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Foot Deformity Correction with Hexapod External Fixator, the Ortho-SUV Frame™

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A R T I C L E I N F O

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A B S T R A C T

External fixators enable distraction osteogenesis and gradual foot deformity corrections. Hexapod fixators have become more popular than the Ilizarov apparatus. The Ortho-SUV Frame™ (OSF; Ortho-SUV Ltd, St. Petersburg, Russia), a hexapod that was developed in 2006, allows flexible joint attachment such that multiple assemblies are available. We assessed the reduction capability of several assemblies. An artificial bone model with a 270-mm-long longitudinal foot was used. A 130-mm tibial full ring was attached 60 mm proximal to the ankle joint. A 140-mm, two-third ring forefoot was attached perpendicular to the metatarsal bone axis. A 130-mm, two-third ring hindfoot was attached parallel to the tibial ring. A V-osteotomy, which was combined with 2 oblique osteotomies at the navicular–cuboid bone and the calcaneus, was performed. The middle part of the foot, including the talus, was connected to the tibial ring. We assessed 5 types of forefoot applications and 4 types of hindfoot applications. The range of correction included flexion/extension in the sagittal plane, adduction/abduction in the horizontal plane, and pronation/supination in the coronal plane. Additionally, we reported the short-term results in 9 clinical cases. The forefoot applications in which the axis of the hexapod was parallel to the axis of the metatarsal bones had good results, with 52°/76° for flexion/extension, 48°/53° for adduction/abduction, and 43°/51° for pronation/supination. The hindfoot applications in which the hexapod encircled the ankle joint also had good results, with corresponding values of 47°/58°, 20°/35°, and 28°/31°. Clinically, all deformities were corrected as planned. Thus, multiple assemblies and a wide range of corrections are available with the OSF.

Foot deformity corrections include acute corrections and gradual corrections using external fixators. In conventional acute corrections, extensive soft tissue releases, tendon transfers, resection osteotomies, and arthrodesis with screws or wires are used (1–3). However, these corrections can result in skin necrosis, lack of correction, and neurovascular complications, especially in the presence of multiplanar deformities or scar tissue owing to a history of infection, burns, or multiple operations in which the motion of the nerves and blood vessels are potentially restricted (4,5). The surgical goals are maximum correction with minimal bone resection and the establishment of a functional, pain-free, and plantigrade foot with good mobility (6).

The use of external fixation can avoid complications and is less invasive. It also enables distraction osteogenesis, in contrast to the simple shortening resulting from resection osteotomy for acute corrections. The Ilizarov apparatus has been widely used for foot deformity corrections, and many reports have described its advantages (4–9). However, hexapod frames, which have recently become popular, enable us to correct complicated deformities simultaneously. In contrast, the Ilizarov apparatus needs to be reassembled and adjusted for each deformity (4). Corrections with the Taylor Spatial Frame™ (TSF; Smith and Nephew, Memphis, TN), the most widely used hexapod, have been reported (10–12).

The Ortho-SUV Frame™ (OSF; Ortho-SUV Ltd, St. Petersburg, Russia) was developed in 2006. To date, it has had success in long bone corrections and knee contractures (13–19). The OSF, which is the same as the TSF, can be adjusted in all 6 spatial degrees of freedom using 6 struts (Fig. 1*A*). On the strut, a mobile cylinder can be rotated to change the length. It has a minimum length of 94 mm (Fig. 1*B*). The joints can be attached to the many types of base apparatuses, including the Ilizarov, TSF, and other types of rings, and the attachable places and levels are not limited (Fig. 1*C*). This flexibility is the greatest difference between the OSF and the TSF and allows for various assemblies. After measuring all the lengths of the struts and the

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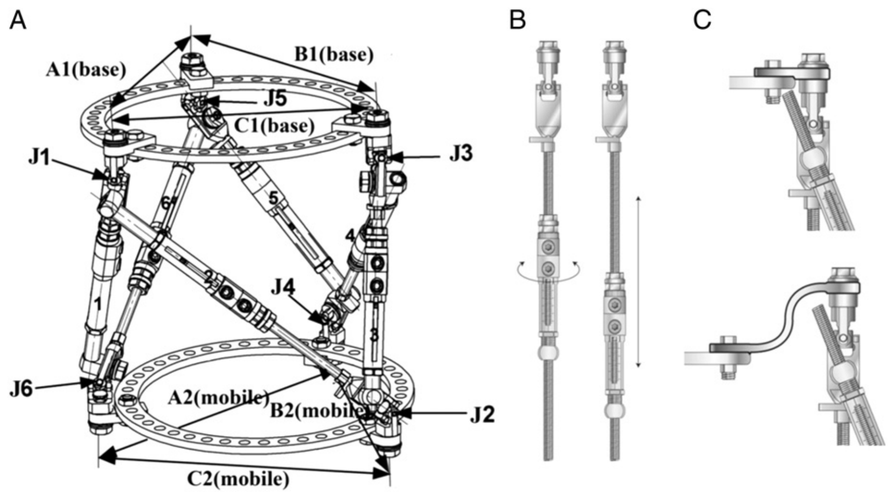

Fig. 1. Structure of Ortho-SUV Frame™. (*A*) Struts and joints are numbered counterclockwise from 1 to 6 as viewed from above. (*B*) The length of the strut is changed by rotating the cylinder. (*C*) Each joint is attached to the ring with 2 types of connecting devices, which are short (*top*) and Z-shaped (*bottom*).

distances between the adjacent joints and inputting the data into the computer software, multiplanar corrections are available with a user-friendly program with which mistakes rarely occur (Fig. 2).

Applying the hexapod to the foot is difficult owing to its L-shaped contour in the lateral view. The narrow space can result in a collision between the struts, frames, and skin; thus, consideration of these issues beforehand is necessary to acquire a wide range of correction. In addition, the flexible joint attachment of the OSF allows multiple applications, which could be confusing to select. The aim of the present study was to assess the reduction capabilities of several configurations of the OSF. In addition, we assessed the short-term outcomes of 9 adult patients who were treated with OSF.

Patients and Methods

Artificial Bone Model and Basic Components

The ranges of correction vary according to the shape of the bone and the size and location of the rings. The basic composition used in the present study is described below.

Artificial bone models of the tibia, fibula, and whole foot were obtained from Pacific Research Laboratories (Vashon, WA). The length of the tibia was 38 cm, and the longitudinal length of the foot from the rear edge of the calcaneus to the toe point was 27 cm. The components of the Ilizarov apparatus were obtained from the experimental factory of Kurgan Research Ilizarov Center (Kurgan, Russia). These included several types of rings, threaded rods, female/male posts, hinges, plates, twisted plates, washers, 6-mm-diameter half-pins, half-pin fixators, 1.8-mm-diameter olive wires (wire with a stopper), wire-fixation bolts, bolts, and nuts.

First, the bones were assembled and fixed in a neutral position without plantar-flexion or dorsal flexion of the ankle joint. A 130-mm full ring was attached 60 mm proximal to the ankle joint with a wire inserted through the fibula and tibia, and 2 half-pins were inserted into the tibia. The talus was fixed with a wire (for forefoot correction) or a wire and a half-pin (for hindfoot correction) and then fixed to the tibial ring. A 140-mm, two-third ring was attached to the forefoot with wires at the base of the first metatarsal bone and the mid-diaphyseal of the fifth bone. The ring was perpendicular to the axis of the metatarsal bones. A 130-mm, two-third ring was attached at the calcaneus, parallel to the tibial ring. Two crossed olive wires and a half-pin that went through the longitudinal axis of the calcaneus were inserted. During the forefoot correction, a calcaneal ring was connected to the tibial ring so that the posterior composition was more stable (Fig. 3).

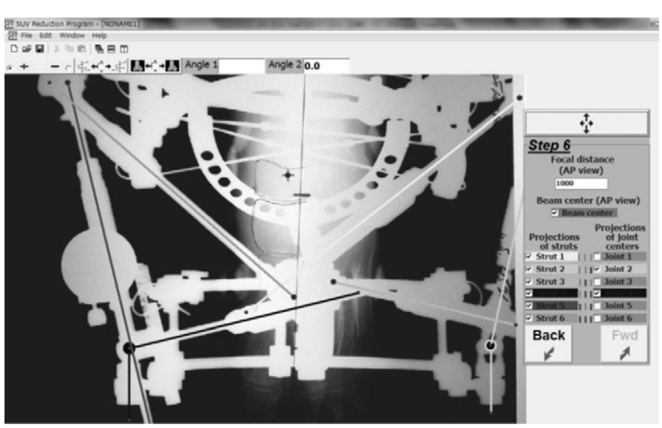

Fig. 2. Input screen of the Ortho-SUV Frame™ program. The direction of the 6 struts and joints are traced on the imported anteroposterior and lateral radiographic images. After inputting the data, confirmation steps can be acquired.

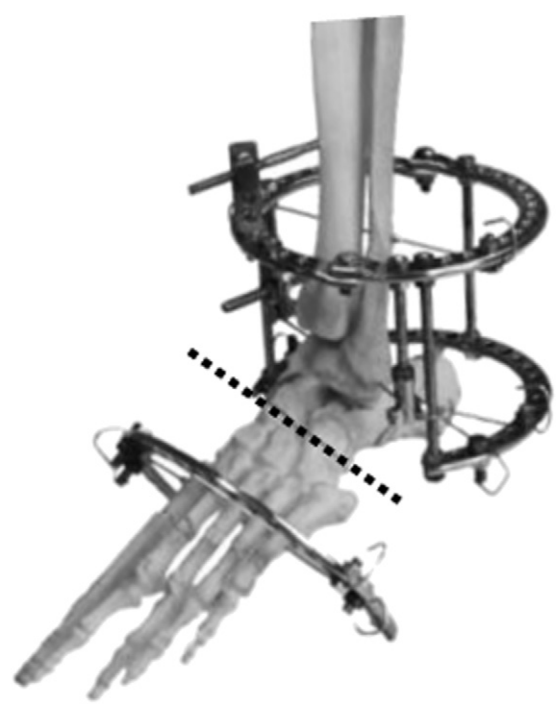

Fig. 3. Basic assembly for forefoot corrections. The tibial ring was fixed 60 mm away from the ankle joint and connected to the calcaneal two-third ring. A wire was inserted into the talus, which was connected to the tibial ring by rods. The two-third ring was attached to the metatarsi. An osteotomy was performed at the navicular–cuboid bone.