Use of Ilizarov External Fixation Without Soft Tissue Release to Correct Severe, Rigid Equinus Deformity

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ABSTRACT
The purpose of the present retrospective study was to report the correction of severe, rigid equinus deformities using an Ilizarov external fixator alone, without adjunctive open procedures. Ten feet in 10 patients with rigid equinus deformities were enrolled and underwent gradual correction using an Ilizarov external fixator alone, without additional open procedures. The range of ankle joint motion was measured preoperatively and at the last follow-up visit. The radiographic outcome was assessed using the lateral tibiotalar angle on ankle radiographs taken preoperatively, immediately after removal of the Ilizarov fixator, and at the last follow-up visit. The mean duration of external fixator treatment was 40.1 ± 13.5 days. The preoperative mean ankle range of motion was −55.5° ± 22.2° of dorsiflexion and 63.0° ± 20.8° of plantarflexion. At the last follow-up visit, the mean dorsiflexion had increased to −2.5° ± 6.8° and the mean plantarflexion had decreased to 30.5° ± 12.6°. The mean lateral tibiotalar angle was 152.9° ± 19.7° preoperatively, 103.9° ± 9.4° immediately after removal of the Ilizarov external fixator, and 113.9° ± 11.6° at the last follow-up visit. Immediately after fixator removal, all the patients had clinical correction of their deformity to a plantigrade foot using the Ilizarov external fixator alone, with a mean correction of 49.0° ± 17.4°. Some recurrence was noted at the last follow-up examination, with a final mean correction of 39.0° ± 18.0°. The present study has demonstrated successful correction of severe, rigid equinus deformity with the use of an Ilizarov external fixator without the need for adjunctive soft tissue procedures. This method can be effective for patients with a high risk of complications after open procedures owing to their poor soft tissue envelope.

Equinus deformity is associated with congenital disorders, trauma, burns, neuromuscular disease, and limb lengthening (1–3). A rigid equinus deformity will result in a tip-toe gait, making ambulation difficult. Conservative treatment, such as stretching exercises, dynamic splinting, and serial casting, can be attempted for mild equinus deformities (4). If conservative treatment does not result in adequate heel weightbearing or a compensated toe gait, surgical options should be considered (5–7). The surgical options for correction of equinus deformities include soft tissue release, tendon transfer, osteotomy or wedge resection, and hindfoot fusion (4,8–18). These procedures are technically challenging and the risk of complications is high, in particular, in the setting of associated infection or poor soft tissue envelope (8,12).

In such cases, an Ilizarov external fixator with the concept of distraction histogenesis has been used as a less-invasive attempt to correct equinus deformities (19–23). Most of the existing studies have reported the use of an Ilizarov external fixator combined with open procedures such as soft tissue release (11,24–27). Experience with correction of equinus deformities using an Ilizarov external fixator alone without adjunctive soft tissue procedures is limited.

Thus, we hypothesized that the ankle range of motion would significantly improve both clinically and radiographically using an Ilizarov external fixator alone in cases of severe rigid equinus deformity. Our primary aim was to evaluate the extent of correction possible using an Ilizarov external fixator alone, without adjunctive soft tissue procedures, in patients with a rigid equinus deformity and to investigate the extent to which equinus deformities recur after correction.

Patients and Methods

Our institutional review board approved the present study, and all patients provided informed consent. Ten feet in 10 patients with an equinus deformity were enrolled from March 2000 to October 2012 and underwent placement of an Ilizarov external fixator alone for gradual correction. Of the 10 patients, 8 were male (80%) and 2 were female (20%), and the mean age at correction was 28 (range 15 to 55) years. All patients were ambulatory preoperatively, with varying severity of limp due to the tip-toe gait. The etiology of equinus deformities was spastic type cerebral palsy in 2

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(20%), congenital neuromuscular disease (hereditary spastic paraplegia) in 1 (10%), chronic osteomyelitis after an open tibia fracture in 3 (30%), pyogenic Achilles tendinitis in 1 (10%), peroneal nerve palsy in 1 (10%), limb lengthening in 1 (10%), and tumor excision on the calf in 1 patient (10%). None of the patients showed improved ankle dorsiflexion, even after repair of the knee joints. No patient had previously undergone surgical treatment of the equinus deformity. The mean duration of the equinus deformity was 7.4 (range 1 to 21) years. A mean of 3.5 (range 0 to 11) operations had been performed for the treatment of the causes of the equinus deformities but none for correction of the equinus deformity itself. The skin condition was poor in almost all patients because most of the previous surgeries had been performed on the ankle or around the foot.

The mean follow-up period from the removal of the Ilizarov external fixator was 1 year, 3 months (range 12 months to 2 years, 2 months). The clinical results were evaluated using the range of ankle joint motion. The heel weightbearing ambulation was measured preoperatively and at the last follow-up examination. The radiographic outcomes were measured using the lateral tibiotalar angle (lateral angle between the long axis of the tibia and the long axis of the talus) on weightbearing lateral ankle radiographs taken preoperatively, immediately after removal of the Ilizarov external fixator, and at the last follow-up visit. In addition, the Wilcoxon signed rank test was used to identify whether significant ankle dorsiflexion and plantarflexion improvements had occurred postoperatively. A p value of < .05 was considered statistically significant. All statistical analyses were performed by a statistician using the SPSS statistical software, version 13.0 (SPSS Inc, IBM Corp, Armonk, NY).

Surgical Technique

The procedure was performed with the patient under general or spinal anesthesia. With the patient in the supine position and the leg under tourniquet control, a pillow was placed under the hip to rotate the ankle internally. Two rings were mounted to the tibia using 2 tensioned wires. The tibial rings were considered as the base for distraction. The calcaneus was fixed with a wire and a half ring. A wire was passed through the midshaft of the first and fifth metatarsals. An additional wire was added just proximal to the metatarsal wires. The 2 wires used on the metatarsal bones were fixed to the straight plates connected to the half ring of the calcaneus, and another forefoot half ring was connected to the distal part of the straight plate to which the metatarsal bone wires were fixed. The calcaneal half ring was connected to the tibial ring using 3 rods: 1 posterior and 2 on each side (medial and lateral). From the anterior aspect, the forefoot half ring was connected to the tibial ring, again using 1 rod placed in the central hole of the half ring. One plane hinge was placed on the medial and lateral rods to pivot on the talus center. We used unplane hinges in most patients (Fig. 1).

Gradual correction was started 1 week after application of the Ilizarov external fixator. Initially, correction was performed 4 times daily to the maximal extent that was not painful to the patient. When the patients began to feel pain, correction was advanced at a rate of 3 to 4 mm daily, or 1°. If the pain intensified, correction was briefly suspended until the pain had subsided. After receiving training on pin site dressing, the patients performed the dressing changes themselves on a daily basis. A radiographic examination was performed every 2 weeks to check for anterior translation of the talus. Clinically, correction with the Ilizarov fixator continued until <5° of ankle dorsiflexion had been achieved. After correction of the deformity, the Ilizarov external fixator was maintained for a period equal to that required to achieve correction. When pin site infection was observed, the Ilizarov external fixator was removed earlier and replaced with a short leg cast or a brace for the remaining treatment period. At completion of the fixation period, full weightbearing ambulation was gradually attempted for several weeks with the brace in place. The patients used an ankle foot orthosis after completion of the correction.

Results

The mean duration required for correction of equinus deformity using the Ilizarov external fixator was 40.1 (range 28 to 58) days. The mean duration of maintaining the corrected ankle with the Ilizarov external fixator or cast after completion of the correction was 37.5 (range 28 to 59) days. The preoperative mean ankle range of motion demonstrated rigid equinus deformity, with −55.5° (range −80° to −15°) in dorsiflexion and 63° (range 15° to 90°) in plantarflexion. These had significantly changed at the last follow-up visit to −2.5° (range −20° to 5°) in dorsiflexion (p = .003) and 30.5° (range 0° to 40°) in plantarflexion (p = .003; Fig. 2). The overall mean ankle range of motion showed statistically significant improvement from 7.5° (range 0° to 30°) preoperatively to 28° (range 5° to 40°) postoperatively (p = .011). At the last follow-up visit, ankle dorsiflexion was 5° in 1 patient (10%), 0° in 6 patients (60%), −5° in 2 patients (20%), and −20° in 1 patient (10%). All the patients, except for the patient with −20° of dorsiflexion, were able to achieve adequate correction to allow heel walking during gait (Fig. 3). All patients were ambulatory without assistance at the final follow-up visit.

The mean lateral tibiotalar angle on the weightbearing radiographs of the ankle was 152.9° (range 114° to 170°) preoperatively and had improved to 103.9° (range 89° to 120°) after removal of the Ilizarov fixator. The mean radiographic correction was 49° (range 14° to 72°). Some recurrence was seen at the final follow-up visit, with a
mean lateral tibiotalar angle of 113.9° (range 100° to 135°) and mean radiographic correction of 39° (range 6° to 66°; Table).

No neurovascular complications were observed. Also, no hammer toe deformities were present. One patient (10%) demonstrated anterior translation of the ankle joint 3 days after correction, for which reduction was performed with the patient under local anesthesia. Mild superficial pin site infection was observed in 3 patients (30%), and these were successfully treated with oral antibiotics. No radiographic finding of the progression of postoperative arthritis was noted for any of the patients.
Abbreviation: SD, standard deviation.

Discussion

Equinus deformity interferes with a normal gait owing to excessive plantarflexion of the ankle, which limits the ability to achieve a neutral position. Surgical correction is performed to allow a plantigrade foot for improved gait (11). Although open soft tissue release has been the standard treatment of equinus deformities, skin and wound complications can easily develop in the course of the correction (8,12). The present study reports the successful use of Ilizarov external fixation without an adjunctive soft tissue procedure to correct severe, rigid equinus deformity in a group of 10 patients with soft tissue compromise.

One of the main risks of open surgical procedures to correct equinus deformities is soft tissue complications. David et al (8) reported infection and wound complication rates as high as 27% with acute surgical correction. Moreover, neurovascular complications can occur, specifically in the posterior tibial artery and tibial nerve. To prevent such complications, Lamm et al (28) recommended tarsal tunnel release for a correction angle $>10^\circ$.

Ilizarov external fixator is an appealing alternative to open correction, because it can reduce the risk of skin problems or neurovascular complications by allowing for gradual correction rather than acute correction. In most previous studies on the treatment of equinus deformities, an Ilizarov external fixator was applied in combination with various open procedures. Therefore, it has been difficult to assess how much correction can be achieved with an Ilizarov external fixator alone (11,24–27). To our knowledge, only 4 studies have been published on this subject. Hosny (29) reported good results with their bloodless technique using only an Ilizarov fixator. Hosny (29) did not report the ankle range of motion or the radiographic correction angle, making it difficult to precisely analyze the extent of correction. Melvin and Dahners (30) reported correction of equinus contracture $\leq 35^\circ$ with a dynamic technique using an Ilizarov fixator in pediatric patients. Carmichael et al (1) also reported a correction of about 41° with an Ilizarov fixator; however, these results also applied only to pediatric patients. A study by Tsuchiya et al (31) was the only study that used a method similar to that in our study, using an Ilizarov external fixator alone in adult patients. They reported an equinus deformity correction of 36.1° (31).

Our results support the use of Ilizarov external fixation alone, without adjunctive soft tissue procedures, in adult patients with severe equinus deformities. We were able to obtain a mean correction of 49.0° ± 17.4°, with a maximum observed correction of 72°, 12.9° larger than the mean correction of 36.1° reported in the only previous series of adult patients (31). The high level of correction might have resulted because our patients had very severe deformities. We did observe some recurrence after removal of the Ilizarov external fixator at the last follow-up visit, with a mean loss of 10.0° ± 5.0°, for a final mean correction of 39.0° ± 18.0°. Carmichael et al (1) also reported that a relapse after correction with an Ilizarov external fixator was common in pediatric patients with burn contracture. Biedermann et al (32) also described a relatively high recurrence rate and found correction with an Ilizarov external fixator meaningful as an alternative technique but not as a final treatment technique. In our series, clinical correction with the Ilizarov fixator continued $\leq 5^\circ$ of ankle dorsiflexion; however, a slight recurrence was found at the last follow-up visit in most patients. Ankle dorsiflexion was $5^\circ$ in 1 patient (10%), 0° in 6 patients (60%), $-5^\circ$ in 2 patients (20%), and $-20^\circ$ in 1 patient (10%). All the patients, except for the patient with $-20^\circ$ of dorsiflexion, were able to achieve adequate correction to allow heel walking during gait (Fig. 3). The 1 patient with severe recurrence had undergone 6 surgical procedures, including skin grafting and sural flaps around the foot and ankle for the treatment of an open tibial fracture and subsequent osteomyelitis. Gradual correction using an Ilizarov external fixator was performed for 50 days until 5° of ankle dorsiflexion had been achieved. The Ilizarov external fixator was maintained for another 14 days, and a short leg cast was applied for the next 28 days for additional fixation. However, the equinus deformity recurred gradually during the follow-up period, demonstrating $-20^\circ$ of ankle dorsiflexion at the last follow-up visit. To avoid such postcorrection recurrences, we have continued to recommend the use of an ankle foot orthosis even after completion of the correction. The ankle foot orthosis helped prevent recurrence of the equinus deformity in most patients, but it was not very effective for the 1 patient, in whom heel walking was impossible because of the severe recurrence. The relatively severe recurrence in 1 patient was attributable to the very severe equinus deformity and poor soft tissue envelope observed preoperatively. Additional surgical treatment was also considered when necessary; however, no additional surgery was performed for recurrence in the present study, because the patient with $-20^\circ$ of dorsiflexion was satisfied with the correction angle.

Although recurrence of equinus deformities, determined by the radiographic measure using the lateral tibial angle, had developed at the last follow-up visit, we obtained satisfactory clinical results. Specifically, the range of motion examination showed a mean correction of ankle dorsiflexion of 53.0° ± 21.4° at the last follow-up visit. This was 14° greater than the mean radiologic correction angle of 39.0° ± 18.0°. This suggests a possible measurement error between the clinical measure of the ankle range of motion and the radiologic measurement. However, our clinical observation was that some of the difference resulted from additional correction in the midfoot joint that was not reflected on the ankle radiographs. Clinically, we observed significant improvement in ankle dorsiflexion and heel contact on ambulation. The results of our study support the use of the Ilizarov external fixator alone, without adjunctive soft tissue

<table>
<thead>
<tr>
<th>Patient No.</th>
<th>Age (y)</th>
<th>Preoperative Ankle Plantarflexion (°)</th>
<th>Preoperative Ankle Dorsiflexion (°)</th>
<th>Radiographic Correction (°)</th>
<th>At Last Follow-Up Visit</th>
<th>Correction Loss (°)</th>
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Mean ± SD 28.2 ± 14.5 55.5 ± 22.2 63.0 ± 20.8 49.0 ± 17.4 39.0 ± 18.0 10.0 ± 5.0 2.5 ± 6.8 30.5 ± 12.6
procedures, in particular, to reduce the complication risks in patients with skin and soft tissue problems.

In our series, no severe skin or soft tissue complications were observed, except for mild pin site infections in 3 patients (30%). Although we did not perform tarsal tunnel release in correcting deformities by a mean of 49.0° ± 17.4°, no neurovascular complications occurred. This might have been because most of the patients in our study had an equinus deformity without severe varus. However, it was more likely the result of the gradual correction made possible using the lizarov external fixator. Our study reported fewer pin site infections than other studies. The patients were trained to perform pin site dressings before undertaking the daily dressing changes.

In the present study, we used an lizarov external fixator to correct the equinus deformities in all 10 patients. The lizarov external fixator, which achieves correction through a manual adjustment program, is distinguished from the Taylor spatial frame (Smiths & Nephew, Andover, MA), which relies on a computer-based program (24). The Taylor spatial frame is able to correct complicated deformities more precisely and predictably than any other external fixator. Compared with the lizarov external fixator, it requires a shorter learning curve and does not need the application of multiple hinges to correct multiplanar deformities (25). However, the lizarov external fixator is a powerful and efficient method of correction and more cost effective than the Taylor spatial frame (11). We achieved successful outcomes with the lizarov external fixator using the uniplane hinge system, because all the patients in our study had simple equinus deformities that were not associated with varus deformities. Both systems can provide correction in a gradual and controlled manner over several weeks. The results of our study indicate that the concept of gradual correction of equinus deformities is important and that the type of an external fixation system to be applied depends on the condition of the patient and surgeon preference.

The limitations of the present study included the retrospective design, small sample size, and short follow-up period. In addition, the etiology and duration of equinus deformity and the period required for correction varied among the patients. Despite this variability, we obtained satisfactory correction without severe complications and have confirmed the efficacy of equinus deformity treatment with an lizarov external fixator.

In conclusion, we obtained a mean correction angle of 49.0° ± 17.4° without severe complications and with statistically significant improvement in the ankle range of motion in patients with an equinus deformity using the lizarov external fixator alone without open procedures such as soft tissue release or osteotomy. This method is particularly useful for patients who have a poor soft tissue envelope and are at a high risk of complications from open procedures. These results also support the use of gradual correction with an lizarov external fixator before open procedures to minimize the extent of procedures required to obtain an adequate plantigrade position.

Acknowledgments

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References