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Subtalar Release in Clubfeet: A Retrospective Study of 10-Year Outcomes

R. Frank Henn III, M.D.; Dennis C. Crawford, M.D., Ph.D.; Craig P. Eberson, M.D.; Michael G. Ehrlich, M.D.
Providence, RI

ABSTRACT

Background: **Optimal management of congenital talipes equinovarus continues to be controversial. There is a dramatically renewed emphasis on non-operative management partly because there has been a high recurrence rate among operated feet. Our hypothesis is that early, extensive subtalar ligament release as the cornerstone of aggressive hindfoot realignment prevents recurrence and retains mobility.** ***Materials and Methods:*** **Twenty-two congenital clubfeet (14 patients) corrected by one surgeon were evaluated using two validated patient-based outcome instruments, dynamic pedobarographic analysis, hindfoot mobility, and weightbearing radiographs. Pedobarographic analysis consisted of quantifying peak plantar forces and pressures during the gait cycle in 22 corrected feet and 24 control feet using the FSCAN in-shoe device.** ***Results:*** **The mean age at surgery was 8 months and mean followup was 10 years. No patients experienced recurrence of deformity. Reported foot function and satisfaction were very high for all patients and were comparable to reported normal population values. AP and lateral talocalcaneal angles for each foot were within normal limits for age. Hindfoot range of motion, including dorsiflexion, was preserved in all feet. Peak regional forces throughout the gait cycle and plantar pressures at foot flat were mildly, but statistically significantly, higher in the midfoot of corrected feet suggesting slight flattening of the arch. One patient had tendon transfers for bilateral calcaneal deformity and one patient had surgical correction of a bilateral valgus deformity.** ***Conclusion:*** **Aggressive hindfoot realignment provides definitive treatment of an equinovarus deformity, but care must be taken to avoid overcorrection.**

INTRODUCTION

Optimal management of congenital talipes equinovarus continues to be controversial. A recent multicenter study demonstrated substantial variability in the treatment methods utilized by members of the Pediatric Orthopaedic Society of North America (POSNA).[9] However, nearly all orthopaedic surgeons agree that the initial treatment of clubfoot should be nonoperative, consisting of serial casting with some type of manipulation. A successful course of serial casting is then typically maintained by foot bracing for several years. Supplementing the serial casting with a percutaneous heel cord tenotomy is a common practice, and is a prominent component of the well-known Ponseti method. The encouraging reports of improved success of conservative treatment with or without heel cord tenotomy in up to 97% of idiopathic clubfeet has stimulated increased interest and utilization of a more conservative approach.[15,19] However, cases that are refractory to conservative management still require surgical correction. Data from the POSNA survey published in 2003 suggests that over 50% of idiopathic clubfeet are ultimately treated with a comprehensive release.[9] The overall recurrence rate after surgical correction in the survey was 15.6%, but has been reported in some series to be as high as 40%.[21]

The purpose of this study was to comprehensively evaluate a series of clubfoot patients who were refractory to nonoperative management and underwent the same corrective procedure performed by a single senior surgeon (MGE). Our hypothesis was that failure to perform an extensive subtalar release fails to correct the abnormal talocalcaneal relationship and thereby leads to recurrence. Our aggressive hindfoot realignment prevents clubfoot recurrence and results in a more functional foot.

MATERIALS AND METHODS

Between May 1989 and December 1994, 44 patients underwent clubfoot surgery by the senior author. Of these 44 patients, 15 had no previous surgical procedures and had no underlying neuromuscular disorders such as spina bifida nor arthrogryposis. We were able to obtain followup data on 14 of 15 patients (93%). Thus, our study population consisted of 22 surgically naive idiopathic congenital clubfeet in 14 patients (10 males and 4 females) that underwent surgical correction by the senior author between 1989 and

Corresponding Author:
Michael G. Ehrlich, M.D.
Rhode Island Hospital
Department of Orthopaedics
Providence, RI 02903
E-mail: Michael_Ehrlich@Brown.edu

1994. Each clubfoot had failed initial conservative treatment, which usually consisted of at least 3 months of serial casting. Patients were selected for surgery after 3 months of casting, when the calcaneus was still directly under the talus and the foot inverted with dorsiflexion. Without normal eversion, the foot was also in a variable degree of equinus.

Each foot was corrected using the same operative technique. A standard posteromedial approach was utilized for exposure, and the Achilles, tibialis posterior, flexor digitorum longus, and flexor hallucis longus tendons were each z-lengthened. The spring ligament, talonavicular capsule, and superficial deltoid ligament were sequentially released. All subtalar interosseous ligaments were then released after opening the subtalar joint medially. After release of the interosseous ligaments, the lateral calcaneofibular ligaments were released through the subtalar joint. The calcaneus was then easily disengaged from the talus, and the foot was pinned in anatomic alignment with talonavicular and talocalcaneal Kirschner wires. Intraoperative radiographs confirmed reduction and Kirschner wire placement. The 4 tendons were each repaired, the wound was closed, and the extremity was placed in a long leg cast. The cast and pins were removed under anesthesia 3 months later.

Our comprehensive method of followup evaluation included a patient-based outcome assessment, physical examination, weightbearing radiographs, and gait based pedobarographic analysis. The study was approved by the Institutional Review Board.

Patient-based outcome assessment was performed by using the "Pediatric" and "Foot and Ankle" outcome instruments produced by the American Academy of Orthopaedic Surgeons.[10] The parents completed the "Pediatrics-Parent/Adolescent" questionnaire, and the patients completed the "Pediatrics-Adolescent" and "Foot and Ankle" questionnaires. The results were compared to published normal values from the general population. In addition to the AAOS questionnaires, parents were queried regarding satisfaction, comorbiditities, and additional treatment of the corrected foot.

Standard weightbearing AP and lateral radiographs of each foot were obtained. All measurements of radiographs were made by the same examiner. The AP and lateral talocalcaneal angles were measured using the same plastic goniometer.[17] Angles were compared to the normal ranges reported by Vanderwilde et al.[22]

Hindfoot range of motion was evaluated using the same standard goniometer with the patient prone with the legs extending off the edge of the bed by the same examiner.[5,6] Subtalar joint motion was assessed by measuring the angle between the sagittal midline axis of the posterior calcaneus and the sagittal midline of the posterior lower leg with the heel in full inversion and eversion. The mean of 3 measurements was recorded for both passive inversion and eversion, and active inversion and eversion. Ankle range of motion was measured on the lateral side of the foot with the patient in the same position. The goniometer was used to measure the angle between the longitudinal axis of the fifth metatarsal and the coronal midline axis of the lateral leg in full dorsiflexion and plantarflexion. The mean of three measurements for both active and passive motion was recorded for each foot.

Peak plantar forces and pressures during the gait cycle were assessed in all corrected feet and compared to 24 control feet using the Fscan in-shoe pressure monitoring system (Tekscan, Boston, MA).[2,12] The control population was composed of 4 "normal" contralateral feet of patients with unilateral corrections and 20 feet from 5 male and 5 female volunteers with no history of foot pathology or surgery. The average age of the control population was 14.6 years. All subjects underwent the same protocol. An ultrathin (1.8 mm) flexible pressure sensitive in-sole was trimmed to match the plantar surface of each foot. The sensor was then placed in the subject's usual footwear and connected by wire to a transducer and a PC compatible computer with F scan version 4.12 software. A custom belt ensured that the connecting wires did not encumber the subject's feet during gait. Each subject was then weighed on the same standard scale, and the sensors were calibrated to the subject's body weight. Each subject was asked to walk a distance of 10 meters to the end of a straight hallway. No attempt was made to influence the subject's gait pattern or rate of ambulation. Pedobarographic data from 3 consecutive steps, excluding the first step for each foot, was analyzed by region. The area of each foot was divided into 6 regions, which included the forefoot (distal 1/3), midfoot (mid 1/3), and hindfoot (proximal 1/3) on the medial and lateral sides. Division of the foot into medial and lateral regions was accomplished by drawing a line bisecting the widest area of the heel and forefoot.[20] We quantified the peak regional forces throughout the gait cycle as well as the relative plantar pressure in the medial midfoot region at foot flat, which was defined as the moment of greatest plantar contact area. The peak regional forces and relative medial midfoot pressures in corrected feet were compared to the control feet.

Statistical analysis was performed with aid of a statistician using STATA 7.0 (STATA corp, College Station, Tx). Statistical comparisons were made using two-tailed t-tests. P-values less than 0.05 were considered statistically significant.

RESULTS

The average age at surgery was 8 (range, 3.5 to 28) months, and mean followup was 10 (range, 6 to 13) years. There were no perioperative complications, and no patients experienced recurrence of their deformity. Two female patients who both underwent bilateral corrections subsequently developed bilateral deformities that required additional surgery. One patient operated on at 9 months of age developed bilateral calcaneal feet that were managed

by transfer of the tibialis anterior tendon posteriorly. The calcaneal deformities were most likely caused by overlengthening of the heel cord. The oldest patient at the time of clubfoot correction (28 months) required subsequent surgical correction of bilateral planovalgus deformities.

Reported foot function and satisfaction were very high for all patients and parents. All parents considered the procedure(s) to be a success, including the parents of the two children who required re-operation. All parents indicated they would elect to undertake the procedure again. All patients indicated they would be satisfied with living out their lives with the condition of the foot at the time of followup. All but one patient participated in competitive sports, and no feet required orthotics at the time of followup.

The mean scores for 5 subscales of the AAOS outcome instruments are shown in Table 1, along with the published normal values from the general population.[10] The overall global scores of patients on the "Pediatrics-Parent/Adolescent" and "Pediatrics-Adolescent" questionnaires were greater than 90 on a 100-point scale, and were not significantly different from population controls ($p > 0.05$). In contrast, the scores for the three subscales of the "Foot and Ankle" questionnaire were significantly better than the reported normal population values ($p < 0.0001$).

Hindfoot range of motion was preserved in all corrected feet, and the mean values for active and passive motion are given in Table 2. The average active range of motion was consistently less than the mean passive range of motion. Of note, all feet could be actively dorsiflexed past neutral and each patient was observed walking on their heels without difficulty. In addition, each patient could walk on their toes without evidence of heel sag.

The mean AP talo-calcaneal angle on the weightbearing radiographs was 23.2 ± 3.5 degrees and the mean lateral talo-calcaneal angle was 36.2 ± 6.1 degrees (Table 3). Both the AP and lateral talo-calcaneal angles for each corrected foot were within normal limits for their age.[4] There were no cases of navicular subluxation, flat top talus, or talar osteonecrosis.

Table 2: Hindfoot range of motion

	Mean Passive ± SD	Mean Active ± SD
Inversion	$28.4 \pm 5.7^\circ$	$19.4 \pm 6.4^\circ$
Eversion	$17.0 \pm 8.0^\circ$	$10.7 \pm 4.5^\circ$
Subtalar Motion†	$45.4 \pm 8.0^\circ$	$30.1 \pm 9.3^\circ$
Plantar flexion	$37.7 \pm 10.4^\circ$	$34.2 \pm 9.3^\circ$
Dorsiflexion	$15.3 \pm 7.6^\circ$	$9.2 \pm 7.5^\circ$

Values are expressed in degrees (°) ± standard deviation (SD).
†Subtalar motion is the sum of inversion and eversion motion.

Table 3: Weightbearing radiographic AP and lateral talo-calcaneal angles

	Mean Angles ± SD
Mean AP Talo-calcaneal Angle	$23.2 \pm 3.5^\circ$
Mean Lateral Talo-calcaneal Angle	$36.2 \pm 6.1^\circ$

Values are expressed in degrees (°) ± Standard Deviation.

Figure 1 is a representation of the pedobarographic data obtained from a typical corrected and control foot at foot flat. The two-dimensional map represents the pressure gradient on the plantar surface in greytones that correspond to kilopascal ranges. The pressure ranges are comparable in the corrected and control feet, but slightly more pressure is evident in the medial-midfoot region of the corrected foot. Quantification demonstrated that the mean percentage of pressure in the medial midfoot relative to the entire midfoot was not significantly different between control and corrected feet ($p = 0.13$). However, the percentage of pressure in the medial midfoot relative to the entire foot

Table 1: AAOS outcome instrument scores

	Clubfoot Patients	Normative Population Values[7]	*p* Values
Pediatric-Adolescent Global Function	94.3 ± 6.3	95.9 ± 5.4	0.31
Pediatric-Parent/Adolescent Global Function	96.7 ± 3.8	95.2 ± 7.2	0.17
Foot and Ankle: Lower Limb	98.5 ± 2.9	90.5 ± 13.8	<0.001*
Foot and Ankle: Global Function	96.9 ± 4.5	93.2 ± 12.3	0.009*
Foot and Ankle: Shoe Comfort	96.3 ± 6.1	73.9 ± 29.5	<0.001*

Possible scores for each scale range from 0 to 100, with a score of 100 representing the best possible score and a score of 0 representing the worst possible score. The mean ± standard deviation (SD) is given for each score with the corresponding p value comparing the clubfoot and normative population values. * $p < 0.05$.

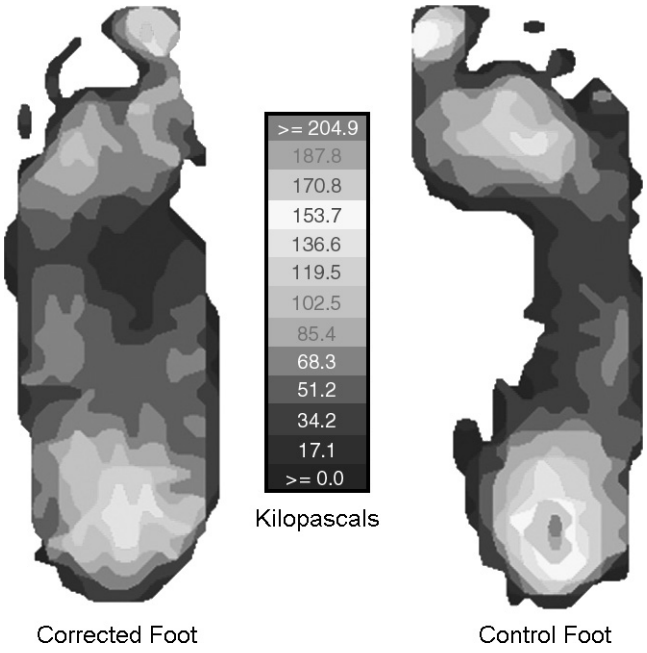

Fig. 1: Representative Plantar Pressure Map demonstrating a representative corrected foot on the left and control foot on the right. The plantar pressure maps for both feet were generated at foot flat. The corrected foot has more medial midfoot pressure than the control foot.

was 7 percentage points higher ($p = 0.001$) in corrected feet, which is consistent with slight flattening of the arch (Table 4).

The peak regional forces throughout the gait cycle and the mean peak force for each region were quantified for each foot (Table 5). The peak forces were comparable to control feet in the forefoot and hindfoot regions. However, the peak forces were 32 N higher ($p = 0.001$) in the medial midfoot and 23 N higher ($p = 0.002$) in the lateral midfoot regions of corrected feet. This also suggests slight flattening of the arch in the corrected feet.

DISCUSSION

Talipes equinovarus, or clubfoot, is one of the most common congenital musculoskeletal deformities. Clubfoot deformities are associated with multiple syndromes and neuromuscular conditions including spina bifida, arthrogryposis, dystrophic dwarfism, and Down syndrome.[14] However, the majority of clubfoot cases are idiopathic, with evidence of a multifactorial etiology from both genetic and environmental factors. The prevalence of idiopathic congenital clubfoot ranges between 0.64 and 6.8 per 1000 live births.[1]

This study demonstrates that extensive subtalar release with aggressive hindfoot realignment is often able to provide definitive correction of the equinovarus deformity that is refractory to conservative management. In addition, no further treatment, such as prolonged bracing, is required after removal of the pins. Howerver, 4 feet (18%) in 2 patients required additional surgery for problems stemming from overcorrection, including valgus deformities in the oldest patient. A similar rate of valgus complications was noted by Simons following complete subtalar release.[18] Consequently, care must be taken to avoid overcorrection, especially in the older patient.

There were no recurrences in this series, which differs from previous studies.[9,21] The overall recurrence rate in a recent multicenter study was 15.6%.[9] However, a recurrence rate of up to 40% was reported after staged surgical correction.[21] The re-operation rate in this series was 18%, which is comparable to previous series after comprehensive releases.[7] Haasbeek and Wright reported an average 1.5 operations per foot in the comprehensive release group, compared to an average of 2 operations per foot in the posterior release group.[7]

Patient-based outcome assessment is an important component of outcome analysis that has only recently been applied to the pediatric population. One group has reported the development of a disease-specific patient-based outcome instrument for clubfoot patients.[16] This study is the first to report outcome scores on the validated AAOS Pediatric and Foot and Ankle questionnaires in a population with surgically corrected clubfeet. We found that the patient scores on the pediatric questionnaire global score did not differ significantly from normal population controls. However, patients in this study had significantly better scores on the foot and ankle questionnaire compared to population controls. This

Table 4: Proportion of medial midfoot pressure at foot flat

	Control Feet	Corrected Feet	*p* value
Percentage of pressure in the medial midfoot relative to the entire midfoot	35.4 ± 10.0%	39.9 ± 10.2%	0.13
Percentage of pressure in the medial midfoot relative to the entire foot	7.5 ± 4.1%	15.0 ± 5.3%	0.001*

Values are expressed as a percentage (%) ± Standard Deviation.
* $p < 0.05$.

Table 5: Peak regional forces during the gait cycle

		Control Feet	Corrected Feet	P value
Forefoot	Lateral	92 ± 42 N	87 ± 29 N	0.06
	Medial	148 ± 42 N	118 ± 48 N	0.73
Midfoot	Lateral	60 ± 14 N	84 ± 31 N	0.002*
	Medial	27 ± 16 N	59 ± 24 N	0.001*
Heel	Lateral	137 ± 38 N	144 ± 50 N	0.68
	Medial	145 ± 41 N	149 ± 54 N	0.47

Values are expressed in Newtons (N) ± Standard Deviation.
* $p < 0.05$.

interesting finding may be due to the presence of foot and ankle pathology in the general population sample. There was no evidence of our patients having lower expectations and being more tolerant of minor aches and pains.

Pedobarographic analysis provides an objective method for evaluating the functional results of clubfoot correction.[4] To date, dynamic pedobarographic systems have been applied to two populations of surgically corrected idiopathic clubfeet. Hee and Lees studied 58 surgically corrected clubfeet at a mean of 5.5 years after surgery and found increased midfoot and forefoot pressures in corrected feet.[8] Huber and Dutoit evaluated 24 clubfeet treated with posterior surgical release at a mean of 40 years after surgery and found that pain correlated with lack of pronation movement with respect to the center of pressure in 5 of the 24 feet.[11] In addition, a similar system has been used to study the long-term results after surgeries for spastic equinovarus foot deformity which demonstrated that the proportion of the total pressure "impulse" of the foot during the gait cycle is significantly higher in the medial midfoot region relative to the entire midfoot in valgus feet and significantly lower in varus feet.[3] In the current study, we evaluated patients an average of 10 years after correction and found that the proportion of pressure at the time of foot flat in the medial midfoot relative to the entire midfoot was not significantly different in corrected clubfeet when compared with controls. However, slightly but statistically significantly more pressure was observed in the medial midfoot relative to the entire foot. Similarly, we found significantly higher peak force in the midfoot region of corrected feet. The increased medial midfoot pressure and peak force in the presence of normal talocalcaneal angles may be related to non-repair of the spring ligament. Nevertheless, the results of Hubert and Dutoit suggest that more medial distribution of midfoot pressure with gait pronation leads to better long term results.

Overall, we feel that for failures of conservative clubfoot management, extensive subtalar release is an effective treatment which eliminates under-correction and recurrence. However, care must be taken to avoid overcorrection, particularly in older patients.

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