The Dynko®
A new dynamic orthosis for the treatment of clubfeet as part of the Ponseti Method

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Introduction
Clubfoot is a congenital deformity with multifactorial etiology. The goal of treatment is to obtain functional normal feet in all patients: straight, plantigrade, mobile and painless feet. The conservative treatment (sequential manipulation and casting) according to Ponseti of congenital clubfoot is well recognised as being quite successful with high outcome scores[1,2,3,4,5]. An essential part of the treatment is the use of an orthosis that externally rotates and abducts the feet. In most studies a static brace like a Denis Browne splint is used for that[1,3,5,6,7,8,9,10,11]. The importance of bracing as part of the Ponseti method is recognised by most clinicians, but unfortunately not by all parents. An increase in frequency of relapses is related to non-compliance with the orthosis in a number of publications[1,6,7,8,9,12,13,14]. Interestingly enough there's little documentation on why parents find it so difficult to comply with use of the Foot Abduction Orthosis (FAO). Most studies emphasise the need for parent education in order to improve compliance[1,6,7,9] but that still isn't enough to enforce all parents to comply.

The use of dynamic techniques has been proposed as an alternative to the static FAO[15,16]. Ponseti states this to be ineffectual[1]. Nevertheless, both Browne and Ponseti state the importance of allowing some motion of the foot and ankle in the braced position[1,10,11]. Recently the use of a dynamic version of the FAO leading to improved compliance has been proposed[17,18]. In this article a new concept for a dynamic FAO with even more degrees of freedom and greater control is presented. We expect this design to have at least comparable outcomes with respect to maintaining correction, but increased outcome with respect to compliance with orthotic treatment and dynamic development of the infant.

Materials and Method
Orthotic treatment with an FAO is an essential part of the Ponseti method for treating clubfoot. The goal of the use of the FAO is to prevent relapse by holding the feet in an externally rotated and abducted position. This is to prevent recurrence of varus deformity of the heel, adduction of the foot and in-toeing. The brace should furthermore bring the ankle in dorsal flexion to prevent equinus[1]. Footware used in conjunction with a brace should be able to hold the alignment of the forefoot in balance with that of the hind foot to maintain the correction of pro- and supination that has been achieved in the plaster corrections. With the orthosis ligamental structures that need to be lengthened are strained and structures that need to shortened are relaxed from stresses. It is believed that by doing this the internal stress distribution in the various joints is brought back to more normal situations, leading to a more normal growth of the bony structures (that, as we know, are quite sensitive in their growth to the applied stress situation) With the conventional Denis Browne splint this is al done statically.

In other clinical conditions, such as contractures, stretching ligamental and muscular structures is a goal as well. The combination of a long term use of dynamic (stretching) braces, combined with a physiotherapy programme is often reported to have superior results above static orthotic treatment, not entirely without the bonus of a higher compliance to dynamic bracing than to static bracing[19,20]. We believe that a proper combination of straining and releasing the necessary structures in resting periods on the one hand with dynamic muscle activity and movement in active periods on the other may have positive results on the growing conditions of the foot and ankle region in children with clubfoot, but most definitely will have positive effects on compliance with orthotic treatment and well being during orthotic treatment.

For that purpose we have designed a brace with multiple degrees of freedom, allowing for almost every combination of motions of the ankle joints. The system has been named Dynko®. The system contains various springs, forcing the foot into external rotation and abduction, as well dorsal flexion, but allowing internal rotation, adduction and plantar flexion against a built up of spring tension. As a result, the system allows for great mobility of the child when active. Our subjects have shown that they could turn over, crawl, stand up and even walk with the systems very well. On the other hand the springs are strong enough to bring the feet back to the required externally rotated, abducted and dorsal flexed position during resting periods.

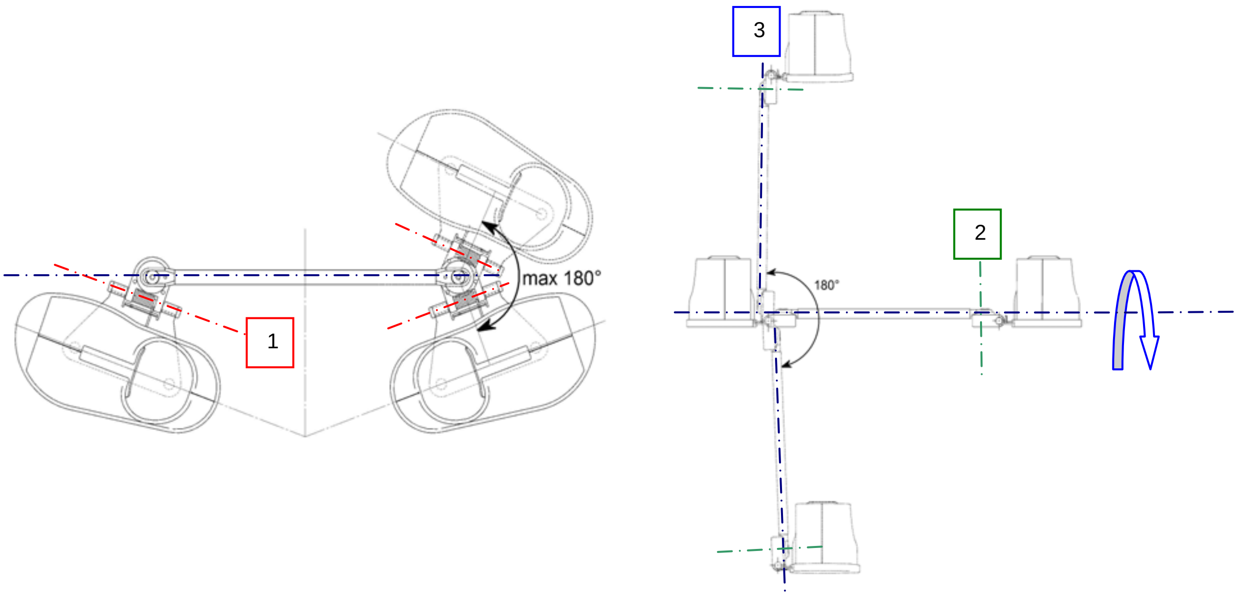

Figure 1 The Dynko®. A footplate, mounted to the shoes is connected to a housing and a central beam. Each footplate-housing combination has three spring loaded rotatory degrees of freedom, (axes 1 to 3).

In Fig. 1 the Dynko® is shown. The system consists of two footplates, to which commercially available shoes for clubfoot can be mounted. The footplate is connected to a housing by means of an axis (1) that allows the foot to ab- or adduct with respect to the house. An internal spring enforces abduction in rest. To the housing a central beam (length dependent on shoulder width) is connected that allows the foot to internally or externally rotate around axis 2. This axis too is spring loaded, enforcing external rotation in rest. The central beam furthermore allows for relative dorsal or plantar flexion of one foot with respect to the other. An internal spring enforces neutral alignment of both feet with respect to each other in rest. By placing both feet in dorsal flexion on the footplate (i.e. a raised forefoot with respect to the hind foot, which can be achieved by spacers or by putting this in the construction of the footplate) a dorsal flexing moment of force will be generated by the external rotation and (even more important) the abduction spring moment components to the dorsal flexing axis (due to the relative rotation of the dorsal flexion axis with respect to the other two, once some external rotation is present). This coupling between dorsal flexion and abduction due to non-orthogonal axes is not unlike the coupling between these two degrees of freedom in the ankle itself. This results to a system that allows for great mobility during active periods (see Figure 2), combined with stressing the internal structures in external rotation, abduction and dorsal flexion in rest periods.

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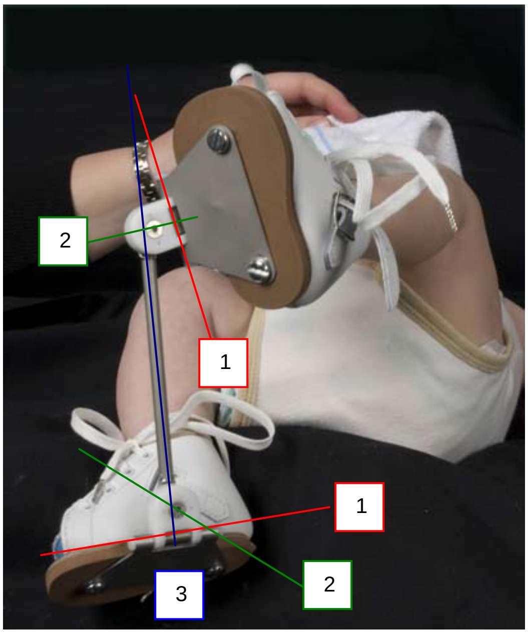

Figure 2 The Dynko® in an active position. The rotatory degrees of freedom around the three axes (1: ab-adduction axis, 2: internal-external rotation, 3: dorsal-plantar flexion) allow for great mobility of the infant in active periods. The springs inside the system brings the feet back to external rotation, abduction and dorsal flexion in rest.

In unilateral applications the external rotation spring and the abduction spring can be removed to prevent undesired moments of force on the unaffected limb.

The range of motions and stiffnesses are given in Table 1. Note that the stiffness of the various spring components varies with increasing length of the system. This is to accommodate for higher required forces when the child gets older and stronger. Also note that for the dorsal-plantar spring the stiffness decreases with increasing length of the system. This allows for more freedom of motion once the child gets older, which facilitates crawling and walking. However, in an externally rotated situation the actual dorsal moment of force on the ankle-foot complex is to a larger extent determined by the co-action of the abduction spring (as explained above). Meaning that in rest there still is a larger dorsal component.

	ROM	Stiffness (shortest - longest)	Minimal active moment (shortest - longest)
Endo-exorotation	160° (80° endorotation, 80° exorotation)	0,25 Nmm/° - 0,67 Nmm/°	20 Nmm - 53 Nmm (at 80° exototation)
Ab-adduction	180° (80° abduction, 100° adduction)	0,47 Nmm/° - 0,65 Nmm/°	29 Nmm - 40 Nmm (at 80° abduction)
Dorsal-plantar flexion	90° (relative to contralateral foot)	3,6 Nmm/° - 1,9 Nmm/°	0 Nmm

Table 1 Mechanical characteristics of the Dynko® system in the various degrees of freedom

Results

Currently a study to investigate the functional outcome of clubfeet treated in the Ponseti method using our fully dynamic Dynko® brace is in the start-up phase. Until now we have fitted over 25 Dynko® systems at the Deventer Hospital. Children are regularly checked by the orthopaedist and physiotherapist. During checks Pirani[22] scores are taken. Initial outcome shows promising results with Pirani scores of these patients as least as good as with conventional Denis Browne splints. The use of the Pirani score as an outcome measure is a proven method.

Compliance with the orthosis seems very good. Particularly parents with previous experience with the Denis Browne splint comment positively on the ease of use, freedom of mobility and child acceptance. The children can kick unilaterally as well as bilaterally, turn over, crawl and even walk very well (dependent on their age and dynamic development, obviously). The orthosis returns feet to the desired externally rotated, abducted and dorsal flexed position in resting period markedly, as reported by parents based on the sleeping position of their child, but also observed by the researches in day-time observations of the infant's actions with the orthosis.

Conclusion

In recent literature the importance of use of a Foot Abduction Orthosis as part of conservative treatment of clubfeet using the Ponseti method is stated.[7] However, there have been problems. Compliance rates are sometimes reported to be low and as a consequence recurrences occurred.[7,17,18] Our believe is that, after consulting with the caretakers, improving the brace in order to make it more comfortable will increase compliance and therefore reduce recurrences.

Speaking to parents about the use of the Denis Browne Foot Abduction Orthosis (FAO) quickly reveals some of the difficulties they have to face:

- Donning and doffing is a challenge, since quite some corrective forces are required, leading to a struggle to force the feet into the shoes in the required orientation.
- Initial response of the infant to donning and doffing, as well as to initial wearing of the brace is seldom one of great joy. High straining of the structures around the feet in the orthosis, as well as the immobilising effects, usually lead to discomfort for the infant, which in its turn has very successful strategies in letting its parents know that.
- Discomfort of the orthosis may lead to grumbling or crying infants. Since quite a bit of the use of the FAO is done at night-time, this has implications for sleeping hours for both the child and its parents.
- The FAO limits the infant in turning over or lying sideways, but not entirely prevents that. During night time this leads to frequent discord between FAO and blankets, leading to the infant becoming cold and asking for its parents to do something about that.
- Some parents question the influence of the FAO on the dynamic development of their child. Will it limit or postpone turning over, crawling, standing up, sitting down and/or walking?

With our Dynko® brace we have addressed these remarks. Initial results are good. Wearing the Dynko® brace appears to be more comfortable.

Also we believe that the dynamic component will positively influence the neuromotor development of the child. We assume that the dynamic loading of soft tissue structures that constitute the limits of range of motion in abduction, eversion and dorsal flexion will lead to a more natural growth balance in these limiting factors of range of motion.

Further research is needed (and planned, as stated above) to validate these findings and to come up with guidelines for recommended use of the Dynko®. We furthermore hope that this research will give us some more insight in possible improvements in design and application of the Dynko®.

References

1 Ponseti, IV; Treatment of congenital club foot; J Bone and Joint Surg Am;74:448-454;1992

2 Ippolito, E.; Farsetti, P.; Caterini, R.; Tudisco, C.; Long-Term Comparative Results in Patinets with Congenital Clubfoot Treated with Two Different Protocols; J Bone and Joint Surg Am; 85:1286-1294; 2003

3 Laaveg, S.J.; Ponseti, I.V.; Long-Term Results of Treatment of Congenital Club Foot; J Bone and Joint Surg Am.; 62:23-31; 1980

4 Dobbs, M.B.; Nunley, R.; Schoenecker, P.L.; Long-Term Follow-Up of Patients with Clubfeet Treated with Extensive Soft-Tissue Release; J Bone and Joint Surg Am; 88:986-996; 2006

5 Cooper, D.M.; Dietz, F.R.; Treatment of idiopathic clubfoot. A thirty-year follow-up note; J. Bone and Joint Surg Am.; 77:1477-1489; 1995

6 Staheli, L (ed.); Ponseti Clubfoot management. Technical Manual for Healthcare Providers in Uganda; Global-HELP organisation, 2008

7 Thacker, M.M.; Scher, D.M.; Sala, D.A.; Bosse, H.J.P. van; Feldman, D.S.; Lehman, W.B.; Use of the Foot Abduction Orthosis Following Ponseti Casts. Is it Essential?; J. Pediatr Orthop; 25-2:225-228, 2005

8 Morcuendo, J.A.; Dolan, L.A.; Dietz, F.R.; Ponseti, I.V.; Radical Reduction in the Rate of Extensive Corrective Surgery for Clubfoot Using the Ponseti Method; Pediatrics; 13-2:376-380; 2004
9 Treatment of Congenital Clubfoot with the Ponseti Method. Authors Translation; Acta Orthop Traumatol Turc; 36:281-287; 2002
10 Browne, Denis; Talipes Equino Varus; Post-Graduate Med J; October: 349-354; 1937
11 Browne, Denis; Modern Methods of Treatment of Club-Foot; The British Med J. September: 570-572; 1937
12 Hattori, T.; Ono, Y.; Kitakoji, T.; Iwata, H.; Effect of the Denis Browne splint in conservative treatment of congenital club foot; J Pediatr Orthop B.; 12-1:59-62; 2003
13 Yamamoto, H.; Muneta, T.; Morita, S.; Nonsurgical treatment of congenital clubfoot with manipulation, cast, and modified Denis Browne splint; J Pediatr Orthop.; 18-4:538-542; 1998
14 Dobbs, M.B.; Rudzki, J.R.; Purcell, D.B.; Walton, T.; Porter, K.R.; Gurnett, C.A.; Factors predictive of outcome after use of the Ponseti method for the treatment of idiopathic clubfeet; J Bone and Joint Surg Am.; 86-1:22-27; 2004
15 Lusskin, R.; Neonatal Therapy for Congenital Clubfoot; J Assoc Child Prosthet Orthot Clinics; 11-10:1-11; 1972
16 Lusskin, R.; The technique of dynamic adhesive strapping for congenital clubfoot. Bull. Hosp. Joimit Dis., 47: 235-244, 1987.
17 Garg, S.; Porter, K.; Improved bracing compliance in children with clubfeet using a dynamic orthosis; J Child Orthop.; 3-4:271-276; 2009
18 Chen, R.C.; Gordon, J.E.; Luhmann, S.J.; Schoenecker, P.L.; Dobbs, M.B.; A new dynamic foot abduction orthosis for clubfoot treatment; J Pediatr Orthop.; 27-5:522-528; 2007
19 Larson, D.; Jerosch-Herold, C.; Clinical effectiveness of post-operative splinting after surgical release of Dupuytren's contracture: a systematic review; BMC Musculoskeletal Disorders; 9:104-110; 2008
20 Hepburn, G.R.; Case Studies: Contracture and Stiff Joint Management with Dynasplint; J Orthop Sports Physical Therapy; 8-10:498-504; 1987
22 Dyer, P.J.; Davis, N.; The role of the Pirani scoring system in the management of club foot by the Ponseti method; J Bone and Joint Surg Br; 88:1082-1084; 2006