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REVIEW ARTICLE

Idiopathic congenital clubfoot: Initial treatment

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KEYWORDS

Congenital clubfoot;
Ponseti method;
French functional
method

Summary Clubfoot (talipes equinovarus) is a three-dimensional deformity of unknown etiology. Treatment aims at correction to obtain a functional, plantigrade pain-free foot. The “French” functional method involves specialized physiotherapists. Daily manipulation is associated to immobilization by adhesive bandages and pads. There are basically three approaches: the Saint-Vincent-de-Paul, the Robert-Debré and the Montpellier method. In the Ponseti method, on the other hand, the reduction phase using weekly casts usually ends with percutaneous tenotomy of the Achilles tendon to correct the equinus. Twenty-four hour then nighttime splinting in abduction is then maintained for a period of 3 to 4 years. Recurrence, mainly due to non-compliance with splinting, is usually managed by cast and/or anterior tibialis transfer. The good long-term results, with tolerance of some anatomical imperfections, in contrast with the poor results of extensive surgical release, have led to a change in clubfoot management, in favor of such minimally invasive attitudes. The functional and the Ponseti methods reported similar medium term results, but on scores that were not strictly comparable. A comparative clinical and 3D gait analysis with short follow-up found no real benefit with the increasingly frequent association of Achilles lengthening to the functional method (95% to 100% initial correction). Some authors actually suggest combining the functional and Ponseti techniques. The Ponseti method seems to have a slight advantage in severe clubfoot; if it is not properly performed, however, the risk of failure or recurrence may be greater. “Health economics” may prove decisive in the choice of therapy after cost-benefit study of each of these treatments.
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Introduction

Clubfoot (talipes equinovarus) has a prevalence of 1.52 per 1000 in Europe. Management was classically surgical, correcting the deformity during the first year of life. Results, however, showed deterioration over time, with only 27% remaining good or excellent after 30 years of age [1]. At the same time, the good results found with the so-called “French” functional method, of which there are several variants [2–5] and, even more, those of the Ponseti method

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Figure 1 Right clubfoot, 3rd day of life. Thanks to R. Seringe.

[6], have led to a radical rethink. In the USA [7], the use of extensive surgical release during the first year of life fell from 70% in 1996 to just 10% in 2006.

The present article is an update on current management of clubfoot, discussing the apparent antagonism between the two non-surgical methods, without retailing the details already presented in previous studies – notably, Lascombes's lecture (1990) [8] and Wicart and Tourné's chapter in Seringe, Besse and Wicart's monograph (2010) [9]. It is limited to idiopathic clubfoot, despite the difficulty of definition entailed by possible late revelation of etiology. Treatment initiated after 3 years of age was comprehensively dealt with by Laville in 2004, and will not be discussed here [10].

Anatomy – Etiopathogenesis

Clubfoot is a three-dimensional deformity (Fig. 1) 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 [11]. The tibiotalar and subtalar equinus and calcaneal adduction induce "false" hindfoot supination [11]. Forefoot supination, induced by that of the hindfoot, is less severe, giving a "pes cavus" aspect (1st 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 systematic amyotrophy of the lower-limb muscles [8,9].

Several anatomic abnormalities may be associated to varying degrees: agenesis or hypoplasia of the anterior or posterior tibial artery, accessory soleus muscle, 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, muscles) 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 [9,12], 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.

Classifications and degree of initial severity

Numerous classifications are available for initial foot severity assessment, monitoring and exchange of information. The most frequently used at present are the reliable and reproducible scores of Dimeglio and of Pirani, based on the physical aspect of the foot [13].

The 20-point Dimeglio score rates equinus, forefoot adduction, varus and CPB derotation on one to four points each, with four extra points for the posterior and plantar creases, cavus and muscle status [14].

The 6-point Pirani score is internationally used for assessment with the Ponseti method. It studies three morphological elements of the hindfoot (rigidity of equinus, emptiness of the heel, severity of posterior crease) and of the midfoot (curvature of the lateral border, reducibility of lateral head of the talus, severity of medial crease), attributing one point for severe, 0.5 points for moderate and 0 for no deformity.

Prognostic value, especially as regards cavus, the medial and posterior creases and emptiness of the heel, has not been demonstrated, and both scoring systems are imperfect [13].

Complementary examinations

Radiology

The usefulness of radiography during the first months of life is debatable, given the form or absence of ossification nodes (with the navicular bone being invisible up to 3 years of age).

Some teams perform radiological examination regularly [9,15], others in case of correction defect. Two incidences are used: dorsoplantar in reduction, and lateral in maximal dorsiflexion. As of walking age, views are taken under weight-bearing (Table 1).

Table 1 Standard radiological measurements.

Incidence	Angles measured (according to ossification nodes)
Dorsoplantar	Talocalcaneal Talus-1st metatarsal Calcaneus-5th metatarsal
Lateral	Talocalcaneal Tibiocalcaneal Talus-1st metatarsal 1st-5th metatarsal Calcaneus-5th metatarsal

Table 2 Possible cross-sections and measurements on ultrasound.

Cross-section	Bone parts studied	Possible measurements
Coronal medial projection	Medial malleolus Talus Navicular Medial cuneiform 1 st metatarsal	Medial malleolus– navicular distance Talocalcaneal divergence Angles Talonavicular Talocuneiform Talomatarsal
Coronal lateral projection	Calcaneus Cuboid 4th metatarsal	Talocalcaneal divergence Angle Calcaneometatarsal Calcaneocuboid
Anterior projection	Talus Navicular	
Posterior projection	Distal tibial metaphysic-epiphysis Talus Calcaneus	Tibia-calcaneus distance Metaphyso-talo-calcaneal angle
Plantar projection	Calcaneus Cuboid 4th metatarsal	Plantar arch curvature

A wide tibiocalcaneal angle is an indication for equinus correction by Achilles tenotomy [9]. A wide angle associated with clinically normal dorsiflexion indicates a “broken” midfoot (iatrogenic convex foot) [16]. The talocalcaneal index (sum of both talocalcaneal angles) is considered pathological when less than 40°, indicating insufficient CPB derotation.

Ultrasound

Ultrasound examination is inexpensive, non-irradiating and easy to perform, enabling foot cartilage exploration up to 1 year of age [17]. Various cross-sections are taken (Table 2), with the subject relaxed, the foot in maximum reduction (Fig. 2).

The examination is especially valuable in feet showing difficult or unusual evolution under treatment: is the correction in the right joints? [18]. A sagittal cross-section on an anterior approach can rule out dorsal dislocation of the navicular (iatrogenic convex foot [16]).

Functional analysis of results

Gait analysis (GA)

Spatiotemporal, kinematic (joint range of motion) and kinetic (moment and strength) data enable lower-limb functional analysis [19] (Table 3). In unilateral deformity, comparison with the healthy foot is unwise: compensation for altered ankle kinematics by the knee and hip modifies the contralateral parameters so as to conserve symmetrical gait [20].

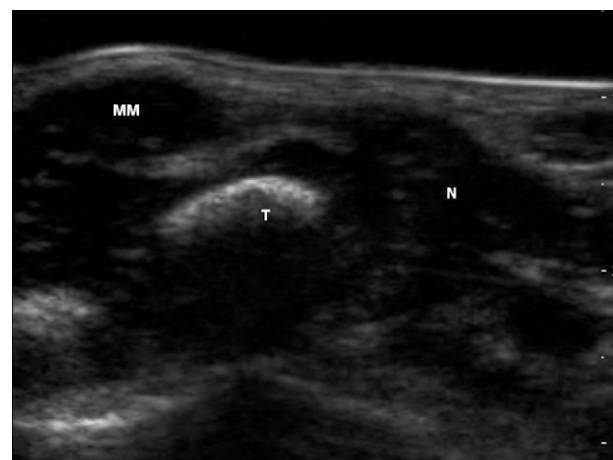


Figure 2 Axial medial US section, day 36, foot managed by Ponseti method. MM: medial malleolus; T: talus; N: navicular. Thanks to C. Treguier.

Table 3 GA kinematic criteria.

Measurements	Pathologic criteria
Equinus gait	DF < 3° during stance
Calcaneus gait	PF < 7° at toe-off
Excessive DF	DF > 16° in stance
Foot drop	PF > 9° during the last 25% of swing
Internal shank-based foot rotation (int)	> 0° average internal rotation during stance
Internal foot progression angle	> 5° average internal rotation during stance

DF: dorsiflexion; PF: plantar flexion.

Baropodometry

Baropodometry assesses plantar pressure distribution during gait, completing radiography and GA [21]. Like GA, it is used as a research tool, but is also useful in the study of long-term results.

Scores and assessment questionnaires for long-term results

Various scores are available, analyzing physical, functional and radiographic criteria. As they contain varying proportions of subjective items, comparison is difficult [22]. The 60-point International Clubfoot Study Group (ICFSG) score is based on foot morphology (12 points), and radiologic (12 points) and functional assessment (36 points) testing the eight main leg muscles; it is, however, only moderately adapted to idiopathic clubfoot [23]. Laaveg and Ponseti's functional score, with 70 out of 100 points dedicated to subjective items [22,24], is overoptimistic! Ghanem and Seringe's 100-point score [9] has only 26 subjective points, 40 for foot morphology, 50 for function and 10 for patient satisfaction. There are also other scores, such as Magone's or McKay's [22].

Many specific or generic questionnaires analyze the impact of clubfoot on quality of life [1]. The Short Form-36 (SF-36) provides a general physical and mental assessment. The Foot Function Index FFI measures pain, disability and activity restriction, as does the clubfoot Disease Specific Index (DSI [25]), which exists in a pediatric version.

Treatment

The objective is to obtain an "esthetic, functional, pain-free and plantigrade foot". Recurrence is possible, defined by the reappearance of deformity, often of the hindfoot, in an entirely corrected foot, requiring renewed treatment.

Surgery

Percutaneous Achilles tenotomy (pAT)

pAT lengthens the Achilles tendon to help correct residual equinus. It reduces treatment duration, risk of recurrence, talar flattening ("nut-cracker" effect) or convex foot [16] and the number of surgical releases required.

It involves a risk, as yet poorly defined, of triceps insufficiency [20], moderate forms of which can be screened for by single-foot tiptoe jumping [9]. Rare cases of posterior tibial vascular-nervous lesions have been reported, with severe consequences when associated with vascular deformity.

A complete transverse section of the tendon is performed 1 or 2 cm from the insertion, under local or general anesthesia [26]. A needle or size-11 blade tip is inserted into the medial part of the tendon and moved laterally and posteriorly. A click-like perception of hiatus in the tendon under more than 15–20° dorsiflexion is the sign of complete sectioning. After 21 days' femoropedal immobilization, the tendon, though thick and disorganized, should be continuous on ultrasound. At 6 months, it should be hypoechogenic,

without retraction; at 1 year, although still thick, it should be structurally normal on ultrasound [27].

Lengthening may be performed as open surgery or with several percutaneous incisions in children over 2 years of age.

Anterior tibial muscle surgery

Muscular disequilibrium in favor of the anterior tibial muscle is frequent after treatment including Achilles lengthening, and is seen by dynamic supination of the foot during the oscillating phase, with deficient anteromedial support, "piano key" sign [9] and forefoot supination in active dorsiflexion of the ankle (Fig. 3).

If not corrected after walking age, there is a risk of deformity fixation (pes cavus, forefoot adduction, hindfoot varus, navicular dorsal subluxation). Anterior tibialis surgery may be recommended as of 2–3 years of age, mainly in case of recurrence with flexible foot, and may comprise:

- transfer of half of the anterior tibialis tendon onto the cuboid, to conserve balanced dorsiflexion;
- anterior tibialis tendon transfer onto the lateral cuneiform (fixation onto the cuboid entailing a risk of hypercorrection). This is an integral part of recurrence management in the Ponseti method. Despite a 15.2% rate of further recurrence [28], long-term results are excellent, as the joints are spared, avoiding degenerative lesions [6];
- Z-lengthening of the anterior tibialis tendon. Unlike transfer, this isolated lengthening of a muscle that is too short and too active [26] is also systematically performed during posteromedial release, which, by lengthening the medial arch, would further shorten the anterior tibialis.

Posteromedial soft-tissue release (PMR)

By lengthening the tendons and sectioning the aponeurosis and joint capsules, which hinder reduction, soft-tissue



Figure 3 Muscle imbalance: right foot dynamic supination by anterior tibial predominance with anteromedial lack of contact. Thanks to F. Chotel.

release corrects tibiotarsal and subtalar equinus, CPB adduction and mediotarsal adduction. This is not light surgery, and should not be performed before 1 year of age, and should respect the subtalar structures [26]. Beginning with posterior release, it moves on to the medial part of the foot. The talonavicular joint is temporarily pinned in maximum reduction to avoid navicular dorsal subluxation. In case of incomplete correction of adduction or pathologic calcaneocuboid joint orientation, the lateral column of the foot may be shortened by distal calcaneus subtraction osteotomy (Lichtblau technique).

Correction is achieved in 75–80% of cases, with 20–40% recurrence, which may require heavy revision surgery [29]. Over and above the usual risks [9], there are risks of hyper- or hypocorrection, dorsal bunion and triceps insufficiency.

The quality of results degrades over time. Sixteen years after adapted PMR, mean Laaveg and Ponseti score was 80.6 [30], at 25 years, 75 [24], and 30 years after mainly subtalar release, 65.3 [1]. Muscle weakness, joint stiffness and pain (appearing after 20 years) reduce tolerance for effort and endurance, although without impairing everyday activities.

Twenty-two years after PMR, pace speed and length on GA were reduced [25]. On ground contact, the forefoot showed dorsiflexion and adduction with the hindfoot in equinus. Triceps stiffness and weakness made inversion and plantar flexion insufficient in the pre-oscillatory phase. Ninety-six percent of patients reported pain on the DSI and 40% had moderate or poor ICFSG scores.

External rotation of the hip and genu recurvatum frequently compensate respectively the somewhat internalized pace angle and reduced ankle dorsiflexion. Pressure is reduced on the hindfoot (reduced dorsiflexion) and under the first metatarsal and increased under the midfoot. Loss of subtalar pronation (contact shock absorption) contributes to onset of pain.

Independent scales (Laaveg and Ponseti, FFI and SF-36) agree on impaired quality of life after 30 years, due to degenerative lesions, mainly of the hindfoot, found in 50% of cases [1]. Results were all the poorer with more extensive or iterative release.

PMR is therefore a last resort in feet resistant to conservative management.

Non-surgical treatment

Ponseti method

The Ponseti method is typically implemented during the first weeks of life, but can also be applied after walking age, and even, according to some authors, up to the age of 9 years. It comprises a correction phase involving weekly or 5-daily application of 3 to 9 femoropodal plaster of Paris casts on cotton laid on the skin [18]. The cavus deformity is corrected by positioning the forefoot in supination so as to align it with the hindfoot; then the hindfoot adduction, varus and equinus are progressively corrected by positioning the foot in abduction and external rotation with counterpressure on the lateral side of the talar head. The calcaneus thereby shifts, without manipulation, into eversion and dorsiflexion (Fig. 4).

If the residual dorsiflexion, after correction of the other components of the clubfoot, is less than 15°, pAT is

performed, followed by 21 days' immobilization in maximum dorsiflexion and 60° abduction, in 70 to 90% of cases (Table 4); given the risk of triceps insufficiency, it should not be systematic, especially in less severe deformities.

A modified technique is implemented for "complex idiopathic" or "atypic" feet, which slide inside the casts and become resistant [33]. These feet, probably iatrogenic, are short and thick, with fixed equinus and deep posterior crease, hyperflexed metatarsals with a plantar crease and a short first ray in hyperextension. When fitting the casts, the forefoot should be abducted, with dorsiflexion induced by pressure under the metatarsal heads, and pAT should be performed earlier.

Strong pressure applied under the metatarsals before correcting the calcaneal varus induces iatrogenic convex foot or "rocker bottom deformity" [16]. The foot is then cast in slight equinus for a week or two to let the plantar ligaments retract ahead of pAT.

The consolidation phase begins once the deformity has been fully corrected (90–100% of cases irrespective of initial severity [13,18,32]) or when only slight residual deformity remains after 1 or 2 cast phases. A foot abduction brace holds the foot in 60° to 70° external rotation (40° for the normal foot if the deformity is unilateral) with 15° ankle dorsiflexion, for 22 hours a day for 3 months, during the night and the afternoon nap up to 1 year of age, and then nocturnally up to 3–4 years of age (Fig. 5).

Recurrence. Recurrence is rare after 5 years and very rare after 8 years; it occurs in 20–41% of cases. It may constitute the only sign of unnoticed underlying pathology. The determining factor is poor compliance with the derotation splint, admitted by 50% of parents and entailing a 183-fold elevated risk of recurrence [32].

Non-compliance may have a mechanical origin if an incompletely corrected foot, badly positioned in the splint, becomes uncomfortable and deteriorates, so that the splint is quickly abandoned [33].

To improve compliance, cruropedal and/or unilateral splints may seem useful; however, without abduction and external rotation, correction cannot be maintained [34] and the recurrence rate is as high as 83%. It is thus crucial to explain to the parents the importance of the bipedal derotation splints, to provide them with an information sheet, to involve the family physician and to check regularly for signs of intolerance.

Recurrence is managed by a new cast and possibly iterative pAT. In late recurrence, treatment focuses on the residual post-cast deformity, with possible bone, joint or soft-tissue surgery (anterior tibialis transfer, etc.). Major recurrence with several components requires "customized" surgery with PMR as a last resort (Fig. 6).

An internalized position of the foot under the knee is due to tibial torsion, CPB adduction, forefoot adduction and/or anterior tibialis hyperactivity. With the Ponseti method, it is found in 57% of cases at 2 years, and in 85% at 5 years (end of splint phase), while in adults tibial torsion on CT scan is normal [35].

Results. Repeated immobilization in reduction, after stretching of the retracted tissue, slackens the collagen and leads to joint surface remodeling under continuous static pressure. Pirani et al. [36] took 3 MRIs over a period of 1 month in 12 children and found rapid remodeling of

Table 4 Comparison between the two non-surgical methods.

Author	Date	Number of feet (patients)	FU (years)	pAT (%)	Initial correction (%)	Recurrence (%)	Non-compliance (%)	AT transfer (%)	Extensive surgical release (%)	Good and excellent results (%)	Functional score used
<i>Functional method</i>											
Souchet [5]	2004	350 (234)	14	—	—	—	—	—	—	77	ICFSG
Richards [31]	2008	119 (80)	4.25	32	95	29	—	—	33	67	—
Chotel (Wicart) [15]	2011	116 (77)	5.5	17	—	17	—	—	21	75	Ghanem Seringe
<i>Ponseti method</i>											
Cooper [6]	1995	71 (45)	34	90	—	—	—	53	—	78	—
Ippolito [24]	2003	49 (32)	19	—	—	41	—	—	—	78	Laaveg Ponseti
Dobbs [32]	2004	86 (51)	2.1	86	100	31	41	—	—	—	—
Richards [31]	2008	267 (176)	4.25	73	94.4	37	61	—	16 (PMR)	72	—
Halanski [29]	2010	40 (26)	3.5	95	92.5	37	65	27	10	—	—
Chotel [15]	2011	103 (69)	5.4	94	—	22	—	5.8	6	94	Ghanem Seringe

pAT: percutaneous Achilles tenotomy; AT: anterior tibialis; PMR: posteromedial release.



Figure 4 Progressive clubfoot correction by Ponseti method. Thanks to F. Chotel.

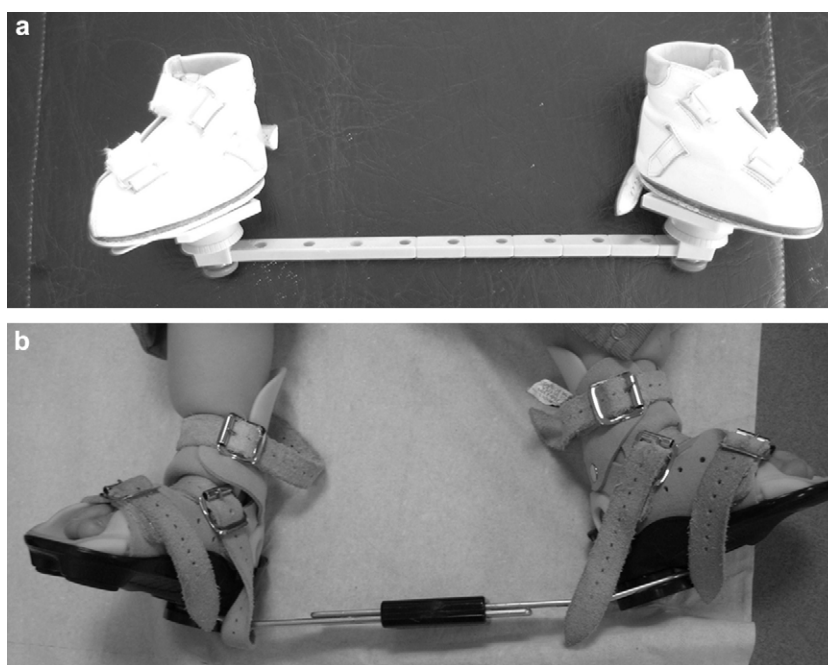


Figure 5 Examples of derotation splints comprising “Denis Browne bar” and boots. a: Unibar®; b: Ponseti Mitchell.

the cartilage, associated with joint surface reorientation induced by the casts.

After well-conducted treatment, surgical release is required in only 6% of cases [15]. A low rate of pAT, splints worn for less than 2 years and a low rate (1/3) of recurrence managed by cast account for certain reports of abnormally high rates of PMR [29,31] (Table 4).

Partial correction of medial displacement of the navicular and of the talocalcaneal index does not exclude achieving a functional foot of normal aspect. The classic residual varus found at walking age may self-correct or be treated by late

casts (Fig. 7). Using pain and functional restriction as assessment criteria, Cooper [6] reported that perfect anatomic correction of the foot was not a prerequisite for good long-term results: 78% good and excellent results at a mean 34 years’ follow-up, despite restricted joint range of motion, radiologic imperfections and a 35% rate of benign degenerative lesions.

Functional method

The functional method, implemented during the first months of life, is based on daily physiotherapy: decoaptation of the

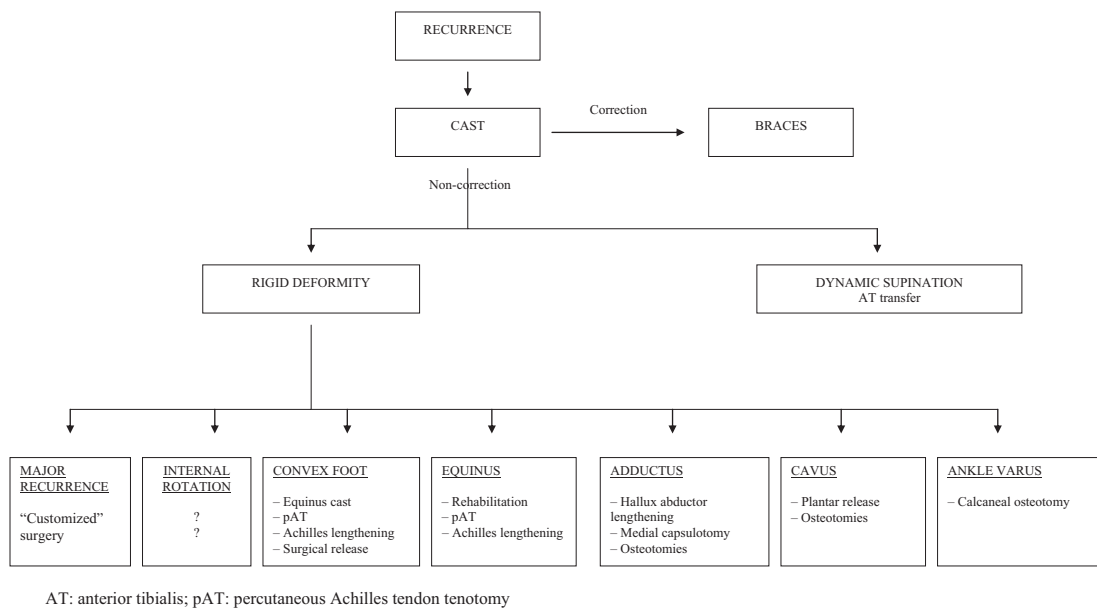


Figure 6 Chu algorithm [33]: recurrence management in Ponseti method.



Figure 7 Bilateral calcaneal varus after cast treatment, after walking age.



Figure 8 Functional method (Robert-Debré) [5]: correction maintained by flexible splint.

navicular from the medial malleolus, correction of forefoot adduction and calcaneal varus, CPB derotation, and then talar reintegration with equinus correction associated to evorsor muscle stimulation.

First introduced by Masse [37], the method exists in three main forms, developed by Seringe (Saint-Vincent-de-Paul method) [2], Bensahel (Robert-Debré method) [3] and Dimeglio (Montpellier method) [4]. They all use the same basic principles (applied successively or simultaneously), differing in the use of a continuous passive mobilization device [4,38] or in the rigidity of foot immobilization. In the Robert-Debré method correction is maintained by a flexible splint [3] (Fig. 8). In the Saint-Vincent-de-Paul method, the foot is immobilized on a plate, usually with plantar concavity; a permanent femoropedal splint is associated for 6 months to keep the CPB in abduction under the talar-tibiofibular unit [11] (Fig. 9), then maintained only overnight, with a cruropedal splint by day [9].

Other differences concern performance of pAT [9] or triiceps lengthening by the Vulpius technique [38], practiced for some 10 years now at 4–12 months in case of plantar convexity, radiologic tibiocalcaneal angle greater or equal to 75° or equinus with normal talocalcaneal divergence.

Evolution after 3 and especially 6 months of treatment identifies at-risk feet requiring surgery, which should be as non-invasive as possible, adapted to the deformities, as of 12 months.

After walking age, depending on the method, a night-time femoropedal or cruropedal device is prescribed either systematically or to correct sequelae.

Results. Although accused of causing inflammation, fibrosis and stiffness “fibrotic response”, the functional method seems to restore muscle balance and provide a biomechanical environment that changes the growth pattern of the osteochondral structures of the foot. An MRI study found results similar to those of Pirani [36], although with the calcaneus remaining in equinus [39].

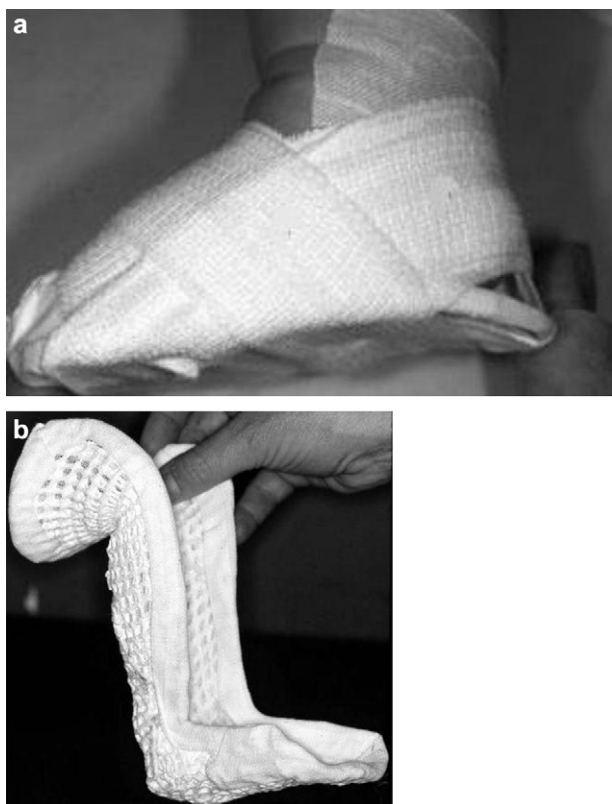


Figure 9 Functional method (Saint-Vincent-de-Paul) [9]: a: foot held by rigid plate with plantar concavity; b: femoropodal splint to stabilize CPB in abduction under talar-tibial-fibular unit. Thanks to P. Wicart.

The rate of surgical release of 20% to 30% (Table 4) fell to 10% by 2002 thanks to pAT, the rate of which rose from 10% to 24% in 2 years [15].

Which method to choose?

Opponents of the functional method claim it takes too long and is too expensive, as patients may have to travel miles to find a trained physiotherapist. The associated rate of surgical release, with results known to be poorer in the long term, is high, although it can be reduced by pAT.

Richards' study [31], which involved a great deal of bias, found identical rates of initial correction, recurrence and good results on both methods. There seemed to be a slight trend for casts to be more effective in severe forms, as Chotel confirmed [15], although on a short follow-up (Table 4).

Patients managed by the two methods were compared on GA at 2 and 5 years [19]. At 2 years, difference in results was related to pAT: associating it to the functional method reduced equinus (5%), genu recurvatum and foot drop (5%). The rate of normal sagittal ankle kinematics was better with the functional method (75% vs. 53%), and improved between the two follow-up time points. Thanks to increased triceps force, excessive dorsiflexion was found following pAT in only 24% of cases with the Ponseti at 5 years (versus 48% at 2 years). No correlation was found between pAT and reduced ankle strength (20% of cases).

Conclusion

Extensive surgical release is to be avoided as much as possible: it is better to tolerate a little imperfection than to undertake surgery that gives poor results over the long term.

The short follow-ups of the comparative studies preclude any firm conclusion as to which attitude is preferable, especially since percutaneous Achilles tenotomy has been added to the functional method. A hybrid attitude combining both methods is conceivable [31,38], but initial results have not proved conclusive. Moreover, Jowett's meta-analysis [18] showed that the Ponseti method works best when unaltered.

Better knowledge of etiology, family geographic and/or sociocultural context and the respective costs of the methods in the difficult current situation of health finance may be the main decision factors in treatment choice.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

References

- [1] Dobbs M, Nunley R, Schoenecker P. Long-term follow-up of patients with clubfeet treated with extensive soft-tissue release. *J Bone Joint Surg Am* 2006;88:986–96.
- [2] Seringe R, Atia R. Pied bot varus équin congénital idiopathique : résultats du traitement fonctionnel (269 pieds). *Rev Chir Orthop* 1990;76:490–501.
- [3] Bensahel H, Guillaume A, Czukonyi Z, Desgrippes Y. Results of physical therapy for idiopathic clubfoot: a long term follow-up study. *J Pediatr Orthop* 1990;10:189–92.
- [4] Dimeglio A, Bonnet F, Mazeau P, De Rosa V. Orthopaedic treatment and passive motion machine: consequences for the surgical treatment of clubfoot. *J Pediatr Orthop B* 1996;5:173–80.
- [5] Souchet P, Bensahel H, Thamar-Noel C, Pennecot G, Csukonyi Z. Functional treatment of clubfoot: a new series of 350 idiopathic clubfeet with long-term follow-up. *J Pediatr Orthop B* 2004;13:189–96.
- [6] Cooper D, Dietz F. Treatment of idiopathic clubfoot. A thirty-year follow-up note. *J Bone Joint Surg Am* 1995;77:1477–89.
- [7] Zions L, Zhao G, Hitchcock K, Maewal J, Ebrahimzadeh E. Has the rate of extensive surgery to treat idiopathic clubfoot declined in the United States? *J Bone Joint Surg Am* 2010;92:882–9.
- [8] Lascombes P. Pied bot varus équin idiopathique congénital. Description et conduite à tenir avant l'âge de 2 ans. In: *Cahier d'Enseignement de la SOFCOT n° 38*. Paris: Elsevier SAS; 1990. p. 67–84.
- [9] Wicart P, Tourné Y. Pied bot varus équin congénital. In: *Les déformations du pied de l'enfant et de l'adulte*. In: *Cahiers d'Enseignement de la SOFCOT*. Paris: Elsevier Masson SAS; 2010. p. 93–126.
- [10] Laville J. Traitement des séquelles du pied bot varus équin invétéré ou tardif (après l'âge de 3 ans). In: *Cahier d'Enseignement de la SOFCOT n° 85*. Paris: Elsevier SAS; 2004. p. 159–73.
- [11] Seringe R, Wicart P. Le concept de « bloc calcanéo-pédieux ». In: *Cahier d'Enseignement de la SOFCOT n° 94*. Paris: Elsevier SAS; 2007. p. 177–90.
- [12] Dobbs M, Gurnett C. Update on clubfoot: etiology and treatment. *Clin Orthop Relat Res* 2009;467:1146–53.

- [13] Chu A, Labar A, Sala D, van Bosse H, Lehman W. Clubfoot classification: correlation with Ponseti cast treatment. *J Pediatr Orthop* 2010;30:695–9.
- [14] Dimeglio A, Bensahel H, Souchet P, Mazeau P, Bonnet F. Classification of clubfoot. *J Pediatr Orthop B* 1995;4:129–36.
- [15] Chotel F, Parot R, Seringe R, Berard J, Wicart P. Comparative study: Ponseti method versus French physiotherapy for initial treatment of idiopathic clubfoot deformity. *J Pediatr Orthop* 2011;31:320–5.
- [16] Koureas G, Rampal V, Mascard E, Seringe R, Wicart P. The incidence and treatment of rocker bottom deformity as a complication of the conservative treatment of idiopathic congenital clubfoot. *J Bone Joint Surg Br* 2008;90:57–60.
- [17] Darnault P, Chapuis M, Treguier C. Échographie du pied de l'enfant. In: *Le pied de l'enfant. Chirurgie et Orthopédie*, monographie du GEOP. Montpellier: Sauramps Médical; 2001. p. 67–73.
- [18] Jowett C, Morcuende J, Ramachandran M. Management of congenital talipes equinovarus using the Ponseti method. A systematic review. *J Bone Joint Surg Br* 2011;93:1160–4.
- [19] Karol L, Jeans K, Elhawary R. Gait analysis after initial nonoperative treatment for clubfeet. Intermediate term followup at age 5. *Clin Orthop Relat Res* 2009;467:1206–13.
- [20] Maton B, Wicart P. Centrally adaptations in unilateral idiopathic clubfoot children following conservative treatment. *J Electromyogr Kinesiol* 2005;15:72–82.
- [21] Jeans K, Karol L. Plantar pressures following Ponseti and French physiotherapy methods for clubfoot. *J Pediatr Orthop* 2010;30:82–9.
- [22] Munshi S, Varghese R, Joseph B. Evaluation of outcome of treatment of congenital clubfoot. *J Pediatr Orthop* 2006;26:662–72.
- [23] Bensahel H, Kuo K, Duhaime M, the International Clubfoot Study Group. Outcome evaluation of the treatment of clubfoot: the international language of clubfoot. *J Pediatr Orthop B* 2003;12:269–71.
- [24] Ippolito E, Farsetti P, Caterini R, Tudisco C. Long-term comparative results in patients with congenital clubfoot treated with two different protocols. *J Bone Joint Surg Am* 2003;85:1286–94.
- [25] Graf A, Hassani S, Krzak J, Long J, Caudill A, Flanagan A, et al. Long-term outcome evaluation in young adults following clubfoot surgical release. *J Pediatr Orthop* 2010;30:379–85.
- [26] Wicart P, Seringe R. Chirurgie du pied bot varus équin congénital. EMC, Techniques chirurgicales – Orthopédie – Traumatologie 2011;1–11 [Article 44-921].
- [27] Maranhão D, Nogueira-Barbosa M, Simão M, Volpon J. Ultrasonographic evaluation of Achilles tendon repair after percutaneous sectioning for the correction of congenital clubfoot residual equinus. *J Pediatr Orthop* 2009;29:804–10.
- [28] Masrouha K, Morcuende J. Relapse after tibialis anterior tendon transfer in idiopathic clubfoot treated by the Ponseti method. *J Pediatr Orthop* 2012;32:81–4.
- [29] Halanski M, Davison J, Huang J, Walker C, Walsh S, Crawford H. Ponseti method compared with surgical treatment of clubfoot. A prospective comparison. *J Bone Joint Surg Am* 2010;92:270–8.
- [30] Van Gelder J, van Ruiten A, Visser J, Maathuis P. Long-term results of the posteromedial release in the treatment of idiopathic clubfoot. *J Pediatr Orthop* 2010;30:700–4.
- [31] Richards B, Faulks S, Rathjen K, Karol L, Johnston C, Jones S. A comparison of two nonoperative methods of idiopathic clubfoot correction: the Ponseti method and the French functional (physiotherapy) method. *J Bone Joint Surg Am* 2008;90:2313–21.
- [32] Dobbs M, Rudzki J, Purcell D, Walton T, Porter K, Gurnett C. Factors predictive of outcome after use of the Ponseti method for the treatment of idiopathic clubfeet. *J Bone Joint Surg Am* 2004;86:22–7.
- [33] Chu A, Lehman W. Persistent clubfoot deformity following treatment by the Ponseti method. *J Pediatr Orthop B* 2012;21:40–6.
- [34] Janicki J, Wright J, Weir S, Narayanan U. A comparison of ankle foot orthoses with foot abduction orthoses to prevent recurrence following correction of idiopathic clubfoot by the Ponseti method. *J Bone Joint Surg Br* 2011;93:700–4.
- [35] Farsetti P, Dragoni M, Ippolito E. Tibiofibular torsion in congenital clubfoot. *J Pediatr Orthop B* 2012;21:47–51.
- [36] Pirani S, Zenzik L, Hodges D. Magnetic resonance imaging study of the congenital clubfoot treated with the Ponseti method. *J Pediatr Orthop* 2001;21:719–26.
- [37] Masse P. Le traitement du pied bot par la méthode «fonctionnelle». In: *Le pied bot varus équin. Cahiers d'Enseignement de la SOFCOT n° 3*. Paris: Expansion Scientifique Française; 1977. p. 51–6.
- [38] Dimeglio A, Canavese F. The French functional physical therapy method for the treatment of congenital clubfoot. *J Pediatr Orthop B* 2012;21:28–39.
- [39] Richards B, Dempsey M. Magnetic resonance imaging of the congenital clubfoot treated with the French functional (physical therapy) method. *J Pediatr Orthop* 2007;27:214–9.