STUDY ON COMPLIANCE TO ABDUCTION BRACE IN TREATMENT OF CLUBFOOT USING PONSETI METHOD

By

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ABSTRAK

Pengenalan

Sejak hampir sedekad, pengurusan rawatan terhadap penyakit CTEV adalah melalui kaedah Ponseti. Kaedah tersebut telah terbukti efektif dengan kajian di seluruh dunia mendapati peratus kejayaan menghampiri 98%. Kajian ini dihasilkan bagi mencari peratusan kejayaan rawatan CTEV di HUSM dengan menggunakan kaedah Ponseti juga kadar peratusan pematuhan terhadap penggunaan pemegang abduksi. Kajian ini juga dijalankan untuk melihat kaitan diantara peratusan kejayaan kaedah Ponseti ini dengan pematuhan terhadap penggunaan pemegang abduksi.

Kaedah

Kajian retrospektif dibuat di HUSM 32 pesakit dengan 40 kaki yang berpenyakit CTEV yang dirawat di HUSM dari Januari 2008 hingga Jun 2010. Semua pesakit tersebut telah di rawat dengan menggunakan kaedah Ponseti dimana terdiri daripada kaedah urutan dan simen berperingkat, pemanjangan tendon-Achilles diikuti pula dengan pemegang abduksi. Kaki pesakit tersebut kemudian di periksa menggunakan sistem pemarkahan (Pirani and MHJDF) dan soalan mengenai pematuhan terhadap pendakap abduksi.

Keputusan

Purata kadar umur pesakit pada masa permulaan rawatan ialah 28.5 hari (12-120) dengan purata bilangan plaster simen yang di aplikasikan adalah 6 kali (45%). Tiga puluh satu kaki (77.5%) telah patuh kepada peraturan aplikasi pemegang abduksi dan 9 lagi (22.5%) tidak patuh pada peraturan tersebut.Kejayaan rawatan kaedah Ponseti dikira dalam kalangan pesakit yang patuh kepada peraturan abduksi. Kadar peratusan daripada kajian ini telah menunjukkan kejayaan 100% dalam kalangan kumpulan yang patuh kepada peraturan abduksi. Walaubagaimana pun, kejayaan juga dapat dilihat sebanyak 55.6% pada kumpulan tidak patuh pada peraturan applikasi pemegang abduksi. Kajian ini juga telah membuktikan secara

statistik bahawa terdapat perkaitan diantara kadar kejayaan dan pematuhan terhadap penggunaan pemegang abduksi.

Kesimpulan

Kadar peratusan bagi kejayaan rawatan terhadap CTEV di HUSM dengan menggunakan kaedah Ponseti ialah 100%. Kadar peratusan bagi pematuhan terhadap pemegang abduksi ialah 77.5%. Kajian ini telah membuktikan bahawa ada kaitan positif diantara peratusan kejayaan rawatan dan pematuhan terhadap pendakap abduksi secara statistik.

ABSTRACT

Introduction

Management of idiopathic clubfoot since the last decade have been through Ponseti method. It has been proven worldwide to be an effective treatment in correcting the deformity approaching 98%. This study was conducted to find the success rate for Ponseti method of treatment in HUSM and the compliance rate of abduction bracing. This study was also design to find any association between success rate of Ponseti treatment and compliance to abduction bracing. It also look into whether number of cast required and age of presentation influence the compliance.

Methods

This retrospective study was conducted on 32 CTEV patients with 40 feet treated at HUSM from January 2008 to June 2012. All of these patients were treated using Ponseti method comprising of corrective serial casting, tenotomy and abduction bracing. The patients feet were reassessed using 2 scoring systems (Pirani and MHJDF) to asses success rate. Parents were given questionnaire to asses compliance to abduction bracing.

Result

The mean age of presentation was at 28.5 days (12-120) where the mean cast applied for correction was 6 casts (45%). Thirty one feet (77.5%) were compliant to the bracing protocol and 9 feet (22.5%) did not. Success rate was measured in feet with good outcome in patients who followed the Ponseti method and compliance to abduction brace. Success rate in the compliant group for this study was 100%. However, good outcome for the non-compliant group was 55.6%. The chi-square test had proven statistically that there is a significant association between the outcome and compliance to the abduction brace protocol.

Conclusion

The success rate for treatment of idiopathic CTEV with Ponseti method in HUSM is 100%. The compliance rate to abduction bracing was 77.5%. This study had proven statistically that there was an association between outcome and compliance with abduction bracing.

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LISTS OF ABBREVIATION

CTEV	congenital talipes equinovarus
CT	computed tomography
MRI	magnetic resonance imaging
HUSM	Hospital Universiti Sains Malaysia
MHJDF	Modified Hospital of Joint Disease Functional score

CHAPTER ONE:

1.0 INTRODUCTION

Congenital Talipes Equinovarus (CTEV) or idiopathic clubfoot is a musculoskeletal birth defect of the lower limbs. It is presented in a child with equinus of the ankle, hindfoot varus, forefoot adductus and midfoot cavus. If left untreated, the child will grow up with disability and cosmetically unacceptable appearance. This will ultimately affects the quality of life of the patient. The true etiology of clubfoot is still unknown; however, both genetics factors and environmental influences during pregnancy play a role in the developmental of clubfoot. Many theories have been put forward such as mechanical factors in utero, neuromuscular defects, primary germ plasma defect, arrested fetal development, and hereditary. Treatment modalities for CTEV are changing historically, from surgical to non-operative methods. Ponseti method had been shown to be effective with many studies showed positive short term and long term results approaching 90%. However not many studies published the treatment success until application of abduction brace. Ponseti method includes serial manipulation, casting, tendon Achilles tenotomy and followed by abduction bracing, not just only casting. This is why the success rate in this study is measured based on the group that comply to bracing as defined by Lehman et al (2003). HUSM have been using Ponseti method in treating CTEV patient since 2005. There is no short term study in Malaysia reviewing the treatment of CTEV until the maintenance phase with abduction brace. This study is designed to determine the success rate of CTEV treatment and the compliance of abduction bracing which is crucial for the success of treatment using Ponseti method.

2.0 LITERATURE REVIEW

Clubfoot:

Clubfoot is a term used for a congenital foot deformity which is characterized by equinus of the hindfoot, adduction of the midfoot and forefoot with varus through the subtalar joint complex. There is also a cavus deformity over the midfoot .

Incidence of congenital clubfoot is one in every 1000 live births . Usually cases are sporadic in occurrences; however, there have been reports of an autosomal dominant trait with incomplete penetrance. 50% of congenital clubfoot patient occurs bilaterally . The male: female ratio is 2:1. The incidence varies considerably between races . The exact etiology of congenital clubfoot is undetermined till present. Possible etiology can be divided into 3 major groups. They are moulding disorders, neuromuscular disorders and maturational disorders.

Environmental affects during pregnancies and genetic factors are both thought to influence the development of clubfoot . The genetic component is polygenic i.e. the trait is carried not by a single gene but by several genes. Recent studies, however have postulated a single dominant gene with a penetration of 33% . The occurrence rate was 17 times higher than in the normal population for first-degree relatives and six times higher for second-degree relatives.

Clubfoot as mentioned above has four main anatomical abnormalities. This can be easily remembered by the mnemonic ‘C.A.V.E’ (cavus, adduction, varus and equinus). This pathoanatomy of clubfoot must be thoroughly understood before embarking in treatment via manipulation and reduction. The talus is locked in equinus in the ankle mortise by the tight Achilles tendon. The tarsal bones distal to the talus (calcaneus, cuboid and navicular) are

adducted and inverted. As a result of pronation on the hindfoot due to the plantarflexion of the 1st metatarsal, the forefoot has a cavus position (Silvani 2006)

Classification:

There are 3 main varieties of clubfoot that may present at birth

1) A mild postural type that is easily and almost completely correctable manually at birth and requires little or no treatment.
2) A moderate resolving type which is fairly supple and partially correctable manually, show no deep transverse crease in the sole and has a well-defined heel. This type is the commonest and usually responds to manual manipulations and corrective plaster casts
3) A severe type which is rigid, has a deep transverse crease in the sole and has a heel which is difficult to palpate

There are many degrees of severity and rigidity found in idiopathic clubfoot. The three main classification systems are commonly used are:

1) The modified Dimeglio-bensahel method which uses eight components for a total of 20 points. The higher the score, the more severe is the foot deformity.
2) The Pirani system consists of six features with a higher score indicating a more rigid foot deformity (Figure 7)
3) The modified Hospital for Joint Diseases Functional Rating scheme rates six components for a best score of 60 points (Figure 8)

This classification system can also be used to assess clubfeet which had undergone treatments such as after a serial casting via Ponseti method. In this study we are using two systems to assess the outcome of our patients. Those two systems are the Pirani system and

The Modified Hospital for Joint Diseases Functional Rating score. The Pirani method uses six components to be evaluated on a clubfoot. These are the position of the lateral border of the foot, amount of medial and posterior creasing, the emptiness of the heel, degree of palpation of the lateral head of the talus, and the extend of ankle dorsiflexion passively. The higher the scoring means the more rigid the feet thus the more severe the clubfoot is. The Modified Hospital for Joint Disease Functional Rating involved maximum scores of 60 with the higher the score the less severe the clubfoot. It uses six components to be rated. These are ankle dorsiflexion and heel position with maximum passive manipulation, quantity of subtalar motion, the forefoot appearance, the amount of medial creasing and the quantity of cavus. (Lehman WB et al 2003)

Pathogenesis:

Clubfoot is a three dimensional deformity in adduction, equinus and supination. Adduction of the calcaneopedal block (CPB) under the talar-tibial-fibular unit (approximating the navicular bone to the medial malleolus and the calcaneal tuberosity to the lateral malleolus) is associated with forefoot adduction with respect to the hindfoot .The tibiotalar and subtalar equinus and calcaneal adduction induce “false” hindfoot supination. Forefoot supination, induced by that of the hindfoot, is less severe, giving a “pes cavus” aspect (1^{st} ray in pronation with respect to the hindfoot) bone deformities involving the talus. Lateral and medial arch length and lower-limb torsion and length are associated with soft-tissue retraction with posterolateral, anteromedial and anterolateral fibrous nodes and systemic amyotrophy of the lower-limb muscles .

Several anatomic abnormalities may be associated to varying degrees such as, agenesis or hypoplasia of the anterior or posterior tibial artery, accessory soleus muscle and etc. Association with congenital hip dislocation has not been proved, but is classically looked for.

Clubfoot is probably a phenotype with several distinct underlying pathogenic agents. Disturbance of the neuromuscular chain (brain, spinal cord, nerves, muscle) induces the deformity, which is expressed at 8-14 weeks of gestation, allowing antenatal ultrasound diagnosis as of 16 weeks. When isolated, it is considered idiopathic in 80% to 90% of cases.

A genetic etiology of unknown mechanism is strongly suspected given the frequency of familial history (25%), the strong concordance found in monozygotic twins (33%), male predominance (sex ratio= 2.5:1) and ethnic variation. Environmental factors such as smoking, early amniocentesis or viral infection have also been suggested.

Epidemiology:

Initial the incidence of clubfoot varies widely with race and gender. The overall incidence was 1 to 2 per thousand live births .The incidence in the United States is approximately 2.29 per 1000 live births; 1.6 per thousand live births in Caucasians 0.57 per thousand in Orientals; 6.5 to 7.5 per thousand in Maoris; 0.35 per thousand in Chinese; 6.81 per thousand in Polynesians and as high as 49 per thousand of live births in full blooded Hawaiians . Boo and Ong reported the incidence of clubfoot in Malaysia 1.3 per 1000 live births (Boo, N. Y. and L. C. Ong 1990). Males outnumber females by 2:1 with 50% of cases being bilateral . In those with unilateral deformity, there was a right sided predominance. A higher incidence of clubfoot was also noted in patients with a positive family history. The possibility of clubfoot occurrence in a sibling was 1 in 35 and if present in an identical twin, the risk was 1 in 3. Although this was probably due to polygenetic influences, it was suggested that it might also be due to an autosomal dominance of poor penetrance.

Clinical assessment

Diagnosis of clubfoot has been made based on clinical criteria found on physical examination. The talus is locked in equinus in the ankle mortise by the tight Achilles tendon. The tarsal bones distal to the talus (calcaneus, cuboid and navicular) are adducted and inverted. The forefoot has cavus position as a result of pronation on the hindfoot, mainly because of plantarflexion of the first metatarsal (Silvani 2006). Although the diagnosis is evident on physical examination in nearly every case of clubfoot based on the equinus and varus posture of the foot, a complete physical examination must be done because of the high incidence of associated disorders. The examination includes a detailed neurological evaluation as well as assessment of all joints and the spine it is important to examining the lower limbs for length, thigh and calf circumference and skin creases. Patient with ctev have a smaller calf over the affected side compared to the normal side. The depth of skin creases on the medial side of the foot indicates the severity of the deformity. It is important also to differentiate CTEV and adductus metatarsus, which lacks component of any equinus deformity

The clinical assessment should then be based on the following:

1) A general examination including assessment of the vital organs
2) Clinical survey to detect any other skeletal and soft tissue congenital defects.
3) Specific examination of the spine (spina bifida), hips, knees, legs and ankles.
4) A complete neurological assessment
5) Inspection of the skin condition over the calf, heel and sole including the site, depth, numbers and extent of skin creases and grooves.
6) Feel for subcutaneous tissues over the calf, dorsum of foot, heel and toes.
7) Peripheral circulation is check via detection of pulsation of dorsalis pedis, posterior tibial and anterior tibial arteries.

8) Muscles of the leg, mainly in the posterior and peroneal compartments regarding bulk, feel, texture, pliability and power. The motor power of the peronei remains weak in all the cases. The motor power of the tibialis anterior, tibialis posterior and even triceps surae also remain reduced to a variable extent
9) Assessment of bones regarding their position, shape and size
10) Assessment of joints regarding the position of the articulating bones, condition of the capsule and ligaments, any contracture, reducibility of subluxation/dislocation.
11) Extent of manipulative correction of deformity.

Investigations:

Foot prints records give graphic record of static pressure distribution through the sole and reveals persisting deformities (Turco, 1981). Although many radiological modalities have been used, in routine practice no formal investigations are required. The bones of the new-born are mostly cartilaginous with only small ovoid ossification centers present in the calcaneum and talus. This makes assessment of the axes and thus angular relationships difficult to determine. The primary value of roentgenogram is not in the diagnosis of club foot but in determination of the degree of deformity, and as a device for accurate assessment of the amount of correction obtained Radiographs are indicated to assess the degree of subluxation of talocalcanel and talonavicular joints before treatment, to guide progress during conservative management or operative treatment, to ascertain whether reduction and joint alignment have been achieved and to determine later whether alignment has been maintained. Whenever possible views should be taken in the weight bearing position with the feet in the maximally corrected position in a standardized way (Simons 1987)

The position of the infant's foot and x-ray plate is crucial and can be difficult to replicate accurately. This is illustrated by poor correlation between angles measured by plain

radiography and those measured by 3D CT scan. The child is placed in the sitting position with feet resting on a cassette with their medial borders parallel and touching one another. The forefoot is manually put into maximum abduction and the ankle into maximal dorsiflexion, which should be 15 to 20 degree after correction or as near as possible if there is equinus deformity. Initially, when there is uncorrected deformity, the foot is held in the best corrected position and translucent splint may be used to hold the foot, taking one foot at a time. The lateral view is a standard one centred on the hind foot, which should lie parallel to the cassette. The antero-posterior view need to be taken very carefully with the tube angled at 30 to 45 degree to the plane of the sole of the foot aiming at the hind foot and with the leg tilted back to avoid superimposition of the shadows of the leg bones on those of the foot (Simons 1987)

In normal foot in A-P view, by drawing a line through the long axis of the talus, this line normally passes through first metatarsal or lies along its medial edge. The axes of the middle three metatarsals are roughly parallel. By drawing a second line through the long axis of the calcaneus, the axial line of the calcaneus passes through or close to the 4^{th} metatarsal. The axes of the talus and calcaneus subtend an angle of 30-50 degree in clubfoot, due to forefoot adduction. The talar axis does not cut the first metatarsal. Middle metatarsal axes are parallel calcaneal axis does not strike the fourth metatarsal. Thus the angle between the talus and calcaneus reduced (Simons 1987). Another measurement which may be useful in determining the recovery of dorsiflexion is that between the tibial axes and the longitudinal axis of the talus or the calcaneus in the lateral view, which normally measures 40 to 60 degrees as a result of treatment.

The correlation between radiological and clinical outcomes is variable and certainly surgery is not indicated to correct radiological abnormality. Decisions on initial treatment are therefore made purely on clinical grounds.

Ultrasonography has been used to assess clubfeet and monitor the response to treatment. Ultrasonography was used to investigate the anatomy of congenital clubfoot. Routine ultrasonic evaluation of pathology and therapeutic result is an advantage in the management of clubfoot

Ultrasound assessment prenatally has yet to find a definite place in management, with a positive predictive value of 83% in one study (Baron et al, 2005). In the more complex congenital abnormality of the lower limb accuracy is enhanced, particularly if the scans are repeated. A study had found that the immediate prenatal scan identified deformity accurately, 61% requiring subsequent surgery and 26% being treated conservatively (Tillet et al 2000).

Doppler study is used in clubfoot patient to assess the presents of arterial pulses of the foot. Three major vessels of the lower leg are always examined using Doppler blood flow detector. The dorsalis pedis pulse are detected at the ankle and at midtarsal level over the anteromedial aspect of the foot. The posterior tibial vessels are detected 1cm proximal to and 1 cm posterior to the medial malleolus and the peroneal vessel are 1 to 3 cm proximal to the fibula along the posterior border . The incidence of pulselessness increases with the severity and duration of deformity.

Computed tomography (CT) scan are used to help evaluate the subtalar joint where routine radiographic analysis does not visualize the posterior aspect of the hindfoot (posterior facet of talocalcaneal joint). Medial rotation of the anterior part of the calcaneus is seen as an overlap of the talus and the calcaneus on the A-P radiographs but lateral rotation of the posterior part of the calcaneus is seen as a subluxation of posterior facet in coronal sections using CT scan.

Magnetic Resonance Imaging (MRI) is a complementary technique to CT in the examination of the musculoskeletal system. Three dimensional MRI depicts cartilaginous

volume of the tarsal bone and the positioning of the ossific nucleus within the talus and calcaneum.

Treatment:

Treatment of congenital clubfoot has changed tremendously in the last 2 decades. It was thought for years that rigid type of clubfoot cannot be managed with conservative treatment and surgery was needed to achieve better result treatment of clubfoot is non-operative. An immediate surgical correction of the clubfoot component is anatomically impossible (Ponseti IV 2000). Ponseti had proven that correction of clubfeet in infant can be done by using proper manipulative technique followed by application of well moulded long leg cast and percutaneous tendo-achillis tenotomy to correct residual equinus contracture (Dobbs et al, 2004). The success rate of correction of clubfoot deformity treated using Ponseti method is reported to be around 90% (Beaty 2008). Ponseti uses the thumb as a counter pressure on the head of talus laterally and gently abducts the foot around the talus.

The Ponseti method has changed the management of idiopathic clubfoot deformity from a typically surgical approach to a primarily non-operative approach with high success rates . Clubfoot children undergoing corrective surgery often end up with disturbing failures and complications. The need for one or more revision surgeries is common. Even though the foot looks better cosmetically, but it is left stiff, weak and often painful. After adolescence, the pain may increase and child may become crippled (Ponseti IV 1994). In the 1940s, Ponseti was doing many posteromedial releases and noted the outcome was not good. He was convinced, after a few years, that surgery was a wrong approach for the treatment of clubfoot . A study of histological sections of ligaments from virgin clubfeet revealed that the abundant young collagen in the ligaments was wavy, very cellular and could easily be stretched. Ponseti conceived that the displaced navicular, cuboid and calcaneus could be gradually abducted

under the talus without surgically cutting any of the tarsal ligaments. Ponseti casting technique was learned from Bohler and applied during the Spanish Civil War in 1936-1939 when treating more than 2,000 war-wound fractures with unpadded plaster casts. Precise, gentle moulding of the plaster over the reduced subluxations of the tarsal bones of a clubfoot is just as basics as the moulding of a plaster cast on a well-reduced fracture (Ponseti, 1994). Ponseti published his first article on congenital clubfoot in The Journal of Bone & Joint Surgery in March 1963. However, it was disregarded by then orthopaedic society, because it was not read carefully and was misunderstood. A few orthopaedic surgeons studied his technique and began to apply it only after the publication of his long-term follow up article in 1995, the publication of his book a year later and the posting of Internet support group web sites by parents of babies whose clubfeet he had treated. The reason that the congenital clubfoot deformity was not understood for so many years and was so poorly treated is related to the misguided motion that the tarsal joints move on a fixed axis of motion (Pirani S 2001) Orthopaedists try to correct the severe supination in clubfoot by forcefully pronating the forefoot. This causes an increase of the cavus and a breach in the midfoot. The breach in the midfoot is caused by jamming the anterior tuberosity of the adducted calcaneus against the under surface of the head of talus. Clubfoot is easily corrected when the functional anatomy of the foot is well understood. The completely supinated foot is abducted under the talus that is secured against rotation in the ankle mortise by applying counter pressure with the thumb against the lateral aspect of the head of the talus. The varus, inversion, and adduction of the hindfoot are corrected simultaneously, because the tarsal joints are in strict mechanical interdependence and cannot be corrected sequentially

Technique of Ponseti Method:

The technique of Ponseti for treatment of congenital clubfoot should start after birth as soon as possible. The manipulation and casting are always gentle and are never painful. It

should be done while the infant is feeding from a bottle or is distracted. This would make the infant calm and the procedure much easier to execute. We should make the infant and family comfortable.

1) Correction of cavus

The first manipulation concentrates on supinating the forefoot to reduce the cavus component done by gently dorsiflexing the first metatarsal head. This is the key step in the technique. If not done properly, we would not achieve a supple reducible foot . The cavus is due to the pronation of the forefoot in relation to the hindfoot. The cavus is always supple in new-borns and requires only supinating the forefoot to achieve a normal longitudinal arch of the foot. The manipulation consists of abduction of the foot beneath the stabilized talar head. Locate the head of the talus. All components of clubfoot deformity, except for the ankle equinus, are corrected simultaneously. To gain this correction, the head of talus must be located, which is the fulcrum for correction (figure 1). To exactly locate the head of talus, first, palpate the malleoli with thumb and index finger of the stabilizing hand. The toes and metatarsals are held by the other hand. The first hand then is slide forward to palpate the head of talus in front of the ankle mortise. Because the navicular is medially displaced and its tuberosity is almost in contact with the medial malleolus, the prominent lateral part of the talar head, barely covered by the skin in front of the lateral malleolus can be felt. The anterior part of the calcaneus will fell beneath the talar head. While moving the forefoot laterally in supination with the other hand , the navicular can be felt moving slightly in front of the head of talus as the calcaneus moves laterally under the talar head

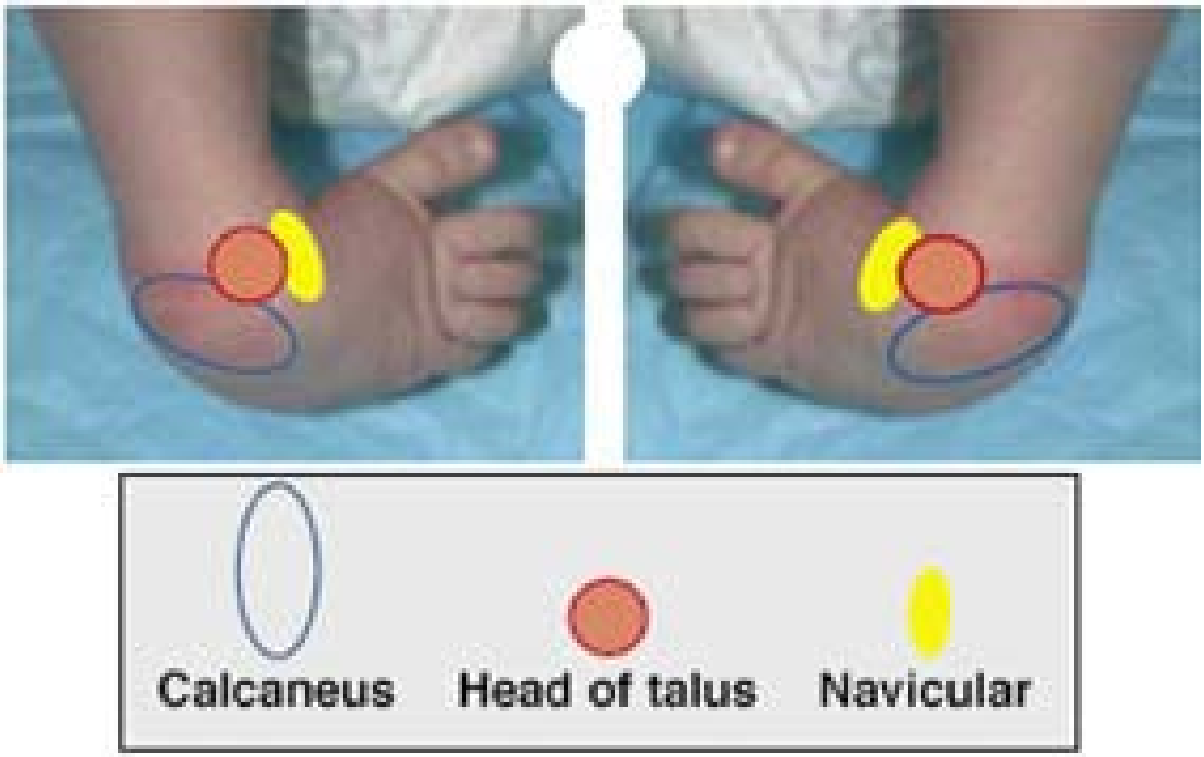

Figure 1: identification of the exact location of the head of talus (shown in red dot) is crucial for the initial step of Ponseti method (adopted from Ponseti IV (2000) Clubfoot management. J Pediatr Orthop 20(6): 699-700).