained on the first manipulation and not by gentle coaxing (21). He described his method of splinting based on the controlling of one foot by way of the other foot. Brockman (1937) favored the method of Browne and stated that with one manipulation under anesthesia the foot would not be so scarred, contracted, with the extreme degree of muscle wasting (6). It was also during the 1930's that J. H. Kite's method of wedge casting became prominent. His interest, judgement, and conclusions based on the study of many cases of clubfoot have contributed immeasurably to our present knowledge in regard to management of clubfoot deformities and his wedge cast method has become a standard conservative treatment in most orthopedic centers today.

B. General Principles

The management of talipes equinovarus is best left to those orthopedists who have received special training in this field. These men are usually associated with a major children's orthopedic center. Because therapy requires a long period of time and follow up it is essential that one begin treatment with the parents. Initial consultation with the parents entails;

(1) a complete description of clubfoot, (2) removal of certain fears and apprehensions, (3) the aim of treatment, (4) patience, (5) the importance of careful long term follow up, and (6) the ultimate prognosis. Only with a full understanding on the parents behalf can the physician hope to obtain the best possible results. The degree of the original deformity, the amount of resistance to correction of any element, and the patient's age are factors which must be considered in the selection of the appropriate method of treatment. Ideally treatment should begin early in life; the exact age is not completely agreed upon but varies only between birth and one month of age (10). In general treatment is divided into conservative and operative groups. In infants and young children correction is usually satisfactory with conservative treatment only. Conservative treatment implies correction by gentle manipulation with no pain or muscle spasm and without anesthesia. Violent wrenching and manipulation under anesthesia is condemned today. This type of treatment results in tearing of soft tissue with resultant scarring and consequent disturbance in growth centers which tends to leave a tight, rigid, more deformed foot and atrophic unsightly legs. In general successful treatment depends upon early and adequate correction followed by prevention of recurrence.

The deformity must be corrected in a specific orderly

fashion. The adduction deformity must be corrected first in order to get the scaphoid which is medial to the head of the astragalus in front of the head of the astragalus. It usually takes four to eight weeks to correct this part of the deformity. When this is completely corrected it will appear on X-ray that the scaphoid to be in front of the astragalus and the cuboid to be in front of the calcaneus. Second the varus is corrected. This is corrected each time new casts are applied for correction of the adduction deformity. The forefoot is not overcorrected in eversion or adduction because this often turns the heel too far out in eversion or valgus and causes a flatfoot. Kite (1935) felt that the success or failure of correcting clubfoot hinges on the proper correction of the inversion deformity. He has noticed that on the feet with recurrence the inversion deformity had not been corrected (25). On the A-P film the corrected inversion shows the shadows of the head of the astragalus and the anterior end of the calcaneus to be separated. In the uncorrected foot the two shadows are superimposed: This finding has commonly been referred to as the "Y" sign. After correction of the equinus in the midtarsal joints the ankle equinus is attacked last. This is best accomplished by wedging the foot in dorsiflexion. If the equinus deformity is attacked before the inversion deformity is corrected, the calcaneus will be forced tighter up against the medial side of

the under surface of the astragalus and the calcaneus will be fixed in this inverted position. Under this condition it is impossible for the inversion deformity to correct itself. In order to correct this, the forefoot must be put in equinus in order to relax the subastragalar joint. Failure to observe this during recorection of the foot will result in a converse deformity of the midtarsal joint which is recognized as a "rocker-bottom" foot. It usually takes six to eight weeks on the average to bring the foot up in dorsiflexion (10). Once correction is obtained it is necessary to maintain the correction. This is usually accomplished with serial plaster casts, wedge casts, or splints. These are used continuously until the patient is able to walk and then night splints are used for the next three to six months. Whenever recurrence of the deformity occurs the patient should be returned to plaster casts for a variable period. The recommendation of orthopedic shoes varies with the various authors but all generally agree that every patient should wear a good straight last shoe. Wearing the shoe on the wrong foot is not advocated today. Careful follow up should continue every three to four months for the first few years then every six months until the age of four or six and yearly check ups until the child reaches adolescence. The above principles are basic in the conservative treatment of congenital clubfoot and a thorough understanding of the various

deformities and the logic of their correction is necessary in the successful management of this condition.

Failure to obtain the desired results with conservative measures is corrected with selected surgical procedures with varying degrees of success. These procedures are also needed to correct those cases which were inadequately treated early or which do not come for treatment until later in childhood and adolescence. The various procedures have very definite indications and must not be used indiscriminately. In particular avoid stripping off contracted soft parts from immature bone structures which would result in a stiff foot which is more contracted and resistantly deformed than before the operation. It is basic not to sacrifice function in order to gain better anatomical correction. No single radical procedure will successfully eliminate all of the elements of the deformity. Each surgical procedure should be designed to achieve a limited goal within the over all correction program. The various procedures will be discussed later in this section.

Any discussion of congenital talipes equinovarus would be incomplete if the essential part of the definition was omitted. I am referring to the particular tendency toward recurrence. The three basic reasons for recurrence are; (1) those feet with inherent nature and pattern which fail to respond to recognized standards of treatment, (2) those that

have been neglected when correction could be obtained by way of conservative means, and (3) those where conservative treatment will take so much additional time that the questionable outlook for success is not practical (31). The number of recurrences tend to increase in the older group of patients, as the length of time of treatment increases, as the length of time of the initial treatment increases, and in more severe initial deformities. Kite (1932) found that fifty percent of the children with other congenital anomalies had recurrences as compared to eighteen percent of the children who had no other associated deformity (26). He also found that the time required for treatment increased significantly after the child began walking, if treated only one or two times every two weeks compared with treatment twice a week, if the child had other congenital anomalies, and if the patient was a male. The percentage of recurrence in any study varies from nine to twenty percent with conservative treatment. With operative treatment the results are much worse but in these cases the correlation is poor.

C. Non-operative Treatment

Wedge or Serial Cast Method

This method was first outlined by J. H. Kite in the 1920's. It was first reported in 1930 with a presentation of the results

in one hundred cases (29). This procedure is indicated in all cases of congenital clubfoot, especially in the younger age group from birth to seven years of age. It is also indicated in older children prior to undertaking a surgical procedure. There are no specific contraindications to this procedure. Advantages over other methods of conservative therapy are (a) good control of the foot at all times, (b) a large percentage of complete corrections of the initial treatment, and (c) good functional as well as good anatomical correction. Disadvantages include (a) frequent cast changes, (b) need of meticulous care in taking of wedges and application of casts, (c) more visits at shorter intervals, and (d) the usual inherent difficulties with the skin in any long term casting treatment. The technic entails the use of short leg casts plus adhesive for maintenance of position. The leg should always be casted just short of the point reached by manipulation in order to prevent pressure necrosis. The forefoot is always casted first. The varus and inversion deformities are corrected more or less simultaneously and first so that the subastragalar space is open and relaxed by way of the equinus position. The scaphoid must be brought around from the medial side of the head of the astragalus to its normal position so that the weight thrust will be in a straight line from the astragalus through the scaphoid to the toe. If the adduction is not completely corrected the

deformity will recur when weight bearing is permitted because the thrust will fall obliquely on the scaphoid. This is most accurately checked by taking an A-P X-ray. If the varus is corrected it will show as a slight separation of the calcaneus and astragalus at their anterior ends. After the varus and inversion is corrected the equinus is corrected by progressive wedging of the foot in dorsiflexion. The casts should be changed every week and it should be applied to the foot as a shoe. It is also important to watch for pressure points on the medial side of the great toe and lateral border of the foot. The boating deformity can be prevented if the "shoe" casting is used with no dorsiflexion until the shoe has set. Clinically the correction is not complete until the foot can be dorsiflexed in eversion. At this time the foot is kept in plaster for eight weeks before freedom is allowed, after which a night splint is worn for six months. If at any time recurrence of the deformity occurs the patient is immediately returned to plaster casts for a variable length of time. Kite emphasizes that our criteria of treatment should not be how few casts or what percentage are cured by only one course of casting, but by how near to normal the foot will be when the child has become an adult (26). Complications inherent in this type of treatment are (a) "rocker-bottom" foot, (b) pressure necrosis from the casts, and (c) muscle atrophy from disuse. Prognosis

is fairly good with the best results given by Kite of ninety percent (25). Usually the deformity is correctable in eighty to eighty-five percent of all cases if treatment is begun early in life. Of course the prognosis depends on the therapist, the age at onset of treatment, the severity of the deformity, the presence of other associated anomalies, and the adequate correction of the varus and inversion before dorsiflexion is begun.

Denis Browne Splint Method

This method was first outlined by Denis Browne in England (9). Many variations of the splint were tried before he arrived at the one that is currently used which consists of aluminum straps bent to the contour of the foot. The method is based on the controlling of one foot by way of the other foot. The indications for the use of this method are the same as for the wedge cast method but is more widely used for only the minor deformities. There are no absolute contraindications but it should not be used in the more severe deformities or in the older children. The advantages of this method are (a) the absence of plaster casts which are difficult to apply, (b) the lower cost for the patient, (c) convenience to the patient, (d) the maintenance of some active movement throughout treatment, and (e) convenience to the physician. The disadvantages are (a) limited application to only the very young children, (b) overall results are not as satisfactory as with the plaster casts, and (c) the strong

tendency towards recurrence especially in the adduction and cavus components. In this method there must be perfect apposition in the attachment of the foot to the aluminum plate. There must not be any windows between the straps or edema will develop and there can be no wrinkles in the skin or local vascular insufficiency may occur. The skin is cleaned and prepared with tincture of benzoin. The normal foot is always strapped first. Treatment should be initiated from two weeks to one year of age, preferably the younger. The patient is inspected every one to two weeks for the first few months and then every month until he begins to walk. After that night splints are used for the next one to two years. The major complications are (a) higher rate of recurrence and (b) skin irritation from the splinting materials. The prognosis varies considerably depending on many of the same factors mentioned under the plaster cast method. Satisfactory correction with splints alone is from fifty to seventy-five percent and somewhat higher if some plaster casting is also used during the treatment. Furlong (1960) states that an estimated five to eight percent have recurrence severe enough to justify surgery(21). Most authors agree that the method should be supplemented with plaster casts.

D. Operative Treatment

In general operative procedures are reserved for those feet which have failed to reach a satisfactory correction with conservative measures in one or more components of the deformity, in those feet which have associated abnormalities so that they do not respond well to conservative measures, and in those cases which have been neglected either partially or wholly in early life. Most of the procedures are merely adjunctive measures and are used as a means of improving a state of correction that does not measure up to the necessary standards. Their use should not be delayed too long after conservative measures have failed so that the greatest preservation of function and structure can be attained. The general indications for surgical treatment in those less than six years old are (a) incomplete correction of equinus with satisfactory correction of varus, (b) incomplete correction of varus with or without satisfactory correction of equinus, (c) persistent intoeing, and (d) persistent functional varus on standing with acceptable correction to passive manipulation. In those older than eight years with complaints of pain and disability associated with a persistent deformity. The specific advantages and disadvantages of each operation will be outlined under each type of procedure. The overall prognosis is generally worse than with conservative management but the correlation is not accurate. Poor results

with the various operative procedures result from overcorrection, recurrence of the varus deformity, skin slough, and rigidity of structures with a concomitant loss of function.

Tenotomy of the Heel Cord with Posterior Capsulotomy(15,23,30,32,43,44)

This procedure was advocated by Thilenius in 1784.

Stromeyer in 1831 emphasized the safety of the subcutaneous tenotomy. This procedure also gained wide acclaim after being used on the English surgeon, Little (32). In the past this procedure was done many times without proper indications. Before proper aseptic technics were used the subcutaneous tenotomy was quite popular. Indications are (a) failure to overcome the equinus relationship of the hindfoot due to a shortened heel cord, (b) adequate correction of the varus component, and (c) a strong enough calf muscle to function properly in the lengthened position. Wiley (1959) recommends tenotomy in early infancy in the treatment of congenital clubfoot based on his findings in anatomical dissections but other authors have not favored any operative procedure this early (43). Contraindications are (a) a "rocker-bottom" foot, (b) uncorrected varus, and (c) structural alteration in the astragalus sufficient enough to prevent its body from rotating upward in the ankle mortise. The advantage is that it is a relatively easy operation which can substantially correct a hindfoot equinus when the proper indications are present. It does little to cause rigidity of

the foot by scar tissue if done properly. The disadvantages have never been significant enough to warrant discussion. The tendon is exposed and divided longitudinally in a transverse plane. The posterior capsulotomy including the astragalotibial and astragalofibular ligaments is usually done at the same time. The foot is then retained in splints until healing is complete. Prolonged wedging is to be avoided so that plantar flexion at the ankle joint is not lost. Good results can be obtained in approximately fifty percent of the cases. The average age of the patients undergoing this procedure has been reported to be one year (30).

Medial Soft Tissue Release Operation

This operation was first advocated by Brockman in 1930. Brockman devised this operation on the premise that the deformity is due to a congenital atresia of the socket for the head of the astragalus. It is used solely to correct a specific soft tissue contracture that persists despite other treatment. The indications are (a) failure to obtain correction by way of conservative treatment, (b) a tendency to lose correction once it has been attained, (c) inadequate correction in the older child in which the prolonged conservative management would prove a burden to all concerned, and (d) in those clubfeet of neurogenic or fibrodysplastic origin. Contraindications are (a) a foot that corrects well to passive manipulation and shows good correction by X-ray, (b) a child that is too young

or too old, (c) a foot with structural changes of the tarsal relationships enough to prevent realignment, and (d) for the correction of residual forefoot deformity. The optimal age for this procedure is from three and one-half to four and one-half years (30,41). The operation consists of dividing all of the contracted tendons, ligaments, and soft tissues on the medial aspect of the ankle. Care must be exercised in overcorrecting the foot because, if the skin is put on too much of a stretch, skin slough may occur. Other complications are aseptic necrosis of the astragalus or scaphoid, recurrence of deformity, rigidity of the foot, and development of a varus deformity. The prognosis depends on the condition of the foot before the operation, the skill of the surgeon, the post-op splinting and exercise, and the presence of the proper indications. Various investigators report satisfactory results in forty-nine to seventy-three percent of the cases (30,41).

Transfer of the Anterior Tibial Tendon

This operation is of value when the power of the transplanted muscle aids in establishing a better balance of power during foot action. Garceau (1947) recommends this operation for the prevention of recurrent deformity (24). He feels that it has a corrective influence. Raynal (1959) feels that this

operation is an indispensable aid in the medial release operation (37). Indication for this procedure is a foot that is used in functional varus but which corrects well with passive manipulation. Thus it is used to control a deformity in activity. The operation can be used in any patient from seven months to ten years with the proper indications (41). The average age at the time of treatment is reported to be from three and one-half to six and one-half years (1,12,24, 32,41). It is contraindicated in any foot that has a resistant fixed varus. After the tendon is freed from its attachment on the first cuneiform and a subcutaneous tunnel is created the tendon is attached to the proximal end of the fifth metatarsal or to the cuboid (1,12,24). The foot is then maintained in a plaster cast for six weeks. Muscle re-education does not appear to be a problem. Occasionally the tendon has to be redivided and moved medially when overcorrection occurs. Complications are usually limited to skin problems and overcorrection with a resultant flat foot. Prognosis again depends on the pre-op condition of the foot, the skill of the surgeon, and the flexibility and structural correction of the foot. Satisfactory to good results are reported in from forty-nine to eighty-two percent of the cases (1,24,41).

Transfer of the Posterior Tibial Tendon

This operation has been widely used by Fried (1959) in the treatment of recurrent talipes equinovarus (19). Indication for the procedure is in a recurrent deformity in which this tendon is tight and is contributing to the deformity. At times it is in place of the anterior tibial transfer. It is usually done along with a generous medial soft tissue release procedure. It is contraindicated in any condition in which the deformity is not due to a tight contracted tibialis posterior tendon or in a foot with a fixed varus. In this operation the tendon is divided and then sutured to the third cuneiform. At the same time a generous medial soft tissue release procedure may be done and also lengthening of the heel cord. Complications are usually limited to skin problems and overcorrection with a resultant flat foot. The prognosis depends on the same conditions as mentioned in the above paragraph. Fried (1959) treated thirteen feet with this procedure with only one unsatisfactory foot. The age group in which this operation is used is the same as for the anterior tibial transplant, that is three and one-half to six and one-half years.

Plantar Fasciotomy

This operation which was first performed by A. Steindler in 1913 is a useful adjunctive procedure when there is a plantar

flexion deformity with a prominent cavus (40). Kuhlman and Bell (1957) state that this procedure appears to assist significantly in the control of the cavus deformity (30). This procedure like many of the other operative procedures has only limited application in the foot with a prominent cavus deformity. The procedure is basically one of division of the plantar fascia of the foot in order to correct the cavus. Complications are that of skin problems and scarring of the underlying structures producing a rigid foot. Prognosis depends on the pre-op condition of the foot, skill of the operator, and the presence of overcorrection. Steindler (1928) reported good results in ninety-seven percent of cases with congenital clubfoot (40).

Triple Arthrodesis (6,15,30,32)

This operation is of value in those cases where simple methods have failed to give a good functional foot. Solly in 1857 performed the first bone operation when he removed the cuboid. Indications for a triple arthrodesis are (a) a persistent deformity in an older patient who has subjective complaints or disability, (b) in those patients in whom the degree of deformity makes future complaints or disability inevitable, and (c) in feet in which earlier operative treatment has failed to correct the deformity. The operation is indicated only in patients older than eight years because in the younger patients the bones have not reached maturity and

severe growth disturbances will be inevitable. It is contra-indicated in the younger patient and in a moderate deformity with no subjective complaints or disability. The advantages over other boney operations are that it gives a good stable foot with no pain and, if good correction is obtained, a regular oxford shoe may be worn with no added correction.

In this operation a wedge of bone is removed with the base directed laterally and dorsally to overcome the varus and adduction deformities. To correct the adduction deformity, a boney wedge is removed at the level of the calcaneocuboid and astragaloscaphoid joints. The varus is corrected by removal of a wedge from the subastragalar joint. The base of both wedges is toward the lateral aspect of the foot. The heel cord is lengthened in order to complete the procedure. The corrected foot is then maintained in a plaster cast for three months. After this a foot and ankle brace guards against recurrence until fusion is solid. Complications are skin problems and vascular problems, both only rarely occurring. Prognosis of a useful, stable foot is good in most cases but occasionally there may be some residual pain. Barring any complications results are uniformly successful in providing a stable, painless, foot with only minimal residual deformity.

VI. DISCUSSION

Management of the clubfoot patient generally falls into two groups, conservative and operative treatment. However, it is important to consider both methods of treatment in those patients in the transition zone. The transition zone refers to those patients from approximately one to ten years of age. In the younger half of this group the simple operative procedures may be used quite early so that the foot can be molded into a good functional, anatomical foot before the usual severe bone changes take place. Likewise in the older half of this group non-operative measures should precede any operative procedures so that there is the best functional, anatomical foot on which to work. In this way the operative procedures need not be nearly so radical.

I want to stress the functional, anatomical foot. Both of these aspects of correction are of major importance in the management of a clubfoot problem. If either one of these are sacrificed in place of the other failure is practically inevitable. The functional foot is more important in the final analysis but both must be considered in the overall management. The ideal anatomical foot allows the patient to wear a standard straight last shoe without braces, alterations, or sole

modifications. The ideal functional foot provides a stable, active, pliable foot without pain or easy fatigability.

Management of a clubfoot in a child should always begin with conservative treatment. Either the serial cast or the splint method appear to be satisfactory. It appears that the serial cast or wedge cast method produced uniformly more satisfactory results. It is especially indicated in the more severe cases. The splint method is satisfactory in the milder deformity. It appears that each method when used in conjunction with the other provide very satisfactory results with greater ease to the surgeon and less discomfort to the patient. Independent of the method used, the progression of correction is of utmost importance; thus the adduction deformity must be corrected first, next the varus, and last the equinus deformity. Failure to follow this sequence usually leads to recurrence, especially in the inversion deformity. Kite has outlined what appears to be a satisfactory method of checking on the adequacy of the inversion correction using radiographic studies. The alignment of the astragalus and scaphoid which can be appraised with X-ray is very important in the management of clubfoot and cannot be overemphasized.

Careful observation of the foot during active treatment is necessary in order to minimize the skin and vascular problems inherent in any long term casting or splinting procedure.

Because of the rapid growth during this period frequent cast changes and modifications are necessary. Once adequate correction is obtained careful and frequent follow-up visits are important in order to recognize any tendency toward recurrence. With recurrence correction, usually with plaster casts, must be undertaken immediately. Therefore, on the initial visit the family should be informed of the entire scope of the problem and the general outline for routine treatment. Only in this way can the many months of treatment with the recurrences and additional complications of plaster casts and splints be tolerated by the child and his parents.

Once conservative methods have failed to produce a satisfactory correction little time should be lost before minor operative procedures are initiated. In general these procedures include lengthening of the heel cord and tendon transfers. These procedures usually produce good results in selected cases if undertaken before the more severe bone changes occur. The operative procedures are not without their own inherent problems and complications. Careful evaluation of each case is necessary in order to minimize the number of unsatisfactory results. The higher rates of unsatisfactory results, recurrence, and overcorrection are due in part to the more resistant deformities initially but a certain number can be attributed to the absence of indications and the presence

of contraindications at the time of operation.

Lengthening of the heel cord is the most widely used procedure. Although some authors (43) recommend this operation in all cases in early infancy, it appears more rational if it were used only after failure of conservative treatment in the presence of proper indications. It appears that this operation is performed in many cases before the age of one year, which is usually before the child begins to walk. I question if accurate evaluation can be made at this time as to the necessity of this operation. It appears that many of the lesser degrees of persistent equinus would lend to correction merely by the introduction of walking. This would not be a question in the more severe cases because here heel cord lengthening would probably aid the patient in earlier walking.

Medial soft tissue release operation is a very useful procedure in those feet that fail to correct under passive manipulation and which demonstrate contracture of the medial soft tissue structures. This operation should only be considered in the three to five year age group. If done before three and one-half years of age serious growth disturbances and contractures can produce an even more severely deformed foot. If it is done in the older child it will produce un-

satisfactory results because of the more permanent bone changes which have taken place. It is obvious that a soft tissue release procedure will not correct a boney deformity which is what the older clubfoot deformity represents.

Anterior and posterior tibial transfer operations are useful in correction of deformities of activity. They are used in the three to seven year age group in those feet which correct well to passive manipulation. They are of no value in the foot which will not correct to passive manipulation. In these cases a release procedure must be done in conjunction with a tendon transfer. A few authors (37) recommend an anterior tibial transfer with every medial soft tissue release operation. It appears that these two procedures should be considered as separate entities and their indications as such also. Thus a certain number of procedures could be eliminated. This is important when the surgeon is attempting to minimize the amount of scar formation and rigidity. The question also arises when to transfer the anterior tibial tendon and when the posterior tibial tendon since in many cases they are more or less substituted for each other. I have found no conclusive remarks on this point in the literature and it appears to rely on the preference of the surgeon in many of the cases. The posterior tibial transfer appears to be a more useful procedure in most cases because it will remove a deforming force in

addition to contributing to the overall dorsiflexion power. Assessment of the presence of adequate muscle strength in the new position is probably the prime factor in choosing the tendon to be transferred. In time more studies will be reported of the newer procedure of posterior tibial transfer and then more accurate conclusions can be drawn.

Plantar fasciotomy is a useful operation and is commonly done in conjunction with a medial soft tissue release operation. This corrects any cavus deformity which is usually present in various degrees in the more severe cases. This procedure must precede any heel cord lengthening when there is a concomitant equinus deformity. If the two operations are done at the same time proper correction cannot be determined and may result in a overcorrection or an undercorrection.

Triple arthrodesis often entailing wedge resection of bone has proved to be a time honored procedure in providing a stable, painless foot when all other methods of management have failed. Its major limitation is that it cannot be used in the younger age group. If this procedure is done before eight or nine years of age the surgeon has to remove a large amount of the cartilagenous tarsal bones in order to obtain bone approximation. This may result in significant shortening and secondary deformity of the foot. In certain instances the other procedures pre-

viously mentioned are used to control a foot until the patient reaches the age of nine so that the foot can then be stabilized. As long as our present measures of management fail to give good results in all of the clubfoot deformities, this operation will remain as an indispensable aid as the final step in correction of a clubfoot deformity.

It appears that the surgeon has available a very satisfactory armamentarium for the correction and control of the clubfoot deformity. It is our duty to see that they are used wisely in order to reduce the incidence of recurrence and poor results. The obstetrician, pediatrician, and generalist should recognize this deformity early so that adequate methods of management may be employed early. With adequate treatment most patients with congenital equinovarus can expect a foot which functions satisfactory without pain or disability. The most satisfactory control will rely on the discovery of the etiology and consequent control of this factor during intra-uterine development.

VII. SUMMARY

1. The present methods used in the treatment of congenital equinovarus have been reviewed.

2. No attempt has been made to describe each method in technical detail.

3. To date no etiological factor has been proven although it appears that the final solution may lie in a metabolic or biochemical defect.

4. The basic principles of management, both conservative and operative, have been discussed.

5. The various methods of treatment are reviewed in reference to their indications, advantages, and complications.

6. It appears that the surgeon has a sufficient number of procedures available to control the clubfoot deformity. It is his responsibility to use them as accurately as possible so that function can be preserved.

7. The majority of clubfoot patients today are assured of a stable, functional foot with a minimum of residual deformity.

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