Ponseti: A podiatric perspective

Introduction

Former Cosyfeet Podiatry Award winner, Janet McGroggan, has worked in private practice for 10 years. While studying for her Masters in Podiatry she developed a special interest in the role of podiatry in the correction of Talipes Equinovarus using the Ponseti method of correction. Janet used the Cosyfeet Podiatry Award to fund her work in this area, and recently presented to the Podopaediatrics conference in Cardiff.

Abstract

The Ponseti method of idiopathic talipes equinovarus correction is now the gold standard of treatment in the UK. Children are ideally treated within the first two weeks of life and although worldwide treated patients have now reached adulthood, late adoption of the technique in the UK means that our oldest treated patients are around 11 years old. This article reviews mid and long term studies to assess the podiatric needs of these patients in adulthood which may have changed from the typical surgically treated patients we are used to treating.

Introduction

When an adult presents in our clinic that has been surgically treated for talipes in childhood we expect a stiff, painful, arthritic, scarred foot with a limited range of motion. The foot would probably display some residual deformity for example equinus, cavus or forefoot adduction or conversely present evidence of over correction for example abduction or even worse a triple arthrodesis[1]. We would know to cast for accommodative orthoses or functional if there was enough mobility to do so. The introduction of the Ponseti Method to the UK means earlier intervention with the outcome aim being to achieve a flexible plantigrade foot[2,3].

This likely means that the patients' of the future will present very differently from those surgical patients we are used to seeing. So far there is not much information on the long term podiatric needs of the modern corrected talipes patient.

Evidence reports an average 10% complete failure of the Ponseti method and in such cases a full surgical approach is adopted[4,5,6]. Gait anomalies and residual deformities are evident in over 20% of treated patients[2] however skeletal development is flexible enough that even children with moderate to severe deformity often do not suffer pain until they reach adolescence or adulthood[7].

Pathoanatomy of the talipes affected limb.

Originally talipes was considered a foot deformity, hence the name clubfoot. However it is now recognised as a whole limb deformity and this is true anatomically[8]. It is a congenital dysplasia[4] characterised by the ankle in a plantarflexed and inverted position. The heel, midfoot and forefoot are adducted and inverted producing a cavus deformity[9]. The tendo Achilles acts as an invertor[10] and the calf muscles are shortened and atrophied[11]. There can be up to 10cm calf circumference difference in unilateral cases with triceps surae and tibialis posterior affected the most[4,10,12]. Medially the ligaments are shortened and thickened and the tibialis posterior, flexor halluces longus and flexor digitorum longus tendons can be wrapped up in a fibrotic mass[13]. On average the total volume of tarsal bones is 88% of that in a normal foot with the navicular and medial cuneiform bones being smaller and the cuboid larger. The talus and calcaneus are also significantly smaller. The posterior surface of the talus is flat and triangular and consequently the sub-talar joint unattainable[8]. The talar neck – troclear angle is increased and there is an increase in the deviation of the talar neck relative to its body i.e. it is adducted. The talar head turns along a longitudinal angle opposite to that in a normal foot. The

anterior surface of the calcaneus is flat, medially twisted and orientated upwards although there is no significant difference in its angle of torsion to that in a normal foot[10,13]. More proximally there can be tibial torsion and femoral antiversion[14]. Idiopathic tallipes is not limited to bony and soft tissue complications, 80%-90% of cases present with an absent or reduced tibial artery[15,16] as opposed to 3.5% in normal feet[17]. In such cases the artery will be hypoplasic and stop at the distal tibial epiphysis[15,16]. The absence of the posterior tibial artery is less common but has been reported, the peroneal artery becomes dominant in such cases. More proximally the deep femoral and popliteal arteries can display hypoplasia[14,18].

Aetiology

At up to 8 weeks gestation all foetal feet resemble talipes[13], the feet then de-rotate into a normal position[15]. Some researchers report no vascular anomalies in stillborn infants with talipes but it has also been theorised that an arterial aberration in the 6th-8th week of gestation is related to the positioning of the calcaneus in equinus. In such limbs some primitive arteries persist[19]. The preservation of these primitive arteries suggests an interruption in embryonic development at a stage where these would normally wither.

Other research has identified an interruption during the 9th week of gestation which may provide defective positional information preventing the foot de-rotating into a normal position[20,21]. It has also been suggested that talipes is the result of anteriolateral tissue growing round an already stunted posteriomedial foot and as muscle fibre is neutrally determined there may be a neural abnormality in conjunction with vascular, soft tissue and bony involvement[20].

Ultimately the cause of talipes is still unknown. Theories support everything from genetic involvement to environmental factors. A phenomenon called the Carter

Effect supports a multifactorial cause linked to genetic loading in which a number of genetic markers are necessary before environmental causes would have an effect. Females need a higher number of markers and consequently have a lower incidence of talipes[8].

Epidemiology

There is a 2: 1 male: female ratio[12] and roughly 50% of cases are idiopathic. Fifty per cent of cases are bilateral[2] and in 24-50% of cases there is a familial link[22]. There is a clear racial prevalence[4] with reported statistics of 6-7 in 1000 live births in Hawaii and Tonga compared with 1.2 in 1000 in the UK[12]. The genetic loading theory of aetiology would suggest the likelihood of an increase in talipes live births due to currant global migration[23]. Also as talipes can now be diagnosed at the 20 week scan and with the success of closed methods of correction and an increase in education of the parents fewer babies may be aborted because of the stigma previously associated with talipes and this may also increase the number of talipes affected babies as has been found in Sweden and Denmark[23,24].

The Ponseti Method

Ideally treatment begins in the first 2 weeks of life. There are four stages to the treatment: manipulation, serial casting, tenotomy and bracing and each of these stages requires the same attention to detail as the others.

Manipulation

In this stage the treatment uses the mnemonic CAVE and corrects the deformity in the order of Cavus, Adductus, Varus and Equinus[25]. The first three are corrected simultaneously[26].

To correct the cavus the manipulator must find the exact location of the talar head. This will be laterally displaced and will be about 1cm anterior to the lateral malleolus

due to the medial displacement of the navicular which will almost contact the medial malleolus. Whilst correcting the right foot the practitioner places their left thumb on the talar head and reaches around the back of the ankle to place their left index and middle fingers on the medial malleolus. They must not touch the rear foot as this will obstruct the calcaneus which will abduct automatically with the forefoot. They then place the index and middle fingers of the right hand below and medial to the first ray and elevate the first ray bringing the forefoot in planar alignment to the rearfoot. Correcting the cavus allows the forefoot to be abducted and simultaneously the rearfoot moves into valgus. This can be felt as the navicular begins to move in front of the talar head and the calcaneus moves laterally underneath it[26].

Casting

The manipulator can spend from 10 seconds to a minute gently manipulating the foot before casting. The knee is held in 90 degrees of flexion to address tibial torsion[25]. A thin layer of padding is applied around the foot and up to the knee while the assistant holds the foot in its corrected position. Then the plaster bandage is applied 3 times around the foot, the assistant holds the foot in the corrected position while the below knee cast is applied. The practitioner then moulds a slight medial arch and moulds gently over the talar head and the calcaneus, this is in order to maintain the foot's position in the cast. Now they begin the above knee cast, padding and plastering up to the groin with extra strengthening at the knee. Lastly the cast is trimmed dorsally to expose the full length of all the toes providing a plantar toe plate to extend the toes and provide an opportunity for the parent and the practitioner to assess for cast slippage. Cast slippage can occur for a variety of reasons including poor casting technique or a difficult limb shape. If the parent or practitioner can see less than five toes then the cast has slipped. When this happens it is essential to

have the cast removed as quickly as possible to prevent sores or further deformity[2,27].

Tenotomy

When the anterior process of the calcaneus is palpable abducting out from under the talus adequate abduction has been reached. This is about 60° to the frontal plane of the tibia and takes an average of six weekly manipulations[28]. Prior to this the foot is never dorsiflexed and now the amount of dorsiflexion available is assessed. A tenotomy is required in 80% of cases[29]. Although Ponseti recommended the use of a local anaesthetic for this procedure it is only recently that surgeons in the UK have converted from a general to a local anaesthetic. This is not only safer but more time and cost effective and allows for a day procedure which is less stressful for parents and baby. The tenotomy is a single cut of the tendo achilies. The blade enters vertically, quite high up the ankle as the calcaneus is not usually in the heel pad yet. The blade is turned horizontally and cuts through the tendon medial to laterally. The wound needs no stitches and the foot is immediately dorsiflexed to between 10 and 20 degrees, abducted to its full potential that's around 60 – 80 degrees and cast. This cast remains on for up to three weeks as the wound heals and the tendo Achilles regrows[30,31].

Pirani Scoring

The practitioner uses a scoring system called the Pirani score. This is an assessment tool used in clinic to grade the foot prior to and during treatment. It uses six measurements and scores each element as 0 – normal, 0.5 – mildly abnormal or 1 – severely abnormal. The use of Pirani scoring is controversial as it bears little relevance to the functioning foot but it is a good clinical tool as it is reliable, valid and responsive to change. Clinicians can use the system to measure the degree of

deformity of each element, to assess if the deformity is correcting as expected or if there is a problem and to assist in deciding if and when a tenotomy is required. It is also used as a tool for predicting the number of casts needed for correction. It has been found that a score of four or more required at least four casts and a score of four or less required three or fewer casts. Referring to the rearfoot scoring alone they reported that a score of 2.5 or 3 has a 72% chance of requiring a tenotomy although this does not mean that a lower score rules out the chance of a tenotomy[32].

Bracing

Once the final cast has come off the foot may look a bit over corrected, but this soon rectifies itself on ambulation. The final stage of the treatment, bracing, can be the key between success and failure and requires parental compliance. The braces or boots and bar are worn full time for three months and then only at night and nap time until the child reaches four years old[30]. There is a 95% chance of failure in the first year if the parents do not comply with the bracing regime and most children, though uncomfortable at first, quickly adapt[33].

In order to assist with compliance the braces must be properly fitted, that is the bar must be shoulder width and enough dorsiflexion must have been achieved to allow the heel to drop down in the shoe and this can be seen through holes in the shoe. If the shoe is too loose there will be friction and the skin will blister. Cotton socks must be worn under the shoes to prevent excessive sweating and sticking. The Mitchell brace provides a soft moulded inner shoe with soft leather straps placed in strategic arrangement to provide adequate support. The shoes come off the bar and are strapped snuggly over the foot then clipped onto the bar which has been set at the correct level of abduction[34].

Modified Ponseti Method

Over the years a modified Ponseti method has emerged, this has been described as an ‘a la carte’ approach to surgery used in combination with the Ponseti method. Common soft tissue procedures include tendo Achilles lengthening and plantar fasciotomy, posterior release and tibialis anterior tendon transfer. Common boney procedures include Rotational Osteotomy of Distal Tibia, Tarsal Resection, Sub-talar arthrodesis, calcaneal osteotomy, ankle arthrodesis, toe arthrodesis. Surgical procedures are carried out in on average 40% of cases as a result of recurrent or residual deformity.

Mid-Term Studies

Ponseti[25] himself carried out a mid-term study on 67 patients with a total of 94 talipes limbs 5-12 years post treatment. They calculated ankle dorsiflexion, heel varus, forefoot adduction and tibial torsion to develop good, acceptable and poor categories. The poor category consisted of one foot which suffered four recurrences and underwent a subcutaneous plantar fasciotomy, an anterior tibial tendon transfer to the 3rd cuneiform and a resection of the exterior halluces longus to the neck of the 1st metatarsal. Of the 56% of feet which had a recurrence the average age of recurrence was 2 ½ years old. In only 5 of the 53 cases did the radiographs show incomplete correction of the talus to calcaneus relationship ruling out poor technique as a cause. Recurrence is a grey area and some researchers think that relapse is evidence of residual deformity. There are correlations between poor bracing protocol and relapse. There is also evidence that more ridged feet with poorly developed muscles are more likely to relapse[2,35].

Ponseti’s acceptable category consisted of 26 feet (28%). These feet displayed less than 10 degrees dorsiflexion, more than 10 degrees rear foot varus, 10-20 degrees forefoot adduction and less than 10 degrees of medial tibial torsion. It is this

category that is most interesting on a long term podiatric level as ‘acceptable’ results at between 5 and 12 years of age may present some less than acceptable results after skeletal maturity.

Ponseti’s team carried out anterior tibial tendon transfers in 39 of the 94 feet to correct residual rear foot varus and in 7 to correct forefoot adduction. They felt that early anterior tibial tendon transfers could reduce the need for a medial release which they resorted to in 3 feet. This procedure often leaves extensive scarring and stiffness in mid-tarsal joints however these patients still made it into the acceptable category.

The researchers looked at clinical and radiographic results but did not correlate the two. They did say ‘mild flattening of the superior articular surface of the talus was observed in the final radiographs of 15 feet’. Fourteen of these were in the acceptable group and one in the severe.

Bor et al[36] also carried out a mid-term follow up of 108 feet on average 5 years post treatment. They aimed to answer some very specific questions related to their clinics which were not relevant to outcomes. However they used Roy et al’s 10 item clubfoot Disease Specific Instrument (See box 1) to gauge parent satisfaction which gives us some useful information but also highlights the need for standardisation of categories.

The results were summarised as satisfactory. However Bor et al used unusual parameters, for example taking only five degrees ankle dorsiflexion as adequate which produced an 89% success rate compared to Ponseti’s 71% who took 10 degrees dorsiflexion as adequate. They considered a good outcome to be ‘an outcome that requires no or minor surgery’, however minor surgery included a

Tibialis anterior tendon transfer with or without a tendo Achilles lengthening which is a step further than just a tenotomy.

Good bracing protocol was described as full time for three months then part time for 9 months as opposed to four years as recommended. The researchers referred to poor bracing protocol as 'brace intolerance' which could detract from parental responsibility. They were surprised that brace intolerance was high at 44.3% in their study. Usual bracing procedure non-compliance ranges from 30% - 49%. In this study 55% of brace intolerant and 20.5% of brace tolerant patient's required additional surgery.

The researchers described two causes of brace intolerance

1. Full correction was not achieved prior to bracing and
2. Relapse made bracing impossible.

Both are relevant but the primary cause 'parental non-compliance' was not discussed.

In 1995 a long term follow up[29] was finally published evaluating 71 feet 30 years post Ponseti treatment. Cooper and Deitz were looking for good life long function of the foot and hypothesised that 'a combination of good muscle strength, well balanced plantar pressure distribution and greater ankle-foot mobility would correlate with less pain in the foot and better function'.

The patients had all been treated using the modified Ponseti method with good bracing protocol. Feet were categorised as excellent - no limitations of daily living and either never or occasionally painful. Good - occasionally limits daily activities and limits or is painful after strenuous exercise. Or poor - limits or is painful during activities or routine walking or at night.

The researchers then placed the excellent and good results together and compared them to the poor category to determine how they differed, meaning that we cannot differentiate the good results from excellent. So we can again see that there are no specifics regarding categories from study to study.

Many evaluation schemes were employed. A questionnaire was used to assess pain and limitation of function and this was compared to an age matched control group. (See Box 2 for results).

There were marked differences between the excellent and good category and the poor category in almost every respect. Physically they measured no leg length discrepancies in unilateral cases although this is often reported[10]. They reported an average 3cm difference in calf circumference in unilateral cases and an average difference of 1cm in foot length and ½ cm in foot width. Callus was evident under the 4th and 5th met heads.

There was tenderness on palpation at the ankle joint in five patients, at the plantar fascia in three, at the metatarsal heads in tree and at the tendo Achilles insertion in one. Many minor discrepancies were reported between the groups physically but the only one with a significant result was the patient's ability to do 40 rapid toe ups. On average the excellent/good group managed 36 and the poor group 28.

Significantly the electrogoneometer measured passive dorsiflexion as -7 degrees in the excellent and good group compared to -4 degrees in the poor category.

Radiographically the Anterior posterior calcaneus – fifth metatarsal angle was -6 degrees in feet with an excellent or good result and -13 degrees in feet with a poor outcome. The researchers stated that they could not correlate the increased angle with a poor result and in their opinion residual forefoot adduction or abduction is not associated with poor functional results.

Other radiographic anomalies included navicular wedging in 6% (severe in 16%), talar flattening in 68% (severe in 31%) and 35% had mild signs of degeneration.

The pedobarograph in fig 1 is of a 42 year old man with Ponseti corrected unilateral talipes affecting his left leg. Typically the affected limb shows evidence of lower pressures at the heel and higher pressures in the mid foot and lateral toes than the unaffected limb. The significant result here is the pressure time integral of the whole foot which was $27^{+}/_{-}6$ Newton-second per square centimetre in the good and excellent category and $21^{+}/_{-}7$ Newton-second per square centimetre in the poor category. Two other results which approached significance were, average peak pressure under the heel and force time integral, which were greater in the excellent and good categories. The researchers could find no association with outcome and range of motion or the pedobarographic and radiographic results.

The research provided an interesting insight with regards to occupation 65% of patients in the excellent and good group and only 20% of the poor group worked in low foot demand jobs like office workers or homemakers. And 35% of patients in the excellent and good and 80% of the poor group had high foot demand jobs like labourers, janitors and waiters. Coupling this BMI results the researchers recommended that a sedentary occupation and avoidance of excessive weight gain may improve overall results.

Wallander et al[37] reported the findings of a long term study on average 60 years post treatment. Eighty three patients with 121 talipes corrected limbs responded to 3 validated questionnaires to determine if the patients suffered from residual foot and ankle problems and, if so, if it influenced their quality of life.

Initially 95% of these feet had been treated non-surgically but by the treatment end 47% had received at least one surgery more than a simple tenotomy.

The results were age and gender matched with a control group.

Foot and ankle function was measured using a Foot & Ankle Questionnaire. Male and female patients scored lower than the control group in the areas pertaining to pain, function, stiffness and swelling and giving way. And in these areas female patients had more problems than males. In the areas pertaining to shoe comfort female patients were the same as the female control group but male patients scored worse than the male control group.

Female patients also scored lower than male patients in the questionnaires which probed into quality of life addressing categories such as Physical Function, Bodily Pain, General Health, Vitality, Social Function and Mental Health. Interestingly male patients scored higher that the male control group in these areas which may be to do with expectations.

Wallander found a positive correlation between quality of life and foot and ankle function for both male and female patients and concluded that the physical aspects of quality of life were influenced by residual foot and ankle problems.

In a final subjective assessment they reported that, of 39 patients who considered their feet to look normal when previously asked in 1974, 25 now classed their feet as non-normal looking. However we have no 'normal' data to compare this to .

These four pieces of mid and long term research give us many positive results but from a podiatric point of view have taken either a too broad approach or too narrow. It seems that there is a general lack of correlation between radiographic anomalies and function however the functional outcomes have not been assessed podiatrically.

Karol et al[7] reported specifically on gait analysis following the Ponseti method and using an age matched control group, rather than the contralateral limb would skew the results but has often in the past been used. They reported sagittal and

transverse plane motion and kinematic and kinetic characteristics. The researchers had previously reported on two year olds and now repeated and expanded the tests on the same children at five years old (See Box 2).

Stance phase dorsiflexion had reduced from 48% at two years old. Increased dorsiflexion was associated with an average 14% less push off. Power is affected by range of motion and muscle strength and talipes patients tend to have decreased ankle range of motion and a smaller calf muscle.

Calcaneus gait was described as less than 7 degrees of plantarflexion at terminal stance phase and had decreased from 10% at two years old.

It is suggested that the increase from 24% of children intoeing at two years old may be related to the bracing stage now being completed.

An internal shank based foot rotation, indicative of tibial torsion, internal calcaneopedal rotation or forefoot adductus was evident in 85% of patients. And 71% of patients also displayed external hip rotation in stance as a compensatory mechanism which may actually mask the problem.

Average hip power was greater and it's likely this is to compensate for the decreased ankle push off power. A tenotomy at initial treatment appeared to have no effect on ankle power. The research will be repeated and expanded upon at age 10.

Currently the researchers say the data supports continuing diminishing mechanical efficiency of the ankle in walking.

The Institute of Motion Analysis and Research (IMAR) in Dundee has since 2008 been developing an assessment tool which incorporates clinical, functional and biomechanical data to produce objective, quantifiable and repeatable outcomes which can evaluate the corrected talipes affected limb and monitor progress. In March 2012 they published the results of five children aged under five with eight

affected limbs who have been monitored for three consecutive years as part of a long term study.

The researchers have identified two distinct patterns of abnormalities using the bean-shape ratio. This is measured by drawing a line from the centre of the heel to the centre of the hallux. A line is then drawn from the midpoint of this line perpendicular to the lateral border of the foot. A second version of this ratio replaces the hallux with the third toe to exclude spurious results caused by an isolated 1st ray metatarsus adductus.

The first pattern of deformity identified is either a residual or relapse related equinovarus. This results in reduced loading around the heel and first metatarsal and increased loading around the fifth metatarsal and styloid process. This deformity will produce low medial to lateral and heel to lateral arch peak pressure ratios.

The second pattern of deformity identified is as a result of overcorrection and is characterised by ‘dropped heel’ or ‘calcaneus gait’. Where peak pressures occur under the heel and the forefoot is minimally loaded.

The researchers showed that an aesthetically pleasing foot or one that scores well clinically and functionally can show a decreasing score in their validated IMAR clubfoot scale which will give early warning for necessary treatment.

Conclusion

So we know that the Ponseti method of talipes correction in association with an ‘a la carte’ approach to surgery produces superior mid and long term clinical and functional results to a solely surgical approach. However mid and long term research dealt with the clinical and functional outcome and when poor radiographic results did not correlate with these researchers did not investigate.

Gait analysis in talipes corrected by the modified Ponseti method is in its infancy as yet but increased mid-foot pressures and delayed mid stance is well documented and relates to radiographic and pedobarographic evidence [3,38,39,40,41,42].

From a podiatric perspective the research often doesn't ask the relevant questions. The researchers are all using different outcome tools and categories. Radiographic and pedobarographic evidence needs more careful consideration. A functional scoring system post treatment[43] with standardised categories is required so all research can be based around specific parameters and become therefore comparable.

We also need large scale long term studies correlating clinical, functional, radiographic and biomechanical data to allow us to understand how the variable treatments affect life-long functions. From these we can categorise gait anomalies and correlate these on a scalar level relevant to the type of additional surgeries carried out and whether the case was unilateral or bilateral as each limb in a bilateral case may have been treated with different surgical procedures. As a result of this we can develop a podiatric plan for best full life functional and biomechanical outcomes

For a FREE DVD called 'How to do "The Ponseti Method" Including Atypical Club Foot' please email Stella Morris at stella@c-prodirect.co.uk or go to www.c-prodirect.co.uk

For a FREE DVD called 'Parents Guide to Clubfoot. The Ponseti Method' please contact www.steps-charity.org.uk You can also stream this film from http://www.steps-charity.org.uk/links/4-14-clubfoot_or_talipes.php

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Please address any correspondence to janetmcgroggan@gmail.com

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