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Clubfoot in children: An overview

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Clubfoot is a case of complex defects affecting mostly newborns and children. Its management represents a great challenge especially in cases of severe resistant cases. Unfortunately, it did not receive the necessary attention in text-books and literature regarding its all aspects under one title. In this article, we aimed to highlight clubfoot focusing pathological anatomy of clubfoot and consequent management options. This might help physicians and surgeons in proper management. Clubfoot shows main anatomical defects including foot cavus, adduction, varus and equinus; the most prominent bony defect has been found in foot talus. Most cases respond to conservative reconstruction including the Ponseti method. However, some cases including those associated with other congenital anomalies are severe and resistant to such conservative management. These cases are suggested to be managed by talectomy that represents a salvage procedure to give a plantigrade foot.

Keywords: clubfoot, anatomy, pathology, talectomy

Clubfoot called talipes equinovarus represents a global health problem affecting 1-2/1000 of live births all over the world. It involves both feet in about half of the reported cases. In unilateral cases, the club foot slightly more affects the right side than the left. It also affects males more than females. The case is mostly managed through conservative measures including the Ponseti method [1]. However, such conservative methods are often unsuccessful for correction of deformity in cases of severe rigid clubfoot [2].

Because of unresponsiveness to many options of management, cases of severe rigid equinovarus deformity represent a challenging problem for orthopedic surgeons. Understanding the pathological anatomy of such cases facilitates their management. There are many surgical options for correction of the deformity including release of soft tissues, Ilizarov correction using an external fixator and triple arthrodesis [3]. However, all these measures also fail to obtain a stable plantigrade foot. Therefore, talectomy has been adopted as a salvage procedure aiming to correct or minimize the deformity. This procedure was used for treatment of deformities of paralytic calcaneovalgus [4].

Although many researchers have tried to clarify the pathogenesis of congenital clubfoot, the exact cause is still obscure. Most of cases (about 80%) occur in normal physical and mental children [5].

In this review, we highlight the clubfoot and its pathological anatomy in a trial for more understanding of its pathogenesis, and hence its proper management. In addition, the options for management were reviewed with a focus on the role of talectomy in severe and resistant cases.

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Methods

The clubfoot was investigated through the database of PubMed, Google Scholar, Web of Science, Scopus and others. Data were collected, represented and discussed into the following main subtitles: epidemiology, etiology, pathological anatomy, diagnosis, classification, features and management.

Results and Discussion

Epidemiology of Clubfoot

Clubfoot is one of the commonest and oldest recognized orthopedic anomalies. It was recognized as early as the ancient Egyptians. It has been reported that Egyptian Pharaohs Siptah and Tutankhamun were suffering from clubfoot. The first medical document describing the case was produced in 400 BC by Hippocrates [6].

Clubfoot is encountered in about one per thousand of the live births, varying from one race to another. It affects approximately 150,000-200,000 of newborns all over the world each year. About 80% of cases are encountered in developing countries. It affects both limbs in about 50% of cases. The unilateral clubfoot occurs in the right lower limb more than the left one with a ratio of 2-1 respectively [7]. It might be isolated congenital defect or associated with other serious anomalies especially if it is severe and bilateral [8].

Moreover, the incidence is more in males than females with a ratio of 2-1 respectively. The prevalence in Western Europe and the USA accounts 1-1.4/1000 live births. A lower incidence has been detected in Chinese and Japanese but a higher amongst Polynesian as well as South Africa black populations [5].

Etiology of clubfoot

Clubfoot is classified into two main types; congenital and acquired. Acquired form isn't inborn-error. It might be caused by associated diseases. These include vascular causes such as Volkmann Ischemic Paralysis and neurogenic diseases comprising poliomyelitis, meningitis, sciatic nerve damage. Congenital clubfoot could be subdivided according to their causes into idiopathic or non-idiopathic types. Idiopathic clubfoot is mostly an isolated birth defect. The causes of non-idiopathic clubfoot include teratologic anomalies, generalized syndromes (e.g. diastrophic syndrome) and neurological diseases of known defects (such as spina bifida). The cases of non-idiopathic clubfoot are commonly associated with the presence of other anomalies with poor response to management either conservative or operative treatment [9].

Many theories have been proposed to explain causes of idiopathic type of clubfoot occurring in normal newborns. One of these theories is the mechanical one laid by Hippocrates which assumes that clubfoot might be caused by an increased intrauterine pressure during pregnancy [10]. This theory is disputed because of absence of association of clubfoot with most cases of overcrowded uterus such as cases of twins, large babies or polyhydramnios [9].

Smoking of mothers at pregnancy might be a cause of increased risk of clubfoot [11]. Another cause might be presence of an aberrant muscle, noticed at surgery to be inserted into the deep fascia of foot opposite the medial side of calcaneus [12]. Zimny, et al., found abnormal contracted plantar fascia with fibroblastic contracture similar to that found in Dupuytren's disease [13].

There are some findings supporting the genetic factor in etiology of clubfoot. These observations include the increased incidence in cases of previous family history. Such history was found in about 25% of isolated cases of clubfoot. Moreover, there is a coincidence of clubfoot of monozygotic twins of about 33% compared with only 3% in dizygotic. It has been suggested that a variety of apoptotic genes are involved in cell death cascade and consequent shaping the defects in clubfoot [14].

Another study attributed the idiopathic clubfoot to be due a disturbance in the germ cells causing arrest of the foot development at the 5-week stage of fetal life. At this period, called physiological clubfoot stage, the foot bones resemble the shape and position of clubfoot [15]. Similarly, Victoria-Diaz and Victoria-Diaz, stated that the development of the human foot passes into three stages in-utero [16]. In

the first (the 15-mm embryo length) stage, the foot appears in the same line with the leg. In the second "embryonic" stage (30-mm embryo length), the lateral side of the leg elongates more in relation to the medial aspect causing the foot to assume the clubfoot position. By the third "fetal" stage (50-mm), the medial side of the leg and foot develops to correct the position assuming that seen normally in the newborn.

Arthrogryposis

It is a common cause for rigid talipes equinovarus found since birth. Its disorders include multiple joints so is commonly called arthrogryposis multiplex congenita. It affects two or more joints with no obvious cause or pathogenesis. There is no specific diagnosis, but this depends mainly on clinical findings [17]. The affected joints involve the large joints of limbs such as hip, knee, ankle, shoulder, elbow and wrist as well as the joints of the foot and hand. The joints of the ankle and foot are mostly affected leading to deformity of clubfoot. Such deformity is resistant to manipulation and conservative measures. It could be improved by radical soft tissue surgery; however, the relapses' rate is high. Therefore, talectomy is recommended as a salvage or even primary procedure in such cases of severe rigid clubfoot [18].

Spina bifida

Spina bifida is a congenital anomaly in which there is failure of fusion of the two halves of the neural arch of one or more vertebrae. It includes many types [Figure 1]. Spina bifida occulta is a non-symptomatic condition and was discovered at investigation. Other types include meningocele with protrusion of sac of meninges through the vertebral defect and meningomyelocele comprising the nervous tissue and meninges' protrusion [19]. It represents one of the non-idiopathic causes of rigid and resistant clubfoot. This foot deformity occurs in about 30-50% of cases of spina bifida. It is evident at birth; and its incidence differs according to the site of spina bifida lesion. Clubfoot is noticed in about 90% of cases in case thoracic and lumbar spina bifida whilst the sacral region is associated with clubfoot in 50% of patients.

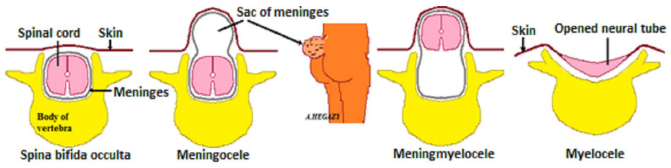

Figure 1 Types of spina bifida.

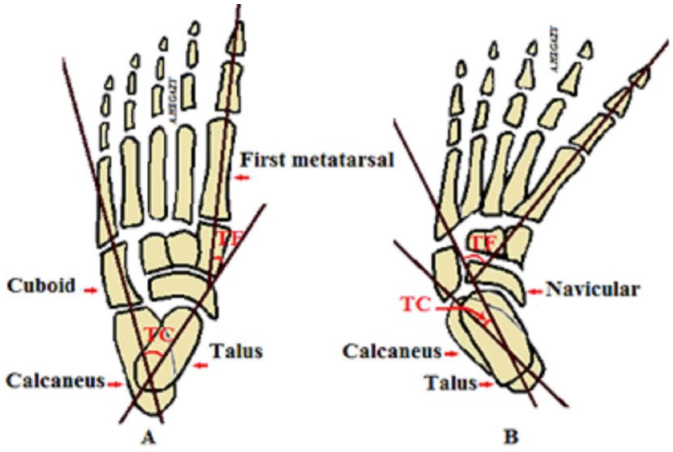

Figure 2 Talo-calcaneal (TC) and talo-first metatarsal (TF) angles: A) Normal foot; B) Clubfoot.

Since the case is rigid, non-surgical management including stretching, splinting and serial casting commonly fails. It might be an indication for surgical interference [20].

Pathological anatomy of clubfoot

Despite the cause of the clubfoot is still uncertain to treat the cases accordingly, knowledge of the pathological anatomy remains the main guide in repair and management. Many theories were proposed to explain the bony changes occurring in the foot.

Scarpa [21] mentioned that the osseous defects in the talus are the primary causative factor in pathogenesis of the clubfoot. This suggestion has been supported by other studies later on. They added that talus defects are noticed in all clubfoot types [15].

Other authors postulated that the calcaneus is the primary fault in pathogenesis of clubfoot attributing their suggestion to the ossification of the calcaneus that noticed to appear before that of talus [22].

In clubfoot, there is a complex musculoskeletal alteration in the foot to be directed down and medially resembling the club used to hit the golf ball. The anatomical deviations are summarized by the 4

letters of the word "cave" (C=Cavus, A=Adduction, V=Varus and E=Equinus) (Figure 2) [8].

The main features include the followings (Figures 2,3):

1- Cavus: It is the increased convexity (or longitudinal arch) of the foot. This is caused by increased plantar flexion of the first metatarsal bone in relation to the hindfoot. It is caused by contracture of the plantar aponeurosis. Also, there is contracture of the plantar and spring ligaments.

2- Adduction: The forefoot is adducted. The cuneiforms and metatarsals are deviated towards the midline but they appear of normal shape.

3- Varus: It is the inversion and adduction of the hindfoot. In other words, the heel forms varus angulation. The calcaneus is adducted, plantar flexed and rotated inwards below the talus to lie nearly in the same line.

4- Equinus: The entire foot shows an increased plantar flexion at the ankle joint.

The soft structures on the medial and posterior aspects of the foot are shortened and thickened keeping the position of the foot in adduction and varus with equinus respectively. These structures include deltoid, talonavicular and spring ligaments as well as tibialis posterior tendon medially. Also, there is tightness of the posterior gastrocsoleus complex [8].

Joints of the foot are distorted due to malposition of its bones. The equinus deformity occurs mainly at the ankle joint, but others also particularly subtalar joints contribute to the deformity of the foot. The talo-calcaneo-navicular joint is dislocated with contracture of the soft tissue surrounding it with the ankle. Such contracture includes the joint capsule, ligaments, tendons and their sheaths and muscles. The contractures are noticed in talofibular, calcaneofibular, spring, deltoid and plantar bifurcated Y ligaments as well as the tendo Achilles. Moreover, there are plantar contractures affecting the intrinsic flexors of the toes, abductor hallucis and plantar aponeurosis [9].

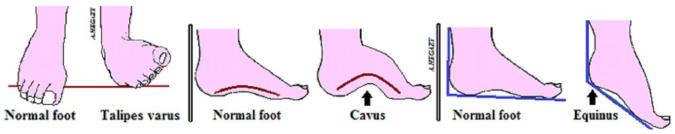

Figure 3 Normal foot compared with varus, cavus and equinus.

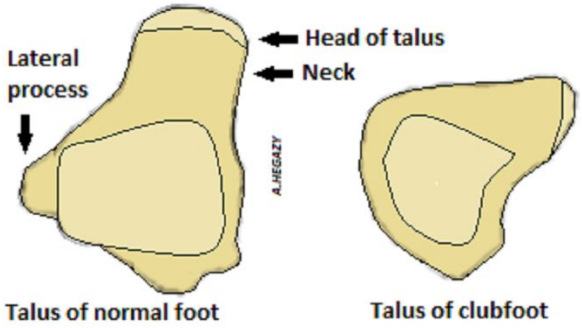

Figure 4 Diagrams showing superior view of talus in normal and clubfoot.

Talus

Rehman and Faruqui found that all clubfeet show nearly the same defects of foot skeleton. The most prominent features are the small sized foot and distorted talus [23]). The talus is distorted in size, shape and orientation in case of clubfoot. Its head and neck are smaller than normal and directed down and medially. Talus is directed in a plantar flexion position. The trochlear articular surface of the body of the talus is less convex. Despite any change in the shape of the talus body, it is reduced in size [22].

The most apparent change in the talus is found in its anterior part (Figure 4). The neck of the talus is always short, directed medially and plantarward on the body. It is sometimes not apparent. The angle between the long axis of the neck and that of the body is much reduced; in clubfoot it is about 115-135° versus normal foot of 150-155°. The articular surface for navicular is no longer directed forwards like that of normal foot, but deviated medially and plantarward [23]. In case of clubfoot, the degree of medial deviation of the head and neck of the talus is more significant than that of the plantar one. Moreover, the volume of talus in congenital

clubfoot is much reduced than that of the normal foot [24].

The navicular bone is dislocated medially lying opposite the tibial malleolus. This causes the front of the head of the talus to be uncovered and pointed towards the lateral instead of medial side [5].

Cuboid is also displaced medially along with the anterior end of the calcaneus displaying foot lateral convexity [9].

Calcaneus

The calcaneus in clubfoot is generally of normal shape but slightly smaller than that of normal foot. It is shifted into equinus, varus and medial rotation along the distorted neck of talus [23]. Epeldegui also noticed a small-sized calcaneus; but added the presence of another deformity in the calcaneus represented by twisting along its long axis with consequent rotational deformities of foot longitudinal axis [25].

Diagnosis of Clubfoot

Prenatal diagnosis

Although most cases of clubfoot are diagnosed at birth, they could nowadays be recognized prenatally. Ultrasonography (US) advent into health care enables the physicians to recognize the case during the intrauterine life. Prenatal US examination has a positive predictive value over 80% with no false results [8]. However, using US at pregnancy doesn't differentiate between its grades. Its importance lies in preparing the parents to be ready to the degree of postnatal management as early as possible. Also, discovery of the case in-utero motivates the doctors to search about the other congenital anomalies that might be associated with clubfoot in up to 50% of affected fetuses [26]. Diagnosis of the case prenatally could be recognized around the twenty-two weeks of gestation. Once noticed, assurance of the parents is essential, focusing that the case is treatable and not an indication for termination of pregnancy. The parents should know that the clubfoot is not a disabling condition but requires patience, compliance and frequent visits and follow-up to achieve excellent results. Prenatal counseling also is important to offer for the parents the options of treatment and results expected from each line management [27].

Postnatal clinical examination

Immediately after birth, the typical clubfoot is diagnosed by the orthopedic physician through taking full history from the parents and inspection of the shape of the foot. Then, the doctor does palpation of foot bones and surrounding connective tissues for abnormal position and contractures respectively. The affected cases should be thoroughly investigated from the head to the foot toes to exclude the other associated congenital defects. All body joints are examined for presence of contracture characterizing arthrogryposis [7]. The case also should be differentiated from paralytic clubfoot such as multiple congenital malformations. The main aim of assessment of cases is to differentiate the postural talipes from the true clubfoot and to define its severity. Postural type is usually easily correctable to the normal anatomical state at birth or in the infantile period after manipulative strapping [28]. Assessment of movements of foot such as inversion/eversion, adduction/abduction of the forefoot, supination/pronation is important. Evaluations of the gait in neglected cases, range of movements and static weight bearing alignment as well as noticing the differences in-between the two limbs are also valuable [29].

Radiological assessment

Though many radiological modalities have been introduced in health investigations, the clinical assessment remains the more informative one in cases of clubfoot. Up till now, there is no consensus regarding the great value of x-ray in routine evaluation and management of such cases. The standard radiograph does not give an accurate single method for evaluation and further management of cases of clubfoot [30]. This is because most tarsal bones are not ossified at birth except the talus and calcaneus of which ossified centers appear in the plain radiographs as rounded ossicles. However, the ossification centers of metatarsal bones are evident at birth; and become sufficiently ossified by the age of 3 to 4 months [31].

The information achieved from radiological examination is usually taken from standing anteroposterior and lateral views. Specific measurements are taken for assessment of cases of clubfoot. These include the angle between talus and calcaneus in lateral and anteroposterior planes as well as the relation of equinus of calcaneus to the longitudinal axis of tibia. The angle between the long axis of first metatarsal and that of talus (called Meary's angle) is an indication for cavus for forefoot [29].

Magnetic resonance imaging (MRI) and ultrasound also have been used in evaluation of management. MRI is introduced particularly to detect the gradual response for conservative treatment. However, it is important to remember that the initial decision of treatment depends mainly on the clinical grounds [8].

It is important to note that even in well-corrected cases, some radiological residual defects might persist for a long time in the well-treated cases. These include a small volume of tarsal bones and flattening of talar dome [8].

Classification and Features of Clubfoot

Although there is no agreement about the methods of scoring or classification of clubfoot till now, it's essential to adopt one of them to predict the appropriate line of management and to assess the progress of the lesion and its prognosis [31].

There are many methods of classification. One of them was mentioned by Nordin, et al., and Diméglio, et al. [28,32]. They classified the lesion into four degrees as follows:

1. Degree 1, benign "postural or positional" clubfoot: The position of the foot is easily corrected through casting and physiotherapy.

2. Degree 2, moderate "soft more than stiff" clubfoot: This degree accounts about 33% of cases. It responds to casting in more than 50% of cases. The others not responding to this line of treatment within 7-8 months may need surgical interference.

3. Degree 3, severe "stiff more than soft" clubfoot: It occurs in 61% of cases. More than 50% of them don't respond to conservative treatment and are mostly released surgically.

4. Degree 4, very severe "stiff" clubfoot: It is irreducible; and congenital anomaly. It often occurs in both sides; and necessitates extensive surgical repair (Table 1).

Grade	Score	Type	Reducibility
I	< 5	Benign	> 90% soft-soft, resolving
II	5 to < 10	Moderate	> 50% soft-stiff, reducible, partly resistant
III	10 to < 15	Severe	< 50% stiff-soft, resistant, partly reducible
IV	15 to < 20	Very severe	< 10% stiff- stiff, resistant

Table 1 Diméglio, *et al.,* classification of congenital talipes equinovarus [32].

Cummings and Lovell mentioned another three degrees of severity [33]:

1- The first "mild" one is called postural clubfoot and needs no great effort in correction.

2- The second degree, called moderate clubfoot mostly does not need surgical interference. The foot is easily flexible with absence of the transverse crease. Cases of this degree usually respond to realignment followed by keeping the foot for a while in plaster cast.

3- The last "severe" degree is called defiant clubfoot. It is characterized by a small foot and tight skin with a transverse crease in the sole. The heel isn't easily identified because of the fatty tissue covering the calcaneus. Fortunately, this type is less common than the previous type; but is resistant to conservative treatment and surgical interference is nearly inevitable.

Another common scoring or classification has been proposed by Pirani, et al. [34]. They divided the cases into three categories according to the six clinical findings; and gave three scores from 0-1 to each, as follows: 0 for absence, half for mild and one for presence of fixed contracture. The investigated signs are related to the midfoot and hindfoot. Those related

to the midfoot are: 1- Curve of the lateral border of foot, 2- Presence of medial foot crease, & 3- Palpation of the head of talus laterally. The hindfoot signs are: 1- Posterior foot crease, 2- Palpation of heel, & 3- Equinus rigidity (Table 2). The clinical investigation is done through looking, feeling and moving the foot.

Foot Clinical examination	**Midfoot**			**Hindfoot**		
	Signs		**Score**	**Signs**		**Score**
Looking	**Lateral border**	No deviation from straight line	0	**Posterior crease**	No heel crease	0
		Medial deviation distally	0.5		Mild heel crease	0.5
		Severe deviation proximally	1		Deep heel crease	1
Feeling	**Head of talus**	Reduced talonavicular joint	0	**Empty heel sign**	Hard heel (calcaneus is in normal position)	0
		Subluxed but reducible talonavicular joint	0.5		Mild softness	0.5
		Irreducible talonavicular joint	1		Very soft heel (calcaneus is not palpable)	1
Moving	**Medial crease**	No medial crease	0	**Rigidity of equinus**	Normal dorsiflexion	0
		Mild medial crease	0.5		Foot is plantigrade with knee extended	0.5
		Deep crease altering contour of foot	1		Fixed equinus	1

Table 2 Pirani scoring of clubfo

The high Pirani score, the more severe clubfoot, i.e. score of six means severe case, while zero is of a normal foot [8].

Neglected clubfoot

Although clubfoot is a major concern for the parents and the whole family as it is a major obvious crippling defect affecting the walking of the child, many cases especially in developing countries are neglected. This neglect might be due to difficulty to gain medical care, shortage in skilled surgeons or ignorance of the parents. In these cases, the children are forced to walk on the dorsolateral side of the foot. The affected cases are unable to wear the shoes in their feet aggravating the problem. Neglecting cases are associated with sequelae and complications [35]. The affected neglected foot is usually reduced in size. This is caused by tethering of the abnormal tight ligaments and tendons that tightly catch the foot impeding its further growth. The clubfoot is often associated with a limitation or even absence of the movements in the subtalar and midtarsal joints leading to their stiffness [36]. The complications include pain, thickened pigmented skin and ulceration. Such ulceration could result in osteomyelitis that might lead to amputation of the foot at the end stages [37].

Management of Clubfoot

The goals of management of clubfoot are to obtain an obvious plantigrade, stable and straight foot with no need to modify shoes and a good range of foot motion without pain [5].

From the beginning of the 20th century till now, the management of clubfoot has fluctuated between conservative and surgical procedures. In the early 20th century, treatment was begun for older children; therefore, it was difficult and resistant to correct [38]. Treatment of clubfoot should start soon after birth; initiated within the first week of life. This is because the joints and bones of the infant's foot are more flexible to allow successful repair. Treatment depends on the clubfoot degree. Mild flexible clubfoot is usually treated by non-operative or conservative treatment. Surgical treatment is reserved for cases not

responded to the first line of treatment and for severe rigid clubfoot [39].

Conservative treatment

History of conservative treatment starts since Hippocrates in 400 BC. Conservative measures could be divided into two phases pre- and post-Ponseti eras. The importance of the Ponseti technique does not mean exclusion of other lines of treatment including surgery depending on the condition of each case [9].

There are many methods for conservative treatment; however, the International Clubfoot Study Group, established in 2003, has approved only three of them as the standardized conservative lines for the treatment of clubfoot; Kite, Ponseti and Bensahel techniques [9].

Kite's technique

This method was introduced in the USA by Dr. Kite in the 1930s. It assumes gradual correction of each of the main deformities separately instead of simultaneous repair. The method depends on a series of manipulations and castings. To start in the next step, the previous one should be completely repaired. The technique starts with correction of med-tarsal adduction, internal rotation and calcaneal varus; and lastly the equinus. The session of manipulation is about five minutes, followed by lower limb immobilization [40]. The immobilization is performed through doing a slipper cast extending to a level below the knee that is changed every week. At the end of the procedure the foot is put in a Denis Browne Bar. The success of this method in various studies ranged from a low as19% to high up to 90% [9]. This method has not been performed longer because of long term treatment, with casting over two years as well the unsatisfactory outcomes in more than 50% of cases [41].

Ponseti method

The method was developed based on extensive anatomical study of the foot. It involves serial manipulations and casting, followed by a further three weeks in a cast. This method is widely adopted as the method of choice in many centers all over the world; however, most of the treated cases have a residual equinus and necessitate tenotomy of the calcaneal tendon. Tenotomy is usually indicated when the hindfoot can't achieve dorsiflexion for 15 degrees after correction [42].

Relapses can be frequent after treatment by the Ponseti method. Such relapses need the child to wear an abduction brace for three months. Thereafter, the abduction brace is advised to be worn by the child only at night till reaching the age of four years to avoid the relapse. The deformity could be corrected by applying counter pressure on the head of the talus during application of the casts with keeping the foot in abduction and lateral rotation [6]. Failure rate of the Ponseti method accounts for 3-5% of cases; and this needs surgical interference [43].

The parents are recommended to be aware that the treatment by this method extends up to at least four years; and this needs their cooperation and serious commitment throughout the process of management.

Bensahel 'French' technique

This method was suggested in France in the 1970s; and entered English literature in the 1980s. It depends on daily sessions of physiotherapy manipulations of the infant's clubfoot for thirty minutes for two months. This is followed by stimulation of muscles at the foot, especially the peronei, to keep the passive reduction achieved by physiotherapy manipulations; and then catching and holding the foot in the new position by adhesive strips. This daily management is reduced to three sessions per week till the age of six months. Then, taping of the foot continues until the infant begins walking. Thereafter, the foot is supported with a splint at night for another two to three years. About half of cases are totally improved; and the other cases only require simple surgical interference through a posterior release. Disadvantages of this method include the long-term management for many years that necessitates close contact of the child and his parents with the hospital [9]

Richards, et al.. compared the outcome results of non-operative techniques of the Ponseti and French methods [44]. They concluded that non-significant

better results were achieved by the Ponseti method; and added that the poor results were the same in both methods accounting for about 16% of cases in each one. However, He, et al., analyzed the clinical outcome of the different conservative measures of clubfoot treatment in a total 1435 cases [45]. They recommended the Ponseti method to be the first method of choice for management of such cases. They added that this method gives better results than the other conservative techniques; and minimizes numbers of the cases requiring surgical intervention.

Complications of conservative treatment

The main complications are summarized in two points; the first is the recurrence or failure of treatment while the second is the false correction leading to a condition called 'rocker-bottom foot'. In such a situation, there is overstretching of the foot without actual correction of the equinus of the hindfoot, but the foot tends to take up position towards the neutral position. If this is detected during treatment, manipulations should be stopped in particular to equinus correction; and the foot is rested in a supporting splint in equinus to allow healing of breach in the midfoot. Otherwise, more disability and pain will occur with more difficulty treating the deformed foot [14].

Surgical treatment

The best time for surgical interference for treating the clubfoot is still controversial. Many authors suggest that clubfoot is best to be operated at 9-10 months. At this age, the infant begins to pull himself to attain standing and hence beginning to put body weight on the feet. This might benefit from the gravity in the process of repair [14]. Despite other authors agreeing to perform surgery as early as possible, no evidence of better results to those operated early in life has been found [46]. The authors added that in very young ages, there may be difficulty to recognize the small bones and other cartilaginous structures in addition to presence of abundance of fatty tissues. Surgery in such a condition requires a meticulous surgeon to avoid residual scarring and stiffness resulting from dealing with immature structures. Therefore, surgeries must be performed by expert surgeons at specialized clubfoot centers established for such purposes especially in large hospitals receiving thousands of births per year [14].

The list of types of operations performed to correct clubfoot that begin at 1891 till now is endless; and no single one gives long-lasting repair [9].

The surgery in the current use can be divided into three categories; the first involving soft tissue, the second with bones and the last including both soft tissue and bones. Operations including bones are usually done for children at an older age; and are considered salvage procedures [6].

I. Soft tissue surgery

This procedure includes release, lengthening or transfer of tight structures such as ligaments and tendons and/or deforming soft tissue structures, e.g. joint capsules. The deformity should be corrected before further surgery [28].

Posterior release is the simplest soft tissue release surgery. It includes lengthening of the tendoAchilles and capsulotomy of the talocrural and subtalar joints as well as cutting the posterior talofibular and calcaneofibular ligaments. Such ligaments act as a tether for the talus and calcaneus so their contracture might prevent normal foot dorsiflexion [46].

Other comprehensive soft tissue release could involve posteromedial release of the soft contractures of the posterior, medial and subtalar soft tissues. This might allow correct alignment of bones. Also, circumferential release and posterior or tibialis tendon transfer might be performed to permit dynamic balance between the invertor and evertor muscles [28,33].

II. Combined skeletal and soft-tissue procedures

Evan proposed a procedure depending on shortening the lateral column of the foot in order to realign the midtarsal joint [47]. The author performed it through a closing-wedge resection of the calcaneocuboid joint associated with a modified soft tissue release of medial aspect of the foot.

Lunderg mentioned performing an opening-wedge osteotomy through the calcaneus in addition to the insertion of a bone wedge [48]. This is concomitant with posteromedial soft tissue release in order to obtain full repair.

Ilizarov found that gradual distraction of structures e.g. soft tissues and bones especially in young ages could lead to cellular proliferation of such structures [49]. The author stated that using the Ilizarov external fixator for management of clubfoot affords correction at many planes. Other authors investigated such methods with soft tissue release and bone procedures; and concluded that this method might give good results in management of neglected and relapsed clubfoot [50].

III. Skeletal surgery

There is a general consensus that surgery on the bones of the foot is reserved for older children or cases resistant to other measures of treatment [5].

Management of neglected and severe resistant rigid clubfoot represents a great challenge to orthopedic surgeons. This is because the excessive and extensive open surgical manipulations could lead to postoperative scarring and many complications. Therefore, talectomy has been suggested to be a salvage surgical method for correction of such cases of clubfoot [3].

Talectomy

Currently, there is an increasing attention all over the world to the role of talectomy in correction of cases of rigid clubfoot not responding to other measures [3].

Talectomy has been suggested as a salvage procedure to manage severe resistant cases of clubfoot. The operation gives satisfactory results through removing the talus "the most distorted bone". The patient could wear shoes with a plantigrade foot following talectomy. It is a safe and one-step surgery without major complications [30].

Conclusions

Clubfoot is a challenging orthopedic problem especially in severe resistant cases. Such cases are mostly encountered associated with other congenital anomalies. Thorough investigation of cases to exclude the association of other anomalies is essential to determine the line of treatment. Therefore, it is suggested to perform talectomy as a salvage procedure in cases of failure of other conservative measures; and it is also suggested as the first line in cases of severe resistant clubfoot associated with other congenital anomalies. Future studies are also recommended particularly to reveal genetic involvement in its etiology. This might be of benefit to alleviate or minimize occurrence of clubfoot.

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