

Knee Flexion Contractures: Soft Tissue Correction With Monolateral External Fixation

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ABSTRACT: We assessed the efficacy of progressive soft tissue distraction using monolateral external fixation in the management of severe knee flexion contractures. We prospectively evaluated 10 knee deformities in seven pediatric patients. After gradual distraction using the modified Orthofix Limb Reconstruction System (LRS), most recent functional status and knee range of motion were determined. This treatment was applied to 10 extremities in seven patients, ranging in age from 2 to 16 years. Diagnoses included arthrogyrosis (4), sickle cell disease (1), previous sepsis (1), and congenital pterygium (1). Average preoperative flexion contracture was 80.5°. Each patient achieved full extension. There was one recurrence, despite bracing, which was managed with replacement of the fixator and soft tissue procedures. Management of knee flexion contractures using a monolateral fixator appears to be a viable alternative to extensive release or femoral osteotomy. Long-term follow-up will be essential to assess the overall risk of recurrence and complications.

Severe flexion contracture involving the knee is a major impediment to functional weight-bearing and ambulation. Such contractures are particularly common in pediatric patients in conjunction with arthrogyrosis, but may be seen in congenital pterygium syndrome, sickle cell disease, sacral agenesis, and multiple other congenital and acquired conditions. Management of these deformities is extremely problematic.¹⁻⁴ The use of gradual correction with circular external fixation has been reported, and use of monolateral fixators has been mentioned briefly.^{2,3} The purpose of this report is to

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review the use of an adaptation of the Orthofix LRS for the gradual correction of severe knee flexion contractures that limit patient function.

MATERIALS AND METHODS

Pediatric patients with severe knee flexion contractures were evaluated clinically and radiographically both preoperatively and postoperatively. Demographics, diagnosis, previous operations, and maximum knee extension were recorded. Each patient was managed with a modified Orthofix LRS external fixator using a standardized postoperative protocol. All patients were placed in long leg braces with double upright drop lock knees and rigid ankle/foot orthoses after removal of the external fixator. Patients with significant truncal weakness or hip contractures were braced with full control hip-knee-ankle-foot orthosis. Physical therapy included rigorous active and passive range of motion exercise of the knees and progressive standing and walking. Most recent functional status and knee range of motion were determined in those patients available for follow-up examinations.

SURGICAL TECHNIQUE

The Orthofix LRS for knee contractures consists of laterally based rails fixed to the femur and tibia and connected to each other by a hinge centered over the approximate center of rotation of the knee (Figure). A minimum of two pins are used in both the femur and tibia. The femoral pins may be spread out over multiple pin clamps, but the tibial pins are placed within one clamp



Modified limb reconstruction system device before application, with femoral portion on left and tibial portion on right.

in the distal tibia, so as to minimize the risk to the anterior tibial vessels. A distractor is placed posteriorly between the rails, as well as a separate distractor attached anteriorly between the hinge and tibial pin clamp. The anterior distractor is opened at the end of the procedure to a subjective sensation of increased soft tissue tension as felt by the operative surgeon.

On postoperative day 1, distraction is initiated anteriorly between the hinge and the tibial clamp at the rate of 1 mm per day in four divided increments. The tibial clamp is loosened from the rail so as to slide freely. This acts to distract the tibia from the femur in line with the deformity, thereby minimizing any potential crushing of the articular cartilage during the subsequent angular correction. Joint distraction is done for 10 days (approximately 10 mm), at which time angular correction is initiated through the posterior distractor. Initially, the law of similar triangles was used to determine and adjust the rate of posterior correction, but this was eventually simplified to 1 mm per day in four equal increments. Patients are allowed to bear weight on the extremity when the contracture corrects to a point at which the individual patient can stand safely with assistance. Correction is continued until full extension is achieved. Lateral radiographs of the knee are obtained at the initial postoperative visit, and then at 7 to 10 day intervals during correction. If the posterior distraction becomes difficult or significant discomfort develops around the knee, a short course of anterior joint distraction is done and then posterior distraction is reinitiated.

Once full extension is achieved clinically and radiographically, the fixator is left in place for approximately 4 weeks. The device is then removed (with the patient under anesthesia), braces are measured, and the extremity is placed in a long leg cast in full extension for approximately 4 weeks. Long leg braces are used full time. These are locked in extension except for

TABLE. Function Before and After Treatment of Knee Flexion Contractures

Patient	Diagnosis	Preoperative Functional Status	Most Recent Known Functional Status
1	Postsepsis	Community/Crutches	Community/No brace or support
2	Congenital pterygium syndrome	Community/Crutches	Community/Light brace/no support
3	Arthrogryposis	Nonambulatory	Community/Braced
4	Arthrogryposis	Nonambulatory	Community/Braced
5	Arthrogryposis	Nonambulatory	Nonambulatory
6	Arthrogryposis	Nonambulatory	Household/Braced
7	Sickle cell disease	Nonambulatory	Household/Braced

knee range of motion and strengthening exercises during therapy sessions. Standing and walking are allowed as tolerated.

RESULTS

We applied the modified Orthofix LRS fixator to a total of 10 extremities in 7 patients. Four patients had arthrogryposis, and one patient each had sickle cell disease, previous knee sepsis, and congenital pterygium syndrome. All patients had had unsuccessful physical therapy and bracing, and 3 had had a total of 6 previous bone and soft tissue procedures without adequate resolution of the contractures. Only the patient who had had sepsis and the patient with the unilateral pterygium were functionally ambulatory, but each used bilateral crutches and were essentially non-weight-bearing on the extremity in question. The remainder of the patients were nonambulatory because of the contracture. The average preoperative flexion contracture was 80.5° (range, 60° to 100°).

Each patient achieved full clinical and radiographic extension at the end of the distraction process. Two patients with pterygium had soft tissue releases in conjunction with distraction. The fixators were in place for an average of 17.1 weeks (range, 12 to 30 weeks). Average follow-up to date is 15 months (range, 3 to 29 months). One patient was lost to follow-up 3 months after fixator removal. According to the grading system proposed by Herzenberg et al,³ results were good in 6 extremities (contractures 6° to 15°), fair in 3 (16° to 29°), and poor in one (≥30°).

Loss of full extension and resumption of some element of flexion contracture were apparent in all cases. This occurred at a rate of approximately 0.9° per month, when averaged over the entire follow-up period. Measurement of flexion and extension was based on clinical examination. Radiographs were not obtained on a routine basis after the fixator was removed. Clinically, however, the recurrent angular deformity appeared to occur primarily during the first 6 to 12 months and then was maintained at that level.

Preoperative total arc of motion was not determined in all patients, thus making comparison at follow-up difficult. In each patient, however, the functional arc of motion was improved. It did not appear that any patient lost range of motion because of the procedure. Functional status was markedly improved in the majority of patients (Table). Four patients are currently community ambulators. This includes two patients using long leg braces because of arthrogryposis. At most recent follow-up, all patients could be adequately braced except for the patient with the poor result.

Complications were minimal. Three patients required intermittent oral antibiotics for treatment of superficial pin tract infections. No patients required narcotic pain medication after the immediate perioperative period. No apparent physeal injuries or fractures were noted during correction. One patient with arthrogryposis had a rapid recurrence of her deformity after fixator removal. She had been treated during our early experience in the use of the device and in retrospect was found to have not

only arthrogryposis, but also a significant popliteal pterygium. She did well after reapplication of the fixator, popliteal Z-plasty, and fascial and hamstring release.

DISCUSSION

Knee flexion contractures are common in certain orthopaedic conditions, particularly in pediatric patients with arthrogryposis.⁵ Significant contractures ($\geq 30^\circ$) are difficult to brace and may severely limit functional and efficient ambulation, as well as standing. Limiting factors to obtaining full extension include musculotendinous structures around the knee, tight posterior capsular and intramuscular ligamentous contractures, and the posterior neurovascular structures that become relatively shortened over time.

Historically, initial surgical management has included releases and lengthenings of the hamstrings and posterior capsule if necessary.⁵ However, such management is often difficult, since simple soft tissue releases are often insufficient to obtain adequate extension. Serial extension casting, with and without simultaneous soft tissue release, may be effective in mild situations. Complications including fracture, physeal injury, and posterior knee subluxation, as well as peroneal nerve injury, have been reported.^{4,5} Skeletal traction has been of benefit in severe cases, but this method requires long-term hospitalization, which is not feasible or cost effective.

Femoral supracondylar osteotomy performed along with a component of shortening has been reported.¹ Although this provides immediate correction, it does so by correcting at a distance from the deformity, thereby introducing a secondary deformity. Complications include peroneal nerve palsy, and induced hypertension.¹ In addition, the recurrence rate is high, particularly in younger patients, since the femur rapidly remodels in an attempt to restore physiologically normal joint position.

External fixation has been used for gradual correction, both with and without simultaneous soft tissue release.^{2,3,6} The majority of reports detail use of the Ilizarov (or similar) circular fixator. Herzenberg et al³ described the use of an early monolateral device in two patients in a review of their experience with correction of knee contractures using circular external fixation. Theoretically, correction with external fixation is more controlled and efficient than acute correction of these deformities. In vivo canine studies have shown that slow gradual correction appears to elongate and stimulate histogenesis within tendons during bone lengthening.⁷ Blood vessels and neural structures have been shown to proliferate and elongate during lengthening.⁸ Similar changes should occur in soft tissue structures during correction of joint deformities.

No study has been done to assess exclusively the use of any monolateral fixator, particularly this modification of the Orthofix LRS, in a series of patients. The device is technically less demanding than the circular fixators and is available in both an adult and pediatric size, allowing its use in young patients. In addition, the lateral placement makes it less cumbersome and more readily adaptable to bilateral deformities than a circular system.

This report shows that severe deformities can be corrected with this device and that complications are minimal. Whereas some recurrence was noted, six of seven patients had improvement of their functional status, which has been maintained at follow-up in all but one case. It appears that in most patients, similar to results reported by Herzenberg et al,³ the overall joint motion was essentially unchanged at the end of follow-up but was in a more functional arc at the end of treatment. Two patients with arthrogryposis continued to exhibit an increase in their total range of motion as compared with preoperative values. Why this occurred is only speculation. However, it may be that the femoral-tibial joint dis-

traction applied before and intermittently during correction of the angular deformity may have lengthened the posterior capsular and intra-articular structures, thereby minimizing postcorrection stiffness.

Questions remain regarding the long-term status of patients having soft tissue correction with external fixation. Regardless, this device is relatively simple to apply and appears to be well tolerated by patients. When recurrent deformity occurs, particularly in younger patients, revision and redistriction is a more desirable option than revision in the face of a previous extensive soft tissue release or supracondylar osteotomy.

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