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Correction of Clubfoot by External Stabilization System (Mini External Fixator)

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Abstract : Correction of rigid, resistant, recurrent and neglected club foot presents a challenging therapeutic problem in clinical practice. Various techniques have been used in the management of these deformities, including soft tissue and bony procedures.

Recently External stabilization system (ESS) has been used, based on the principles of controlled differential distraction of soft tissues as advocated by Prof. Ilizarov.

ESS is most suitable for small feet, where use of Ilizarov's ring fixator is difficult to use. The pins of ESS are put in proximal tibia, hind foot and fore foot. In this way, each part of foot and ankle deformity may be moved separately enabling correction of each component of deformity by differential distraction of controlled soft tissues.

The sequential adjustment of ESS frame is highly necessary. Overcorrection of deformity and period of maintenance both in frame and plaster cast is necessary to reduce the potential of relapse.

This study analyses usefulness, pitfall and complication of ESS technique for management of Rigid, Resistant, Recurrent and Neglected club foot.

Our experience in treating 35 cases is of short duration of 5 years. A longer follow up would be required to see long term results.

Introduction

Correction of rigid, known resistant cases ie arthrogrypotic and severely contracted foot such as associated with congenital contracted band syndrome, recurrent or relapse after two or three surgeries and neglected clubfoot present a challenging therapeutic problem in clinical practice. Various techniques have been used in the management of these complex deformities including extensive surgical release with newer incisions and boney procedures. The use of external fixation and distraction for clubfoot has been reported by many authors,[1)4)7)10)11)]. We have used the ESS fixator for ages varying from 1 year to 15 years.

Key words : Club feet, ESS, Differential, Distraction, Soft tissue taxis
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Instrumental controlled differential distraction has become an increasingly popular method for the management of these complex deformities. We have been using the instrumentation and the method of controlled differential fractional distraction described by Dr. B. B. Joshi of Bombay India[7].

Our Indications :

1. Relapse or recurrence after soft tissue release operations.

2. Resistant foot such as arthrogrypotic.

3. Old neglectedCTEV. In which full correction with soft tissue release alone may be difficult.

Principle of External Stabilization System (ESS)

Instrumental controlled differential distraction is applied to the contracted soft tissues by Kirschners wires anchored in the bones, for correction of all the components of this complex deformity.

Advantages of the External Stabilization System(ESS) for correction of club feet :

1. Controlled correction of all the components of this complex deformity is possible

2. Lengthens the contracted soft tissues and promotes histogenesis in the same tissue thus preventing post surgical scarring. Space created by distraction will accommodate the deformed bones into normal anatomical position.

3. No further shortening of the foot as in revision and neglected cases where bony procedure is not involved.

4. Versatile and can be used with minimal training.

5. Modular System : Addition and subtractions easily done

6. Patient friendly

Material Methods

The study comprised of 35 patients involving 51 feet.

The deformity was bilateral in 16 cases and unilateral in 19 cases.

26 patients were male and 9 were female.

The age ranged from 1 year to 15 years, 14 cases were between 1-3 years, 19 cases between 3 to 7 years and 2 older than 10 years.

Etiology : 5 feet had non idiopathic clubfoot including 4 arthrogrypotic and 1 spinal dysraphism. The remaining 46 were idiopathic and including 14 feet with previous soft tissue release, 12 with previous manipulations and casting and 20 previously untreated feet(i.e. neglected).

Method : Assembly is fitted under general anesthesia without tourniquet ; the frame is essentially constructed on Kirschner wires fixing three segments.

The tibial segment comprises of 3 proximal tibial pins, two transverse and one axial

The calcaneal segment includes two transfixing pins and an axial pin in the calcaneum

The metatarsal segment incorporates one transfixing pin and two smooth half pins. The transfixing wire passes through the necks of the first and the fifth metatarsals. And two half pin through metatarsal shafts. One smooth half pin is passed from the medial side to fix the first, second and the third metatarsals while the second half pin is passed from the lateral aspect fixing the fifth and the fourth metatarsals··

The three segments are then linked together by a system of clamps, rods and distracters to create the ESS clubfoot frame as shown in the diagram.

Two metatarso-calcaneal and two tibia cal-

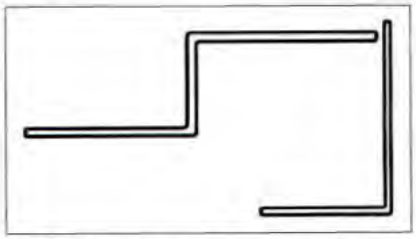

Fig. 1. Z & L Connecting Rods

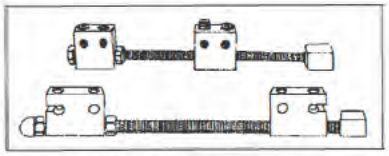

Fig. 2. Distractios

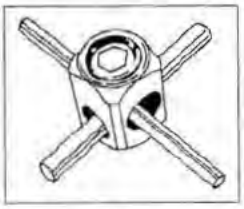

Fig. 3. Connecting Clamps

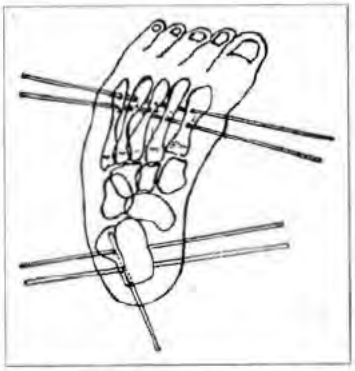

Fig. 4. Metatarsal & Calcaneal Pins

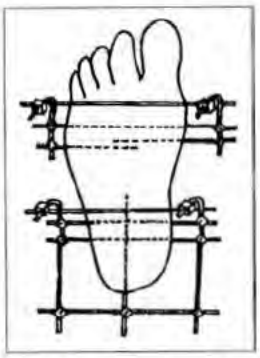

Fig. 5. Construction of Foot Frame

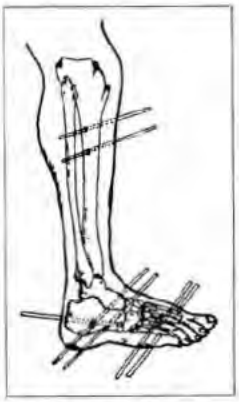

Fig. 6. Tibial Pins

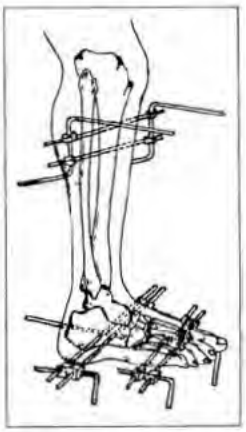

Fig. 7. Tibial & Foot frame

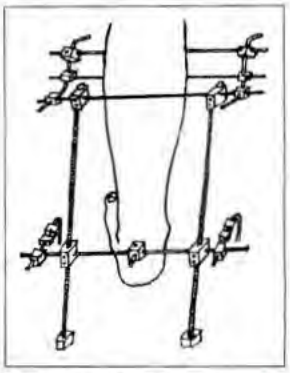

Fig. 8. Application of Distractors

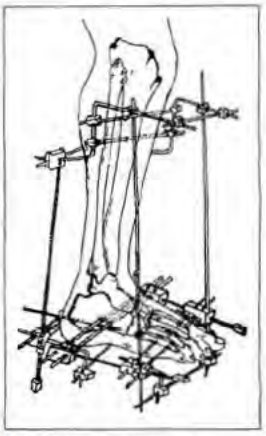

Fig. 9. Final Frame Construct

caneal distracters are applied. Two static anterior tibio metatarsal rods are put to control dorsiflexion of the foot. The rods connecting the forefoot to the tibial segments, lying anterior to the ankle joint were 'de-tensioned' once every third day by loosening the clamps at the tibial end of the rods. Distraction is to start on second or third day at the rate of 0.8 mm per day on medial side distracters and 0.4 mm on the lateral side distracters in fractional doses. After correction of the heel varus tibio-calcaneal distracters are shifted posteriorly for correction of the equines and both distracted at equal rate.

Sequential adjustment of the External frame is necessary for manipulation and manipulative correction of the deformities. After complete correction of deformity (6-8 weeks) the assembly is maintained in stationery phase for equivalent duration. After removal of the assembly foot is put into well molded cast for 8 to 10 weeks. After removal of plaster a CTEV shoe and orthosis given, manual stretching is to be continued along with encouragement for squatting and walking for several months to keep the foot supple and aligned. Night time use of Dennis Brown splint is to be continued for some time, till us gets active range of movement and child is able to walk.

Table 1. Result

Excellent	85 to 100 points	26 feet	51%
Good	70 to 84 Points	16 Feet	31%
Fair & Poor	<70 Points	09 Feet	18%

Table 2. Complications

Recurrence	6% of patients
Pin tract Sepsis	15% of patients
Pin Tract Osteomyelitis	8% of patients
Linear dermal necrosis	4% of patients
Under correction	4% of patients
Lateral translation of Tibial Assembly	2% of patients
Flexion contracture of the toes	53% of patients
Oedema of the foot	43% of patients

Results

The results were assessed on the basis of the functional rating system devised by Lehman et. al[8] described as "Hospital for Joint Diseases Orthopaedic Institute functional rating system for the clubfoot Surgery." We had 26 excellent, 16 good and 7 fair and 2 poor results.

The average talo-calcaneal index was 48 degrees and satisfactory talo-first metatarsal angle on antero-posterior radiographs. Average range of movement at ankle was 25 degrees. Subtalar movement of >10 degrees is seen in around 55% of the feet, <10 degrees in 30% of the patient, remaining had stiffness and restriction of the movement. The patients who had undergone surgical procedures earlier had decidedly less supple feet. And had more subtalar stiffness.

0 to 5 degrees of valgus achieved in almost 70% of the feet examined, 20% showed neutral alignment of the heel where as varus noted in about 5 feet.

Poor result was in patient with spinal dysraphim and arthrogrypohsis in them minimal soft tissue release with refixator was done)

The oldest patient in this series was a 15-year-old girl with neglected clubfeet. The right side was treated first and two years later she underwent the procedure for the left side. She had plantigrade feet and was able to ambulate with minimal pain arising from a plantar callosity of the prominent fifth metatarsal base…

The length and the width of the feet in bilateral cases were identical on both the sides. In unilateral cases, the affected side was invariably shorter and narrower than its mate by 6% (0.8 to 1.2 cms.). At the time of the removal of the frame, the feet were of almost equal size, over the next two years the no obvious difference became apparent.

In addition to the functional rating system, we also assessed other parameters like foot prints, tibio-calcaneal axial alignment and, calf atrophy, foot size and single foot hop distances.

Complications

Recurrence : Has its root in primary under correction or failure to follow the postoperative protocol meticulously.

Three feet in three patients(6%)had to be re-operated by the same method for recurrence of the deformities, one of the patient with the unilateral recurrence had only one post-operative cast after which he went back to a remote village where no aftercare was possible and came for follow-up after some time and reoperated, latter kept in the hospital and got plantigrade foot. Another patient with arthrogryphosis had recurrence in whom assembly was removed because of tibial and calcaneal pin loosening, he underwent re-instrumentation successfully and had got plantigrade foot. One patient with spinal dysraphism got recurrence of deformity reoperated and latter muscle imbalanced corrected by tendon transfer to maintain the correction.

Pin tract Sepsis : It was a problem in initial

few cases, occurred in 69 our of 450 pins(15%). This was more in proximal tibial pins and on analysis was correlated to mechanical weakness in assembly and latter rectified by adding an additional half pin in sagital plane, second most commonly infected pins were transverse calcaneal pins. Most of the pin tract sepsis reported responded to local pin care treatment and some systemic antibiotics in few patients mentioned below we need to remove or change of pins. Two patients had infection in three pin tracks.

Pin Tract Osteomyelitis : (8% of the patients) in two patients one of the calcaneal pins and in other two both tibial pins had to be removed pre-maturely. The radiographs showed considerable osteolysis around the pin tracks. They healed well subsequently and left no residue at the time of the follow up. In one patient assembly need to be removed because of pin loosening especially at tibial and calcaneal site. The same patient was reoperated latter without any pin problem.

Linear dermal necrosis : Between the medial metatarso calcaneal assembly. Seen in 2 feet (4%)

These were the cases with multiplanar forefoot deformity and had a significant element of forefoot supination. This needed acute derotation of the fore foot to enable application of the medial foot distracter and probably was responsible for the oblique band of dermal necrosis. The solution again would be either make a multiplanar foot assembly which would allow gradual derotation of forefoot. We have also tried to put bend rod instead of straight distracter for initial few days then change it to distracter.

Under correction : Seen in 2 feet(4%). For prevention of under correction periodic clinical assessment and sequential adjustment of fixator frame is necessary.

Lateral translation of Tibial Assembly : Seen in one patient(2%), translation was on lateral side, this was because of mechanical weakness at the tibial assembly because of pin sepsis.

Flexion contracture of the toes : Seen in 27 feet(53%) in mild to moderate form Intermittent use of toe strap solved the problem to some extent. After removal of fixator need some manipulation at the time of casting, get fully corrected at the time of second or third casting.

Oedema of the foot : Seen in about 22 feet (43%) Problem can be tackled by stopping the distraction temporarily and elevationg the limb.

Tibial Physeal separation, Ankle dislocation, planter skin necrosis Reported through personal communication from colleagues.

Discussion

Surgical correction of clubfoot continues to result in an unacceptably high proportion of unsatisfactory results. Various authors reported between 13% to 50% of operated feet requiring revision surgery.

Tension stresses applied to tissues by mechanical devices anchored on pins driven through bones has been shown to incite neohistogenesis. Ilizarov, Grill, Paley, Cantin and others have used this method to correct clubfoot deformities in the older child using tensioned wires with the ring frame. When the Ilizarov is used to distract soft tissues, correction occurs through the elimination of contractures and by establishing new position of the joints that result in a plantar grade

position[6)10)] Soft tissue release of this type is based on the view that cartilaginous bones can be remodeled. Distraction methods reshape bones by activating the circumferential physis of the affected bones[10)]. Two Techniques the constrained and and unconstrained may be used for the correction of deformity. In one technique, one grabs the foot at both ends and then twists it through, perhaps 12 different joints. In the other technique, a focal hinge is placed adjacent to the foot and the foot is rotated around one point as for example, an ankle equines contracture. When we try to move whole foot, we try to use the natural hinges that the foot has built in[10)]. If we use constrained system, it dependent on single Cora, it may be difficult to localize Cora in a multidimensional deformity of club foot. Ilizarov is a heavy construct and may not be suitable for small club feet. It needs special training and expertise and has long learning curve.

Paley[10)] strongly advises against the treatment of foot deformities without osteotomies beyond the age of 8 years. However, in our series oldest patient was 15 year's age, our aim was to correct the deformities prior to resorting to stabilization procedures. The objective was to minimize the resection, preserve foot size and avoid neurovascular embarrassment. The deformities were well corrected by the ESS. They were maintained in the corrected position by the ESS for a period of 6 weeks, followed by three retentive casts. At the five-year follow up, her x-rays showed remarkable remodeling in the shape of the metatarsals and the tarsal bones. The realigned joints also remained corrected. The stabilization procedures have not been performed as yet. She is able to ambulate barefoot with a greatly improved gait

Correll J.[12)] presented series of 40 pts treated with Ilizarov for correction, as soft tissue correction and Ilizarov or osteotomies with Ilizarov, good results in 60%, sufficient in 30% and poor in 9%, he also mentions that this method allows surgeon to correct the deformity in addition to lengthening.

Morin Benoit[13)] described use of use of mini external fixator only for maintenance of correction which he achieves with standard soft tissue release. He keeps fixator for 6 to 8 weeks in maintenance phase, checks talo-calcaneal angle radiologically and adjust the fixator if necessary.

The method studied by the author is capable of dealing effectively with these complex deformities using non-tensioned wires. Being a semi-invasive method, it is applicable even in the most severe deformities, there is some fear of skin necrosis in severe deformities with supination, and this may be prevented with proper precautions. The need for extensive incisions and bony procedures would be minimized. The method described differs from the Ilizarov method in a few ways. The wires are not tensioned and rather than depending on the crossing of the wires within the bone, stability depends on the placement of the wires, the use of half pins and pre-tensioning. Hinges are not used in this method. Thus the corrective forces are not directed along a single axis, instead, the soft tissue envelope in conjunction with the shape of the articulating surfaces guide the correction we may call it soft tissue taxis and manipulation.

Watts[10)] described use of small Wagner leg lengthening apparatus to correct the sever deformities of previously operated club feet in

which there is marked medial deviation of forefoot and contracture of soft tissues. Repeated procedure on these areas for extensive soft tissue release may be dangerous and, in sever cases, may even be contraindicated because of severity of deformity. He also performed the capsulotomy of talonavicular and calcaneocuboid joint.

The clinical and radiological results have been encouraging. The improvement in the alignment is maintained and continues to improve with time. No deleterious effects have been noted on the immature cartilage of the bones of the foot. The maintenance of the power in the tendoachillis allows the patients to develop a near normal gait. The foot and calf remain smaller than the opposite normal foot. The discrepancy has been minimal allowing patient to wear the same size of footwear on both feet.

Laud N[14] mentions about computerized gait analysis study conducted in his series of similar patients and results were presented.

The few drawbacks of the procedure identified at present are those associated with any external fixation and include pin track infection, loosening and under correction or dermal necrosis, Oedema foot and clawing of toes. With growing experience, the problems have been minimized to an acceptable level. Newer fixator designs that should overcome the problems of the existing system are already in the pre-clinical testing stage. The fixator has been used to successfully correct similar teratologic deformities. Open surgery and bony surgery for deformity correction should remain as a modality resorted to when all else has failed. Tendon transfers and limited bony fusion surgery may be necessary in an occasional patient who has undergone this method of treatment but we have not used in only in one of our patient with spinal dysraphism.

Conclusion

Instrumental controlled differential distraction has become an increasingly popular method for the management of complex clubfoot deformity. We have been using mini external fixator and the method of controlled differential fractional distraction for correction of club foot deformity. It is extremely useful in treating clubfoot of various etiologies leading to a very well balanced and supple foot.

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