Percutaneous Fixation in Clubfoot Surgery: a Radiographic and Gait Study

Jennifer Tareco, M.D.,* Debra A. Sala, M.S., P.T.,† David M. Scher, M.D.,†§ Wallace B. Lehman, M.D.,§¶ and David, S. Feldman, M.D.†§¶

*Pediatric Orthopedic Surgery, Children's Hospital of New Jersey, Newark Beth Israel Medical Center, Wewark New Jersey; †The Center for Children; §Pediatric Orthopaedic Surgery, Hospital for Joint Diseases New York University Hospitals Center and ¶Orthopaedic Surgery, New York University School of Medicine, New York, USA

Summary: Twenty patients with Type II clubfeet were evaluated an average of 3.1 years after complete surgical soft tissue release. A pinned group had fixation of the talonavicular and calcaneocuboid joints and a non-pinned group had no fixation. The control group consisted of 10 children without foot ailments. Radiographic measurements of talocalcaneal and talus–first metatarsal angles and frequencies of dorsal and medial navicular subluxation were not different for the two treatment groups. Foot progression angle was not significantly different for the two treatment groups, but was significantly different between all clubfoot patients (3.6° of in-toeing) and the control group (5.0° of out-toeing). Tourniquet time was significantly greater for the pinned than for the non-pinned group, but the duration of surgery was similar. Similar radiographic and gait measurement findings suggest that clubfoot surgery with and without percutaneous fixation have comparable outcomes. *J Pediatr Orthop B* **11:**139–142 © 2002 Lippincott Williams & Wilkins.

Key Words: Clubfoot—Percutaneous fixation.

Lehman described a classification system for clubfoot using the following grades: Type I clubfoot for postural clubfoot, Type II clubfoot for rigid clubfoot and Type III clubfoot for teratological clubfoot (9). In the past 20 years, most children with refractory Type II clubfeet underwent operative management. There are several opinions on the best method of surgical intervention. The options available in management include the type of surgical approach, the age of the patient at surgical release, the extent of release, the need for percutaneous fixation, and the type and duration of follow-up care.

Many studies have evaluated the outcomes in clubfoot treatment (1,2,4,5,8,13–15,21,22). Some have compared surgical and conservative treatment of clubfeet (6) and others have compared the results of different surgical approaches (7,11,12).

One surgical method involves using Kirschner wires (K-wires) to percutaneously fix the talonavicular and calcaneocuboid joints while the joint and tendon releases heal in the corrected position. Surgeons who use this internal fixation propose that holding the position of these joints rigidly is necessary to prevent residual or recurrent deformity of the foot. Surgeons who do not use K-wire fixation suggest that the alignment of the foot is maintained by the soft tissue release and post-operative cast, and that the use of K-wires adds the risk of infection, pain with pin removal and increased surgical time.

Only one study addressed the difference in feet that were internally fixated and those that were not (2). Atar et al. used a functional rating scale (3,10), developed at the Hospital for Joint Diseases, to compare the functional outcome of 21 patients with complete soft-tissue clubfoot release with internal fixation and 50 without internal fixation. At an average follow-up of 3 years, no statistically significant differences were found between the two groups.

The present study compared (1) physical examination findings and foot progression angle during ambulation in patients with clubfoot surgery with percutaneous fixation and those without fixation, (2) physical examination findings and foot progression angle in patients with clubfoot surgery and a control group, (3) radiographic findings of patients with

Address correspondence and reprint requests to Debra A. Sala, M.S., P.T., Room 310, Hospital for Joint Diseases, 301 E. 17th Street, New York, NY 10003, USA.

clubfoot surgery with percutaneous fixation and those without fixation, and (4) radiographic findings and foot progression angle of the treated clubfoot and the noninvolved foot of patients with unilateral clubfoot surgery.

METHODS

Twenty consecutive patients with a Type II clubfoot were retrospectively reviewed. A complete soft tissue release was performed as described by Lehman (9). A posteromedial incision was used releasing all posterior structures and medial structures with, if needed, a plantar release through the same incision, and an additional lateral incision, if needed, to release the calcaneocuboid joint. One of the surgeons in this study used K-wire fixation of the talonavicular and calcaneocuboid joints and the other surgeon did not. Ten patients whose clubfeet were pinned and ten whose clubfeet were not pinned returned for evaluation. The cases where pins were not used underwent a least one change of cast at 3 weeks to maintain proper alignment of the foot. All procedures were done between September 1994 and June 1997. Ten patients without foot disorders were assessed as the control group. The contralateral foot in each patient with a unilateral clubfoot was also evaluated as a control. In children with bilateral clubfeet, data from one foot were randomly chosen for the statistical analyses.

All of the patients with clubfeet underwent a physical examination that assessed (1) range of motion of the ankle/foot (dorsiflexion, plantarflexion, inversion, eversion), (2) strength of the ankle/foot (dorsiflexors, plantarflexors, invertors and evertors), (3) range of motion of the hip to assess femoral anteversion, and (4) tibial torsion. Femoral anteversion and tibial torsion were also evaluated in the patients in the control group.

Standing anteroposterior and lateral radiographs of both feet of only the patients with clubfeet were taken. Talocalcaneal and talus–first metatarsal (TMT) angles were measured on both the anteroposterior and lateral radiographs. Assessment of dorsal and medial subluxation of the navicular on the talus was measured as described by Simons (18). All radiographs were blinded and measured by the same pediatric orthopedic surgeon.

The tourniquet time and the duration of the surgery were compared for the two groups. Finally, each patient in the two treatment groups and each patient in the control group walked on the 12-foot walkway of the GAITRite System (CIR Systems Inc., Clifton, New Jersey, USA) which is a noninvasive system capable of measuring multiple spatial and temporal gait parameters. For this study, only the measurement of foot progression angle was used.

Data analysis involved using t-tests for independent samples to compare (1) the pinned with the non-pinned groups, (2) the clubfoot group (combined pinned and non-pinned groups) with the control group, and (3) the treated clubfoot with the noninvolved foot of the unilateral clubfoot cases. For all analyses, a significant P-value was below 0.05.

RESULTS

Fourteen of the patients had unilateral clubfoot and six had bilateral clubfeet. The age of the patients at the time of surgery was not significantly different ($t=1.11$; $P=0.28$) for the pinned (8.6 months) and the non-pinned (6.1 months) groups. The time to follow-up was not significantly different ($t=1.29$; $P=0.21$) between the two treatment groups with the average being 3.1years (range, 1.8–3.8 years) for all cases.

Post-operative care varied between the groups. The pinned group was in cast for significantly longer ($t=-4.33$; $P<0.001$) than the non-pinned group (7.8 versus 6.0 weeks). All of the pinned group used ankle–foot orthoses while in the non-pinned group, three used ankle–foot orthoses, three used Denis-Browne bars, and four used Denis-Browne bars and ankle–foot orthoses. The pinned group used bracing for significantly less time ($t=2.85$; $P=0.01$) than the nonpinned group (10.7 versus 17.4 months).

The findings from the physical examination revealed no significant differences in range of motion of the ankle/foot, strength of ankle/foot musculature, femoral anteversion or tibial torsion between the two treatment groups.

The means, standard deviations and the results of the t-tests of the radiographic measurements of anteroposterior and lateral talocalcaneal and TMT angles for each of the treatment groups are presented in Table 1. The treated clubfoot and noninvolved foot of the patients with unilateral clubfoot are presented in Table 2. The measurements of talocalcaneal and TMT angles from both views were similar for the two treatment groups. In the unilateral patients, the treated foot and the noninvolved foot differed significantly in the anteroposterior and the lateral talocalcaneal angles, and the lateral TMT angle, but not the anteroposterior TMT angle.

The frequency of dorsal subluxation of the navicular on the talar head was similar in the treatment groups, with two patients subluxed in the

TABLE 1. *Radiographic measurements for two treatment groups*

Angle	Pinned group (°)		Nonpinned group (°)	
	Mean	SD	Mean	SD
AP TC	23.4	11.0	18.8	12.2
AP TMT	8.6	12.5	0.0	12.9
Lat TC	28.7	5.9	23.9	8.0
Lat TMT	5.6	8.0	11.3	10.1

AP, anteroposterior; TC, talocalcaneal; TMT, talus–first metatarsal; Lat, lateral.

TABLE 2. *Radiographic measurements for unilateral clubfoot cases*

Angle	Treated foot (°)		Non-involved foot (°)	
	Mean	SD	Mean	SD
AP TC	20.6	13.2	29.9	4.2*
AP TMT	5.9	14.9	3.5	10.6
Lat TC	25.5	7.8	37.8	9.0**
Lat TMT	9.4	10.4	−8.4	14.9**

AP, anteroposterior; TC, talocalcaneal; TMT, talus–first metatarsal; Lat, lateral. *$P<0.05$; **$P<0.01$.

pinned group and one subluxed in the non-pinned group. The frequency of medial subluxation was similar for the two groups, with one in the pinned and two in the non-pinned groups. Other abnormalities included flat top talus in one patient in each group, and skewfoot, which is related to undercorrection of the midfoot and overcorrection of the hindfoot, in one patient in the pinned group and two patients in the non-pinned group. None of these cases required revision surgery.

Tourniquet time was significantly greater ($t=-4.18$; $P=0.001$) in the pinned group (81.5 min) compared with the non-pinned group (58.4 min). However, the duration of the surgery was not significantly different ($t=1.41$; $P=0.18$) for the pinned (113 min) and the non-pinned (124 min) groups.

The comparison of the clubfoot group (combined pinned and nonpinned groups) with the patients in the control group demonstrated a significant difference ($t=-2.14$; $P=0.04$) between the clubfoot group (3.7 years) and the control group (4.3 years) in age at the time of the evaluation. In terms of femoral anteversion, the clubfoot group had significantly greater ($t=2.49$; $P=0.02$) external rotation and significantly less internal rotation ($t=-2.13$; $P=0.04$) than the control group. Tibial torsion was not significantly different ($t=-1.95$; $P=0.06$) for the clubfoot and the control groups.

The foot progression angle during ambulation was not significantly different ($t=-0.94$; $P=0.36$) between the two treatment groups. However, both groups demonstrated in-toeing with the pinned group exhibiting 4.7° and the non-pinned 2.3° of in-toeing. A significant difference ($t=-3.76$; $P=0.001$) was found between the clubfoot group (3.6° of in-toeing) and the control group (5.0° of out-toeing). In patients with unilateral clubfoot, a significant difference ($t=-3.92$; $P=0.002$) was found between the treated foot (3.7° of in-toeing) and the non-involved foot (4.5° of out-toeing).

DISCUSSION

Surgical treatment of the Type II clubfoot is sometimes more of a religion than a science. Most surgeons believe very strongly in their technique without much hard data to support their belief. Our goal in this study was to evaluate one component of the surgical technique: whether or not to percutaneously fix the talonavicular and calcaneocuboid joints with K-wires.

In reviewing the literature, only one study examined complete soft tissue release with and without internal fixation. Atar et al. (2) found no significant difference between the two treatment groups in functional outcome at an average of 3 years follow-up. Our findings, involving radiographic and gait measurements, concurred with these authors in finding no statistical difference between those patients who had K-wire fixation of the talonavicular and calcaneocuboid joints and those who did not.

Interestingly, a subsequent study by Atar et al. (4) evaluated 45 clubfoot releases without internal fixation and found that 48% had dorsal subluxation of the navicular on the head of the talus. They postulated that possibly internal fixation could prevent this problem. Schlafly et al. (16) studied 52 clubfeet that had undergone complete surgical release with wire fixation of the talonavicular joint. They found 44.2% subluxation of the navicular on the talus. Our comparison of navicular position on the talar head showed a similar frequency for the two treatment groups in the occurrence of dorsal and medial subluxation of the navicular on the talar neck. However, both types of subluxations occurred in only 10–20% of our cases, which is less than half of that previously reported.

This study found no difference in the foot progression angle between the pinned and the non-pinned groups, but both groups ambulated with in-toeing of the treated clubfoot. However, a difference was demonstrated between the surgically treated clubfeet and the controls. A difference was also found between the surgically treated clubfoot and the contralateral noninvolved foot in the unilateral clubfoot cases. Since our findings of in-toeing did not relate to the existence of anteversion, the in-toeing is probably due to residual clubfoot.

Several authors (17,19,20) have reported normal ranges of values for the radiographic angles measured. Since all of the angles were not significantly different for the two treatment groups, the means of these angles for the combined clubfoot group were compared with these normal ranges in Table 3. The anteroposterior talocalcaneal, lateral talocalcaneal, and lateral TMT angles were within the normal range (of at least one of these authors' ranges). The anteroposterior TMT angle was outside of the normal range. As the value of this angle (4.3°) indicates the presence of midfoot adduction in this group of patients, this abnormality could account for the in-toeing recorded during ambulation.

Tourniquet time was significantly increased in the feet that underwent percutaneous pinning because the tourniquet was released only after the pinning was completed. However, overall operative time was similar for both groups. There were no post-operative

TABLE 3. *Angle measurements for clubfoot group and normal ranges*

Angle	Normal ranges (°)				
	Clubfoot group (°)		Simons (17)	Tachdjian (19)	Thompson and Simons (20)
	Mean	SD			
AP TC	21.1	11.5	20–40	20–50	20–40
AP TMT	4.3[a]	13.1	0 to −20	0 to −20	
Lat TC	26.3	7.2	35–55	25–50	35–50
Lat TMT	8.5	9.3			0–20

AP, anteroposterior; TC, talocalcaneal; TMT, talus–first metatarsal; Lat, lateral.
[a]Outside of normal range.

complications related either to the K-wires or the increased tourniquet time.

In conclusion, the question of whether or not to percutaneously fix the talonavicular and calcaneocuboid joints in soft tissue release of the clubfoot is, as expected, difficult to answer. We could not demonstrate a difference in the radiographic measurement of the foot angles, navicular subluxation, or the foot progression angle between the two treatment groups. No peri- or post-operative complications occurred in either group. Longer follow-up and a greater number of patients in both groups would be necessary to strongly advocate either method, but our current feeling is that based on the parameters used in this study, percutaneous pinning of the talonavicular and calcaneocuboid joints provides no additional benefit.

REFERENCES

1. Aronson J, Puskarich CL. Deformity and disability from treated clubfeet. *J Pediatr Orthop* 1990;10:109–19.
2. Atar D, Lehman WB, Grant AD. Complete soft-tissue clubfoot release with and without internal fixation. *Orthop Rev* 1993;22:1015–6.
3. Atar D, Lehman WB, Grant AD, Strongwater AM. Fractional lengthening of the flexor tendons in clubfoot surgery. *Clin Orthop* 1991;264:267–9.
4. Atar D, Lehman WB, Grant AD, Strongwater A. Tarsal navicular position after complete soft-tissue clubfoot release. *Clin Orthop* 1993;295:252–8.
5. Brand RA, Laaveg SJ, Crowninshield RD, Ponseti IV. The center of pressure path in treated clubfeet. *Clin Orthop* 1981;160:43–7.
6. Cooper DM, Dietz FR. Treatment of idiopathic clubfoot. (A thirty year follow-up note). *J Bone Joint Surg Am* 1995; 77A:1477–89.
7. Haasbeek JF, Wright JG. A comparison of the long-term results of posterior and comprehensive release in the treatment of clubfoot. *J Pediatr Orthop* 1997;17:29–35.
8. Karol LA, Concha C, Johnston CE. Gait analysis and muscle strength in children with surgically treated clubfeet. *J Pediatr Orthop* 1997;17:790–5.
9. Lehman WB. *The clubfoot*. Philadelphia: JB Lippincott, 1980.
10. Lehman WB, Atar D, Grant AD, Strongwater AM. Functional rating system for evaluation of long-term results of clubfoot surgery. In: Simons GW, editor. *The clubfoot: the present and a view of the future.* New York: Springer-Verlag, 1994. pp. 114–6.
11. Magone JB, Torch MA, Clark RN, Kean JR. Comparative review of surgical treatment of the idiopathic clubfoot by three different procedures at Columbus Children's Hospital. *J Pediatr Orthop* 1989;9:49–58.
12. Nimityongskul P, Anderson LD, Herbert DE. Surgical treatment of clubfoot: a comparison of two techniques. *Foot Ankle* 1992;13:116–24.
13. Otis JC, Bohne WHO. Gait analysis in surgically treated clubfoot. *J Pediatr Orthop* 1986;6:162–4.
14. Porat S, Kaplan L. Critical analysis of results in clubfeet treated surgically along the Norris Carroll approach: seven years of experience. *J Pediatr Orthop* 1989;9:137–43.
15. Porter RW, Youle K. Factors that affect surgical correction in congenital talipes equinovarus. *Foot Ankle* 1993;14: 23–7.
16. Schlafly B, Butler JE, Serwin JS, Criswell AR, Cain TE. The appearance of the tarsal navicular after posteromedial release for clubfoot. *Foot Ankle* 1985;5:222–37.
17. Simons GW. Analytical radiography of clubfeet. *J Bone Joint Surg Br* 1977;59B:485–9.
18. Simons GW. Complete subtalar release in clubfeet: comparison with less extensive procedures. *J Bone Joint Surg Am* 1985;67A:1056–65.
19. Tachdjian MO. *The child's foot*. Philadelphia: WB Saunders, 1985.
20. Thompson GH, Simons GW III. Congenital talipes equinovarus (clubfeet) and metatarsus adductus. In: Drennan JC, editor. *The child's foot and ankle.* New York: Raven Press, 1992. pp. 97–133.
21. Widhe T, Berggren L. Gait analysis and dynamic foot pressure in the assessment of treated clubfoot. *Foot Ankle Internat* 1994;15:186–90.
22. Yngve DA. Foot-progression in clubfeet. *J Pediatr Orthop* 1990;10:467–72.