We present a systematic review of the results of the Ponseti method of management for congenital talipes equinovarus (CTEV). Our aims were to assess the method, the effects of modifications to the original method, and compare it with other similar methods of treatment. We found 308 relevant citations in the English literature up to 31 May 2010, of which 74 full-text articles met our inclusion criteria. Our results showed that the Ponseti method provides excellent results with an initial correction rate of around 90% in idiopathic feet. Non-compliance with bracing is the most common cause of relapse. The current best practice for the treatment of CTEV is the original Ponseti method, with minimal adjustments being hyperabduction of the foot in the final cast and the need for longer-term bracing up to four years. Larger comparative studies will be required if other methods are to be recommended.

Congenital talipes equinovarus (CTEV) occurs in one in 1000 live births and is one of the most common musculoskeletal abnormalities at birth. A variety of non-idiopathic types of clubfoot have been described. Following its success the Ponseti method has become the most widely practised treatment for CTEV. We present a systematic review of the literature on the results of the Ponseti method. Our aims were to assess its success for idiopathic and non-idiopathic CTEV, the effects of modifications to the original method, and to compare it with other similar methods.

Materials and Methods
We searched the following electronic bibliographic databases, without date restriction, up to May 2010: Medical literature Analysis and Retrieval System online (MEDLINE), Excerpta Medica Database (EMBASE), Cumulative Index to Nursing and Allied Health Literature (CINAHL) and The Cochrane Library. The keywords and medical subject heading (MeSH) terms used were ‘Ponseti treatment/method’, ‘clubfoot’ and ‘congenital talipes equinovarus’. We screened the reference lists of the retrieved articles to identify any further relevant studies and then reviewed the titles, abstracts and full texts to determine their eligibility.

Comparison studies were assessed using Detsky et al’s scoring system for randomised controlled trials, and case series were assessed using Bland–Altman analysis, which allowed assessment of inter-rater agreement for the quality of studies. We found 308 relevant citations in the English literature up to 31 May 2010, of which 74 full-text articles met our inclusion criteria. A descriptive summary of the results is presented here.

Results
The Iowa results. Before 1948, extensive posteromedial soft tissue releases were common but often resulted in stiffness and recurrence. Ponseti’s goals were to obtain a plantigrade, mobile foot in the shortest time possible without extensive surgery. Ponseti and Smoley published the first results of the method in patients treated between 1948 and 1956, and demonstrated good results in 71% (94 feet). There are two longer follow-up studies from Iowa. Laaveg and Ponseti reported a ten- to 27-year follow-up of patients treated as infants, 90% of whom were satisfied with the appearance and function of their feet. In 1995, Cooper and Dietz published their results on patients treated from 1950 to 1967.
with a 30-year follow-up, the longest in the literature: 78% (71 feet) had an excellent or good outcome.

With time, slight modifications were made to improve the results of the Ponseti method. These included hyperabduction of the foot in the final cast, and the need for long-term bracing for up to four years. This reduced the rate of relapse from 56% to 11%.8

The largest comprehensive study of the Ponseti method is by Morcuende et al,9 who compared a change of casting after five or seven days and followed 220 patients (319 feet). No difference in outcome was found between the groups.

**General results in other centres.** With the successful results from the Ponseti group and increased awareness of the method, it was adopted by other centres. The earliest results outside Iowa came from Ippolito’s group in Rome,10 where patients treated by the Ponseti method between 1979 and 1984 had better outcomes than those treated with the Maruno-Zuco method, in which posterior release was part of the treatment.11 This led to a large increase in reports from other institutions.12-14 The first of these was by Herzenberg, Radler and Bor.15 Colburn and Williams16 achieved successful correction without the need for a posteromedial release (PMR) in 54 of 57 feet, and further successful results were achieved in many countries.17,18

**Age at initial treatment.** The age at presentation of the first Ponseti cohort of 67 patients was between one week and six months, with initial correction achieved in 83% of cases but with a 33% relapse rate.9 Careful analysis of these results demonstrated that relapses were due to abandoning the brace at an early age. The average full-time wearing of the brace was three months and night-time usage was 21 months, which is known to be too short to prevent relapses.

Alves et al19 found no difference in outcome for patients presenting before or after six months of age. Lourenço and Morcuende20 reported on patients with neglected idiopathic clubfoot presenting up to nine years of age. They achieved successful outcomes in 16 of 24 feet, suggesting that Ponseti treatment may be successful even in delayed presentations. Later reports have shown successful results with Ponseti treatment in adolescents and young adults,21,22 and the oldest reported successful case is an 18-year-old Nigerian woman.18

It is notable that several studies have shown no correlation between age at the start of Ponseti treatment and recurrence, final range of movement at the ankle and the need for additional surgery.12,19,21,23-25

**Pirani score in relation to Ponseti treatment.** The most popular system for the classification of severity in CTEV is the Pirani score.26 This was presented originally in abstract form and there are no direct references. Another system is that of Dimeglio et al.27 Flynn, Donohoe and Mackenzie28 showed good interobserver reliability for the Pirani scoring system and with two examiners they found a mean difference of 0.6 for the Pirani score (out of 10) and 1.4 for the Dimeglio score (out of 20), with a correlation coefficient of 0.90 (p = 0.0001) for the Pirani score.

There is a positive correlation between the initial Pirani score and the need for tenotomy and the number of casts required to correct the deformity.26,29 A low score, however, does not exclude the need for a tenotomy.26 In most studies the Pirani score after treatment is less than one.13,23,30-32

**Number and type of casts required to obtain correction.** Morcuende et al9 suggested that the number of casts necessary to achieve correction can be used as an indicator for the severity of deformity. The mean number required to achieve correction ranges between three and nine in the literature.5,6,8,9,16,17,19,23,25,26,31,33-36 Terrazas-Lafargue and Morcuende37 showed that the timing of cast removal affected the number of casts required for correction. Satisfactory results, using an accelerated programme with three plaster changes a week, have recently been described.38 A variety of casting materials have been used.39-41 Brewster et al39 reported a series of patients treated with a below-knee soft cast which gave similar results to studies using above-knee plasters, and avoided the problems with perineal hygiene. Ng Lam and Cheng40 found acceptable results and slightly increased patient satisfaction in a small cohort treated with synthetic fibreglass instead of traditional plaster, in the initial period. However, these studies were small and little can be drawn with regard to changing the Ponseti technique.

**Percutaneous tenotomy of tendo Achillis.** A percutaneous tenotomy of tendo Achillis to correct residual equinus may be required at the end of the Ponseti casting. The tenotomy rate in studies adhering to the method varies from < 50%31 to 100%,9 with the latter results in patients beyond walking age. In the majority of studies the tenotomy is performed as an outpatient under local anaesthesia; however, tenotomies under general anaesthetic are reported.23 Complications have been noted. Changulani et al23 had a case of neurovascular injury that required exploration, ligation of the posterior tibial artery and primary repair of the posterior tibial nerve. Dobbs, Gordon and Walton42 found bleeding complications in 2% of cases following percutaneous tenotomy of tendo Achilles, and Burghardt, Herzenberg and Ranade43 reported a patient who developed a pseudoaneurysm following a tenotomy.

**The use of ultrasound in Ponseti treatment.** Ultrasound can play a role in monitoring the correction of clubfoot. The small bones of the newborn foot are essentially cartilaginous and are well demonstrated by sonography.44 Desai, Aroojis and Mehta44 showed that correction can be monitored in this manner, as accurate realignment of the talonavicular and the presence of spurious correction can be detected early. Ultrasound assessment can also show that the Ponseti protocol does not influence femoral or tibial torsion.45 Ultrasound has also been used to demonstrate healing between the tendon stumps following Achilles tenotomy;46 and Mangat et al47 used sonography to show that healing after tenotomy of the tendo Achillis often takes up to 12 weeks.
Relapses following treatment. The Iowa group define relapse as the reappearance of any of the components of the deformity, including cavus, adductus, varus or equinus. Laaveg and Ponseti have the longest follow-up for relapses, with a mean of 18 years. They found that 55 feet had no relapse, 49 had one relapse at a mean age of 39 months, 25 a second relapse at a mean of 53 months, ten a third relapse at mean of 63 months and three a fourth relapse at a mean of 77 months.

Recent studies have indicated that the rate of surgery can be reduced by earlier identification of relapses, repeat casting, improved compliance and the wearing of a brace for the correct time. Short-term follow-up studies and recent work from Iowa show that early surgery is required for 3% to 6% of feet after a relapse.

Relapse related to compliance. Compliance with the Ponseti brace protocol is a major problem and has a direct effect on the success of treatment. This is likely to be caused by patients and families having difficulty with bracing, where there is discomfort and the feet are more rigid. The incidence of non-compliance with bracing ranges from 0% to 51%. Dobbs et al showed that families who did not adhere to the bracing protocol were 183 times more likely to have a relapse, and Morcuende et al found that non-compliant patients had up to 17 times greater odds of relapsing.

When assessing sociodemographic factors related to relapse, parental education limited to high-school level or less and a family income of $20,000 per annum were significant risk factors for recurrence.

Treatment following relapse. A stepwise pattern of treatment for relapse is recommended, including repeat casting, repeat tenotomy, tibialis anterior tendon transfer and limited posterior release if necessary. Initial data from the Iowa group showed a relapse rate of up to 56%; however, it had been initially recommended that bracing was for only about 3% to 6% of feet after a relapse.

The use of radiography in the Ponseti method. Although Ponseti recommended palpation alone, radiographs have been used to assess correction before or after tenotomy to confirm that the dorsiflexion obtained from the percutaneous tenotomy of tendo Achillis is truly at the ankle. Radler et al showed radiologically before and after tenotomy that the mean dorsiflexion obtained from tenotomy was 15° and the change in the lateral tibiocalcaneal angle was 17°.

Ponseti method compared to other methods. Kite initially described full correction in 90% of all cases. However, this correction often took months and the results were not reproduced by others. Several studies comparing the methods report better results with the Ponseti method. Others showed similar success rates between the treatments (87% with Ponseti and 79% with Kite), but the former required fewer casts, and had a faster reduction in the Pirani score.

The French functional method, performed daily by physiotherapists can obtain similar outcomes to the Ponseti method, but is less likely to be chosen by parents. The Romanian protocol, which involves manipulations until the age of two months, followed by immobilisation in a long-leg cast, has been compared less favourably with the Ponseti method.

Modifications to the Ponseti protocol. Alvarez et al injected botulinum toxin A (BTX-A) into the triceps surae instead of an Achilles tenotomy, and presented short-term results comparable with the Ponseti treatment. However, in a randomised trial between BTX-A and placebo, where the endpoint was avoidance of a percutaneous Achilles tenotomy, Cumming was unable to show that BTX-A reduces the need for tenotomy, or reduces the chance of relapse. The effect of bracing and bracing adjuncts. Parental noncompliance with the Denis Browne foot abduction brace is a common problem and has led to the development of a new dynamic foot abduction orthosis which has to improved compliance, but at increased cost. Bracing with an ankle-foot orthosis is not as effective as with a Denis Browne brace. In developing countries the Steenbeek foot abduction brace (SFAB) is a much cheaper alternative and provides good results.

Non-idiopathic CTEV. The treatment of patients with non-idiopathic clubfoot is challenging owing to stiffness of the foot and ankle, resistance to correction, tendency to relapse and co-existing hip and knee contractures. Late relapses in idiopathic CTEV may represent the onset of a previously undiagnosed neuromuscular disease. With the increasing success of Ponseti treatment, many groups are using this method as first-line treatment. Successful results have been achieved in patients with arthrogryposis, and despite the need for additional surgical procedures, this is a viable alternative for primary treatment.

Ponseti method in developing nations. Around 80% of those born with CTEV each year live in less developed nations. The Ponseti method is particularly suited to these countries where there are fewer orthopaedic surgeons, as it can be learnt easily by allied health professionals such as physiotherapists and orthopaedic assistants.

In Malawi, a nationwide treatment programme for CTEV, using the Ponseti method, was established in each of the country’s 25 health districts, whereby 327 of the 428 feet treated were corrected to a plantigrade position. In Uganda, the Ministry of Health approved the Ponseti method as the preferred treatment for congenital CTEV in all its hospitals. Consequently, the government set up the six-year Uganda Sustainable Clubfoot Care Project (USCCP), and similar successful projects have also been established in India, Tanzania, Ethiopia and Vietnam.

In conclusion, although other methods of more patient-friendly bracing and casting have been proposed with
successful short-term results and at a significantly greater cost,24,41 there are no large studies with adequate follow-up to suggest that the Ponseti method should be altered. Compared with other treatments, the Ponseti method, with the minor adjustments that the Iowa group made to the original description, produces equally good or better long-term results and is the treatment of choice among parents.57

Although the results of Ponseti treatment for non-idiopathic CTEV are not as successful as for idiopathic CTEV, it should still be considered as the first-line treatment in these patients.70

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References


