Reverse "Ponseti" Casting in Treatment of Congenital Vertical Talus

A Clinical Trial

Abstract

**Background:** The most common method of treatment for vertical talus is the extensive soft tissue release. A minimally-invasive method based on Dobb's serial casting (Reverse Ponseti) was introduced 15 years ago and has yielded significant results. The aim of this study was to investigate and compare the mid-term results of Casting with the extensive soft tissue release method.

**Methods:** 12 patients with vertical talus were included in a prospective study, 6 patients with 10 feet were treated with reverse ponseti, and 6 other patients with 10 feet with extensive soft tissue release. In an 18-24 months follow-up the results were compared together, using ankle range of motion, oxford questionnaire, and radiographic measurements.

**Results:** The mean range of ankle motion was comparable in the two groups (p=0.35), the oxford questionnaire score was not statistically different between the two groups (p=0.876).

**Conclusion:** With the comparable results between the "reverse-ponseti" casting land extensive surgical releases in this mid-term study, the casting technique is recommended because of its lower cost and non-invasive nature.

**Keyword:** Foot Deformities, Congenital, Flatfoot, Minimally Invasive Surgical Procedures

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Introduction

Congenital convex pes valgus or congenital vertical talus (CVT) is an uncommon congenital foot deformity happening in 1 out of 10,000 live births. CVT is one of the main causes of rigid flatfoot in newborns (1). Rigid talonavicular joint dislocation is the hallmark (inflexible in the sole of the foot with no arch) of CVT, accompanied by non-flexible equinus. In this structural abnormality, the convex plantar surface of the foot creates a rocker-bottom appearance (2). It occurs as an isolated deformity in half of patients and is associated with neuromuscular and genetic disorders in the rest (1, 3, 4).

There is bilateral involvement in half of CVT patients, and there is no gender predilection (5). As the heels do not touch the ground, the push-off from the floor is poor and talar head acts as a weight-bearing structure, resulting in painful callosity in this region (6-8).

Evidence shows that skeletal muscle contracture is a source of CVT development (9-12). The navicular bone articulates with the dorsal surface of the talar neck which is not a usual articular surface. The anterior surface of the navicular bone is tilted toward plantar aspect. The head of talus is linear on the surface and ovoid at length. Relative to talus, calcaneus is displaced postero-laterally and is positioned in contact with the distal end of fibula. MRI shows a clear lateral displacement of the anterior calcaneus relative to the head of talus, as well as calcaneus translation in the subtalar joint, which is typically accompanied by eversion (13).
The anterior peroneal and tibialis tendons are taut. Foot is at the valgus position with an external rotation. The navicular bone is at the neck of talus and is palpable. It is tangled with the anterior surface of tibia. Despite some flexibility, passive correction of the foot deformity is impossible\(^1\)\(^4\)\).

The measurable angles in the lateral view include talocalcaneal, tibiocalcaneal, tibiotalar and talar axis-first metatarsal angles. In the lateral view, talus is located vertically and is almost always parallel to the tibia. Calcaneus is at the equinus position with an increased talocalcaneal angle. In the forced dorsiflexion view, talus and calcaneus are plantarflexed. Hindfoot fixed equinus deformity is shown by decreased tibiocalcaneal angle\(^1\)\(^3\)\(^,\)\(^4\)\).

There are various strategies for treating vertical talus. Type of treatment depends on the patient's age, deformity severity, and surgeon's preference. Children under the age of three years usually undergo one-stage or two-stage open reduction of the talonavicular joint. Similar to clubfoot casting, treatment starts with serial manipulation and casting\(^1\)\(^5\)\). Casting treatment, had not been used as a definitive treatment for vertical talus until recently\(^1\)\(^6\)\).

This minimal invasive method is a new method with good result in some studies and is low cost. Low complication strategy, but because heterogeneity in patient and rarity of this condition the studies are limited\(^1\)\(^5\),\(^1\)\(^7\),\(^1\)\(^8\)\). This study aimed to evaluate the early results of this new growing method, and compare it with the traditional surgical treatment.

**Methods**

First this study was approved by the Medical Ethics Committee of Mashhad University of Medical Sciences (ethical approval code number: IR.MUMS.fm.REC.1394.478) in 2014, then we began a clinical trial on patients with CVT in Emam Reza Hospital in Mashhad university of medical sciences. The cases of vertical talus referring to author's clinic were successiraly treated with either "Reverse Ponseti" casting only classic surgical technique. The patients were then evaluated by an 18-24 months follow-ups both clinically and radio graphically. Measurement of mention of foot and ankle, was done, Oxford Foot and ankle questionnaire (Parent 2008 revision) were completed for all the cases\(^1\)\(^8\)\). On radiographic talus-first metatarsal base angles, and tibiocalcaneal angles were measured. The pre-treatment and post treatment results were compared and analyzed. Inclusion criteria were as follows:

1. Sustained talonavicular dislocation (talar axis first metatarsal base angle >35° on lateral plantar flexion X-ray)
2. Age< 4 years

Exclusion criteria were any patient with less than 18 months follow up for any reason, no confirmatory lateral radiography in extreme plantar flexion for vertical talus diagnosis. The parents were informed about these two methods and they knew that "reverse ponseti" is much less invasive. After we received written consent form for each patient, children were randomly allocated to one of the groups. In case of bilateral CVT both feet underwent same treatment method.

Talus first metatarsal base angle, talocalcaneal angle and tibiocalcaneal angle were evaluated in radiographic image preoperative and postoperatively. 10 “< degree of normal talonavicular angle and loss of talonavicular reduction in post-operative lateral x-rays defined as failure.

Oxford Foot and Ankle Questionnaire (parent version 2008) were used for outcome measurement\(^1\)\(^9\)\).

Serial Casting "Technique of Serial Casting"

Correction via manipulation and casting is based on the gradual reduction of talonavicular joint. If possible, treatment should start in the first few weeks of life. Similar to Ponseti method for clubfoot\(^2\)\(^0\),\(^2\)\(^1\), treatment starts with weekly manipulation and casting; however, the forces are applied in the opposite direction (called "reverse Ponseti method"). Casting can be performed in outpatient clinics and does not require hospitalization. All deformity components, except hindfoot equinus, are corrected at the same time; hindfoot equinus is corrected in the last stage\(^2\)\(^2\)\^-\(^2\)\(^6\).
In the first stage, short-leg casting is applied from the tip of the toes to below the knee, planter flexing the forefoot. It is necessary to mold underneath the head of the talus and around the malleoli. The foot should be in the corrective position during casting. After the plaster is dried, long-leg casting is applied at 90° of knee flexion. Typically, four to six plaster changes weekly are sufficient for talonavicular joint reduction. The foot position in the final casting for talonavicular reduction should be at maximum plantar flexion and inversion to ensure sufficient stretching of contracted dorsolateral tendons and soft tissues. The foot in this position seems similar to the position of clubfoot. A lateral foot radiograph should be taken in this cast to ensure talonavicular reduction. As the navicular bone is not ossified in infants, reduction should be done indirectly by the talar axis-first metatarsal base angle. If the talonavicular joint and navicular bones are reduced in the lateral view, blind pining is applied in the talonavicular joint to maintain reduction plus percutaneous Achilles tenotomy. In the operating room, the foot is positioned in plantar flexion and inversion to keep the talonavicular joint reduced. A Kirschner wire is placed retrograde into the talus. The wire is cut and placed underneath the skin to prevent its backing out. Successful wire placement depends on the surgeon's skill in palpating the talus and navicular bone. Radiographs can indirectly confirm the reduction of talonavicular joint; however, they cannot visualize the navicular bones. After the talonavicular joint is reduced and fixed with the Kirschner wire, percutaneous tenotomy of the Achilles tendon is performed to correct the residual equinus deformity. Statistical analysis was performed using SPSS v.24 software with paired sample t test and t test.

**Results**

Out of 22 patients with vertical talus, 18 patient met the criteria and agreed to participate in the study. They were randomly allocated to 2 groups. From the 9 patients in each group, 3 patients from Group 1 and 3 patients from Group 2 dropped out (Fig1). In first group the intervention was reverse ponseti serial casting in addition to minimal surgery while patients in second group underwent extensive surgery method (open reduction and surgical realignment).

Twenty feet completed the follow-up (ten feet and six patient in each group). The mean age at diagnosis and mean age of treatment was 1.08, 9.58 months. 3 patients had right foot involvement, one patient left side and 8 patients bilateral involvement. Family history of CVT was positive in seven children. Accompanying disease is listed in Table 1. Mean follow –up was 25 months. Mean talocalcaneal angle before surgery was 62.5° (range 48°-72°) at final follow-up it was 30.5° (range 24°-58°). Talus first metatarsal base angle was 76.5° (range 62°-91°), post-operative assessment showed mean 5.5° for this angle (range: -4°-14°). Mean tibio -calcaneal angle was 52°,38° post and preoperative. All above mentioned angles showed significant improvement (p value <001) post operatively in both groups but the difference between two groups was not significant (P value=0.339). Major complication was not recorded. One patient experienced skin breakdown following second cast application.

Post-operative Oxford questionnaire scored higher in "reverse ponseti" group (P=0.005), When we compared the Oxford score change postoperatively no significant difference existed between both groups (P=0.661) Ankle range of motion at final follow-up was compared between the two groups and the difference was not statistically significant (P=0.35) In "Reverse ponseti" group treatment protocol was including4-6 times serial manipulation and weekly casting according to Dobb's method and then at final cast percutaneous Achilles tendon lengthening in addition to fluoroscopy guided percutaneous talonavicular fixation with K-wire. The final cast and k-wire kept in place for one month. In "extensive surgery" group was protocol including posterior subtalar and ankle capsulotomy and release of contracted structures such as calcaneofibular ligament in addition to talonavicular and calcaneocuboid capsulotomy and talonavicular realignment.

| Table 1. Accompanying disease in our patients with vertical talus |
|-----------------------|---------|
| Accompanying disease | No.    |
| Club foot             | 1       |
| DDH##                | 1       |
| VSD##                | 1       |
| Arthrogriposis       | 1       |
| Myelomeningocel      | 1       |
| Phocomelia           | 1       |

developmental dysplasia of hip ventricular septal defect
In general there was no deference in results between the two groups, but due to less cost and less invasiveness minimal invasive method can be used instead of extensive surgery. The aim behind the minimal invasive treatments of vertical talus was achievement of a more flexible functional foot\textsuperscript{(16,25)}. Earlier experience with serial and manipulation was unsuccessful, so for decades extensive surgery was treatment of choice\textsuperscript{(2, 8, 15, 17, 18)}. Unfortunately, rate of complications with these extensive surgeries is high. Surgical site skin complications, avascular necrosis of the talus, insufficient correction, ankylosis and pseudoarthrosis are the main components of complication list. Furthermore, when these children grew up to adolescent they frequently need subtalar or even triple arthrodesis\textsuperscript{(27, 28)}.

It seems that first attempt of modern method of minimally invasive treatment of CVT is a series of seven patients studied by Seimon et al.\textsuperscript{(17)}. Their method included a dorso lateral approach and tenotomy of extensor tendons. Early functional results of their series were excellent. In our cases, extensor tenotomy via dorsolateral approach was skipped. Early results of Dobb’s series was promising\textsuperscript{(16,29)}. In a study for minimal invasive surgery method in club foot by Hallaj et al results was good\textsuperscript{(30)}. In Eberhardt study early result was excellent but they had about 15% relapse\textsuperscript{(31)}. In a recent study Aslani reported successful treatment of Dobbs method after two year follow-up\textsuperscript{(32)}. Our treatment protocol is similar to this study but they didn’t have a control group. Also they applied this method to older children (up to 9 years) and reported favorable result and there was no difference between syndromic and idiopathic type. Two other studies with limited cases presented the Dobb’s efficacy in CVT\textsuperscript{(33,34)}.

Our restriction in this study were small sample size of cases and short term follow-up. Preliminary result of “reverse ponseti” was encouraging and comparable to traditional extensive surgical release. However, high level studies with greater sample size and long term follow-up is needed to change the standard treatment of CVT.

Conflict of interest
There was no conflict of interest.