ABSTRACT

**Purpose.** To compare the long-term results of the Kite and Ponseti methods of manipulation and casting for clubfoot.

**Methods.** 42 patients (with 64 idiopathic clubfeet) were equally randomised to Kite or Ponseti treatments in the early weeks of life. 14 males and 7 females (34 clubfeet) were treated by the Kite method, whereas 13 males and 8 females (30 clubfeet) were treated by the Ponseti method. All the clubfeet were manipulated, casted, and followed up (for a mean of 3 years) by one experienced orthopaedic surgeon. The final results were compared.

**Results.** The success rates for the Kite and Ponseti treatments were similar (79% vs 87%). With the Ponseti method, the number of casts was significantly fewer (7 vs 10); the duration of casting required to achieve full correction was significantly shorter (10 vs 13 weeks); the maximum ankle dorsiflexion achieved was significantly greater (12 vs 6 degrees); and the incidence of residual deformity and recurrence was slightly lower.

**Conclusion.** The Ponseti method can achieve more rapid correction and ankle dorsiflexion with fewer casts, without weakening the Achilles tendon.

**Key words:** clubfoot; manipulation, orthopedic

INTRODUCTION

Clubfoot deformity in children is difficult to treat because of the complex pathological anatomy of the growing foot. It is important to understand the pathological anatomy and mechanics of correction and to follow up patients carefully. In early weeks of life (with pliable deformities), the treatment of choice is always conservative. Thus, the manipulation and casting techniques of Kite and Ponseti are commonly used with good outcomes, but comparison of their long-term outcomes is lacking. The type and duration of treatment depend on the age of patient and severity of deformity. We therefore compared the
long-term results of these 2 methods by conducting a randomised prospective study.

MATERIALS AND METHODS

42 patients (with 64 idiopathic clubfeet) were equally randomised to the Kite or Ponseti methods of manipulation and casting in the early weeks of life. 14 males and 7 females (34 clubfeet: 13 bilateral, 5 right, 3 left) were treated by the Kite method, whereas 13 males and 8 females (30 clubfeet: 9 bilateral, 6 right, 6 left) were treated by the Ponseti method. All the clubfeet were manipulated, casted, and followed up by one experienced orthopaedic surgeon. Clubfoot associated with myelocele, meningomyelocele, arthrogryposis multiplex congenital, and other neuromuscular causes were excluded, to avoid the effect of neuromuscular imbalance on treatment results.

The Kite method\textsuperscript{1,2,7} involved gradual correction in order of forefoot adduction, heel varus, and ankle equinus using repeated manipulation and casting. Manipulation was performed with pressure applied over the calcaneocuboid joint (Fig. a) and the foot was never beyond neutral. The toe-to-groin cast was changed every 7 to 10 days until full correction. This was followed by full-time splinting in a neutral position with a heel lock to avoid recurrence of varus, and a straight medial bar to avoid recurrence of adduction. Once the patient began walking, the splints were used at night only. By day, shoes with an open toe box, straight medial border, lateral flaring of the sole, and reverse Thomas heels were used until the age of 4 to 5 years.

The Ponseti method\textsuperscript{3,4} involved abduction of the foot around the head of talus (Fig. b), while avoiding forceful pronation (eversion); the forefoot if everted would lead to cavus deformity. To correct cavus, the forefoot was slightly inverted. To correct adduction, the foot was gradually and optimally abducted, without causing much discomfort to the child. The heel varus was considered corrected when the anterior end of calcaneus rotated laterally (abducted) underneath the head of talus. In severe deformity, the heel was forced into a valgus position to stretch the deltoid ligament. The casts were changed every 7 to 10 days. Once the cavus, forefoot adduction, and heel varus were gradually corrected, the Achilles tendon was also gradually stretched to correct equinus. In patients with residual equinus, the Achilles tendon was percutaneously tenotomised. The final cast after tenotomy was kept for 3 weeks to enable healing in maximum dorsiflexion. The splints were applied after cast removal. They comprised open-toe tarsopronator shoes held by a Dennis-Browne bar bent 10° to 15° with convexity away from the leg and the foot held in 70° of external rotation (thigh-foot axis) to maintain correction. In unilateral clubfoot, the normal side was held in 40° to 45° of external rotation to keep the medial soft tissues stretched and to maintain the abduction of the calcaneus and forefoot around the head of talus. The knees were left free to stretch the gastrocnemius and to provide a corrective force to the other foot. The splints were retained until the walking age, and thereafter worn only at night. By day, shoes similar to those used in the Kite method were used until age 4 to 5 years.

Clinical assessments included: the incidence of residual and recurrent deformities, passive range of movement (measured by goniometer), appearance, muscle power, calf atrophy, foot size, and other complications. Functional assessments included: gait, functional limitation, shoe wear, pain, and patient satisfaction. Radiological assessments included:
measurements of talocalcaneal angles, talo-1st metatarsal angle, and talocalcaneal index (the sum of talocalcaneal angles in anteroposterior and lateral views). Results were graded as excellent (85–100 points), good (70–84 points), fair (60–69 points), and poor (<60 points), according to the scoring system of Atar et al.\textsuperscript{11} (Table 1). Poor and fair results were considered failures and needed further management for residual or recurrent deformity. The results of the 2 groups were compared using the unpaired $t$ test or Chi squared test. A $p$ value of <0.05 was considered significant.

**RESULTS**

Patients were followed up for a mean of 3 years (standard deviation [SD], 4 months). The Ponseti method had a slightly higher success rate (excellent or good results) [87% vs 79%, 26 vs 27 feet, $p=0.66$, Chi squared test] and those in relation to age at presentation ($p>0.05$, Chi squared test, Table 2). It
entailed significantly fewer casts (7 vs 10, \(p=0.013\), unpaired \(t\) test) and shorter duration of casting (10 vs 13 weeks, \(p=0.018\), unpaired \(t\) test) and achieved significantly greater maximum ankle dorsiflexion (12\(^\circ\) vs 6\(^\circ\), \(p=0.037\), unpaired \(t\) test) and slightly greater ranges of inversion and eversion motion (\(p>0.05\), unpaired \(t\) test, Table 3).

The Ponseti method resulted in slightly fewer residual deformities and recurrences (\(p>0.05\), Chi squared test, Table 3). In the Kite group, 3 patients (one bilateral, 2 unilateral) had recurrences and underwent complete posteromedial soft tissue release. In the Ponseti group, one patient had bilateral recurrence, of which one foot responded to re-manipulation and re-casting, and the other underwent complete posteromedial soft tissue release. Isolated equinus recurrence was seen in one foot of each group; the one in the Ponseti group responded to re-manipulation and re-casting and the other needed tenotomy. There were no isolated recurrences of forefoot adduction or heel varus. Among patients with residual deformity, residual forefoot adduction of >5\(^\circ\) was seen in 4 feet (one associated with heel varus) in the Kite group (3 responded to re-manipulation and re-casting and 2 underwent soft tissue release) and 5 feet in the Ponseti group (2 responded to re-manipulation and re-casting and 3 underwent tibialis anterior transfer). Isolated residual heel varus was left untreated in all patients, except one in the Kite group who underwent osteotomy.

The power of the Achilles tendon (assessed by toe walk and hopping test) was normal (grade 5) in all patients. Gait analysis showed that all patients were able to toe walk, whereas 16 (76\%) in the Kite group and 18 (86\%) in the Ponseti group were able to heel walk (\(p=0.69\), Chi squared test). Dynamic inversion of the foot was seen in 3 and 2 patients, respectively, due to pulling of the tibialis anterior tendon during the swing phase of the gait cycle. One patient in the Kite group had functional limitation secondary to dynamic inversion of the foot and responded well to tibialis anterior transfer to the dorsum. None of the 42 patients limped.

Both methods yielded no significant differences with regard to residual deformity, age at relapse, pain, complications, gait, muscle power, calf atrophy, foot size, functional limitation, and patient satisfaction. Respectively in the Kite and Ponseti groups, 2 (10\%) and one (5\%) of the patients had occasional limitation during vigorous activity; one (5\%) in each group had usual limitation during vigorous activity; none had limitation during walking or routine activity; and 18 (86\%) and 19 (90\%) had no functional limitation. In these respective groups, shoe wearing was not feasible in 2 (6\%) and one (3\%) of the feet due to severe deformities; 20 (59\%) and 19 (63\%) of the feet wore tarsopronator shoes; and 12 (35\%) and 10 (33\%) of the feet wore regular shoes. In the Kite group, 3 patients had pain: one occasionally, one usually during vigorous activity, and one during walking. In the Ponseti group, 2 patients had pain: one occasionally and another usually during vigorous activity. 18 (86\%) and 19 (90\%) patients were pain-free, respectively. Treatment outcomes were fully satisfied in 15 (72\%) and 17 (81\%) patients, partially satisfied in 2 (10\%) in each group, and not satisfied in 4 (19\%) and 2 (10\%), respectively. Three (9\%) and 2 (7\%) of the feet had complications, respectively, including plaster sores secondary to skin allergies (n=3) and skin ulceration secondary to tight casts (n=2). None had neurovascular complications.

**DISCUSSION**

In the Kite method of manipulation and casting, the equinus is corrected after full correction of forefoot adduction and heel varus. The foot is never stretched beyond a neutral position. Pressure on the calcaneocuboid joint acts as a block to the corrective force. In the Ponseti method, deformity is corrected by gradually abducting the foot held in supination. The equinus is not corrected until the anterior end of calcaneus abducts and gradually everts from underneath the talus, followed by its eversion and dorsiflexion.\(^{12,13}\) Unlocking of the calcaneus from the talus requires hyper-abduction of the forefoot and calcaneus around the head of talus, which acts as the fulcrum. This hyper-abduction around the head of talus results in severe stretching of medial and plantar contractures and therefore early correction.

In the Ponseti method, the equinus is mostly corrected by percutaneous tenotomy of the Achilles tendon, resulting in greater maximum ankle dorsiflexion. Under microscopy, the bundles of collagen fibres show a wavy appearance (known as crimp) that can be stretched for deformity correction and reappears after a week for further stretching. As collagen fibres of the Achilles tendon are normal (as opposed to being abnormal in most of contractures), they are less readily stretched and require tenotomy to correct the equinus.\(^{14}\)

The Ponseti method required fewer casts and shorter duration of casting to achieve correction. Tenotomy of the Achilles tendon did not decrease its power and enabled better ankle dorsiflexion. The incidence of residual deformity and recurrence was also lower using the Ponseti method.
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