Dokuz Eylül University (DEU) orthosis: an orthotic method of preventing ankle equinus during tibial lengthening

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Abstract
An orthosis developed in Dokuz Eylül University (DEU) at the School of Physical Therapy and Rehabilitation, Department of Orthotics and Prosthetics is described. It is applied as a non-invasive device attached to the distal ring of the Ilizarov external fixator to keep the ankle joint in a neutral position and prevent ankle equinus during tibial lengthening with Ilizarov technique. This minimises additional invasive techniques such as heel cord release and prophylactic pinning of the heel and the foot, and manipulation under anaesthesia. It may also be detached by the physiotherapist or patient when physical therapy is needed during the lengthening procedure.

Introduction
Equinus deformity is seen in the majority of the patients who have undergone tibial lengthening with an Ilizarov external fixator (Ateşalp et al., 1998; Curran et al., 1999; Lehman et al., 1991; Nakamura et al., 1996; Stanitski et al., 1996; Tachdjian, 1990; Valezquez et al., 1993). Any lengthening of the tibia shortens the soleus-gastrocnemius-Achilles complex, and places this complex under increased tension, pulling the ankle into an equinus position (Lehman et al., 1991; Nakamura et al., 1996). A number of methods including temporary fixation of the ankle joint with a Kirschner wire (Yun et al., 2000), heel cord release (Curran et al., 1999; Pavolini et al., 2000; Stanitski et al., 1996; Tachdjian, 1990), prophylactic pinning of the heel and foot (Curran et al., 1999; Nakamura et al., 1996; Tachdjian, 1990) and manipulation under anaesthesia (Aaron and Eilert, 1996; Yun et al., 2000) are current invasive methods to prevent ankle equinus. Disadvantages of these methods remain as a dilemma for surgeons and physiotherapists.

Technique
A positive plaster model has been constructed by applying a plaster cast on a lower limb for experimental study. An Ilizarov external fixator with two proximal and distal rings was applied to the shaped positive plaster model (Fig. 1). A polyethylene foot cap is moulded on the same model and trimmed at the level of the malleolus or below the distal pin sites, and a

Fig. 1. Ilizarov external fixator and prototype orthosis applied experimentally on the plaster model.
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Fig. 2. Trimmed polyethylene foot cap and shaped steel piece with screws.

length of steel material (4mm thick, 20mm wide) is fashioned to fit the foot cap contour. The other end of the length of steel is bent for attaching to the posterior part of the distal ring of the Ilizarov fixator (Fig. 2). The system is attached to the distal ring of the Ilizarov fixator on the positive plaster model after fixing the steel part to the foot cap with two countersunk head screws (Fig. 1).

Applying the orthosis to the positive plaster model with the Ilizarov fixator confirmed that the fitting and position of the orthosis relative to the ankle and foot, and the Ilizarov fixator were as good as possible. A new polyethylene foot cap was moulded on the positive plaster model of the foot on the side that was being lengthened of a patient who had undergone surgery for tibial lengthening and attached to the fixator as explained (Figs. 4 and 5).

Case report

A 22 year old patient has 8.5cm left lower limb shortening due to poliomyeltis when he was 1½ years of age. He had been fitted with a long leg brace from 2½ years of age to 5. The measured discrepancies on x-ray were 4cm on the left femur and 4.5cm on the left tibia. Overall range of motion in joints of lower limbs was normal, except for 30 degree limitation to full extension in the left knee joint. Ankle dorsiflexion limitation in the left side also existed after neutral position.

Surgical operation was decided with recurvatum osteotomies of the left femur and tibia, and Ilizarov external fixator for femoral and tibial lengthening.

The lengthening procedure was started one week after operation and scheduled as 2mm/day (1mm femoral and 1mm tibial). At the end of 5 weeks, lengthening was ceased for a week due to intensive pain and vascular distraction, and restarted in the seventh week. Ilizarov external fixator application was ended after 16 weeks with adequate callus formation and equalisation of the left lower limb.

The orthosis was applied on the second day of

Fig. 3. Weakness of the dorsiflexors, gravity and the Achilles tendon tension pull the ankle and foot into plantar flexion.

Fig. 4. Medial view of the orthosis with good fitting and position.

Fig. 5. Posterior view of the orthosis in standing.
the lengthening period. Before discharge from hospital, the patient was directed to detach the orthosis every 4 hours for 20 minutes for skin care, exercise and hygienic activities. Full night wearing during sleeping time was advised.

During the lengthening period there was no major problem due to orthotic application, however a mild skin rash has been detected at the posterior part of the heel and particularly under the metatarsal heads.

Discussion

Soft tissue elongation is not possible with a direct method of distraction. Equinus of the ankle joint develops as a result of increased tension on the soleus-gastrocnemius-Achilles tendon complex, but the tension on it can be changed by the position of the ankle joint while bone lengthening is controlled by the external fixator (Lehman et al., 1991; Nakamura et al., 1996).

Heel cord release is one of the common methods in the literature to prevent equinus (Atesalp et al., 1998; Lehman et al., 1991; Stanitski et al., 1996; Tachdjian, 1990; Yun et al., 2000). It requires additional surgery and increases the time of the whole procedure. Release must be performed three to six months prior to the bone lengthening, or after removing the external fixator as suggested by Tachdjian (1990).

Manipulation under anesthesia has been found less effective compared with the invasive methods and failure is common (Aaron and Eilert, 1996; Yun et al., 2000). Inclusion of the ankle and foot in the Ilizarov fixator, that is prophylactic pinning of the heel and metatarsal bones and fixing the foot in a 90° position to the circular ring is another invasive method to prevent equinus (Lehman et al., 1991; Stanitski et al., 1996; Tachdjian, 1990). Long-term immobilisation of the ankle and foot with this procedure increases the risk of reduction muscle strength, especially dorsiflexors. However, muscle strength can be maintained by exercise of isometric contraction. On the other hand, performing the range of motion exercises and stretching exercises has been performed from the outset. Therefore, it is also suggested that the physiotherapy may continue alongside the lengthening procedures unless there is a requirement for full immobilisation. When the patient is no longer in hospital and under supervision by the physiotherapist, it may become a useful device for positioning of the ankle, and the patient can easily detach it when range of motion exercises and skin observation are required.

Conclusion

The orthosis developed in DEU may be considered as an inexpensive and easy alternative to invasive techniques to prevent ankle equinus during tibial lengthening with Ilizarov external fixator. Further studies are required to investigate the effects of the orthosis in terms of skin condition and possible changes in skeletal structure of the foot.

REFERENCES


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