ELSEVIER

Operative Techniques in
Orthopaedics

An Introduction to the Taylor Spatial Frame for Foot and Ankle Applications

Dane K. Wukich, MD, and Ronald J. Belczyk, DPM

The Taylor Spatial Frame (TSF; Smith & Nephew Memphis, TN) is an advanced orthopaedic modality that uses the Ilizarov priciples to correct deformities via an external hexapod. Typically, it is used to correct severe deformities that are not amenable to other methods of acute correction or fixation. Historically, these complex deformities have been corrected with the Ilizarov principles and components. Currently, advances in deformity planning, hardware, and software analysis have made correcting severe foot and ankle deformities much easier. This article gives an overview of the indications and contraindications of the TSF, it reinforces the basic principles of deformity planning, and it introduces the different designs of the TSF available.
Oper Tech Orthop 16:2-9

KEYWORDS **foot and ankle, TSF, Taylor Spatial Frame, Ilizarov, Paley, Stewart platform, equinus, equinovarus, Charcot, rockerbottom**

The Taylor Spatial Frame (TSF; Smith & Nephew, Memphis, TN) is an advanced orthopaedic modality that uses the Ilizarov priciples to correct deformities via an external hexapod.[1] Typically, it is used to correct fractures, limb deformity, and limb length discrepancies.[2] Historically, simultaneously correcting a 3-dimensional deformity with angular and translational components has been fraught with difficulty because of the limitations of Ilizarov components. Our increased understanding of deformity in 3 dimensions, coupled with advances in hardware and software analysis, have made correcting severe foot and ankle deformities technically easier. Paley's principles of preoperative planning and CORAnalysis have simplified our ability to describe 3-dimensional deformities in a reproducible manner.[3] The TSF is supported with software (Smith & Nephew) to analyze the deformity parameters of interest.[4] The software analyzes spatial displacements and transformations and prints out a prescription based on the clinician's treatment goals. The patient then assists in their treatment by daily strut adjustments.

Foot and Ankle Division, Department of Orthopaedic Surgery, University of Pittsburgh Medical Center, Pittsburgh, PA.

Address reprint requests to Dane K. Wukich, MD, Department of Orthopaedic Surgery, University of Pittsburgh Medical Center, Kaufmann Building, Suite 911, 3471 Fifth Ave, Pittsburgh, PA 15213. E-mail: wukichdk@upmc.edu

History

The historical concept for how the TSF works can be attributed to the development of projective geometry, Chasles axis, and the technological advances of the Stewart platform. The field of projective geometry, as developed by Gerard Desarques, Blaise Pascal, and Phillipe de la Hire, laid the foundation for understanding the relationship between lines, planes, and points, which was later incorporated in several mathematical theories.[3]

The Mozzi-Chasles' theorem states that "the most general rigid body displacement can be produced by a translation along a line followed by a rotation about that line." Because this displacement is reminiscent of the displacement of a screw, it is called a screw displacement, and the line or axis is called the screw axis. Arbitrary motion of a rigid body can be represented by a screw-like motion.[3,5,6]

The TSF is basically a Stewart platform that uses the Chasles axis. Originally described in 1965, the Stewart platform created a platform with 6 degrees of freedom. By controlling the lengths of single distractors, independent screw-like movements of the fixator's rings result. Through an appropriate combination of the 6 distractors, displacements and rotations can be obtained in all spatial degrees of freedom.[7] By using a platform with 6 degrees of freedom, the TSF permits spatial displacements and translations. Currently, this type of device allows for 3-dimensional positioning of platforms and is used in flight simulators and robotics.[7] Flight simulators use this technology for controlling the ori-

 1048-6666/06/$-see front matter
doi:10.1053/j.oto.2006.02.001

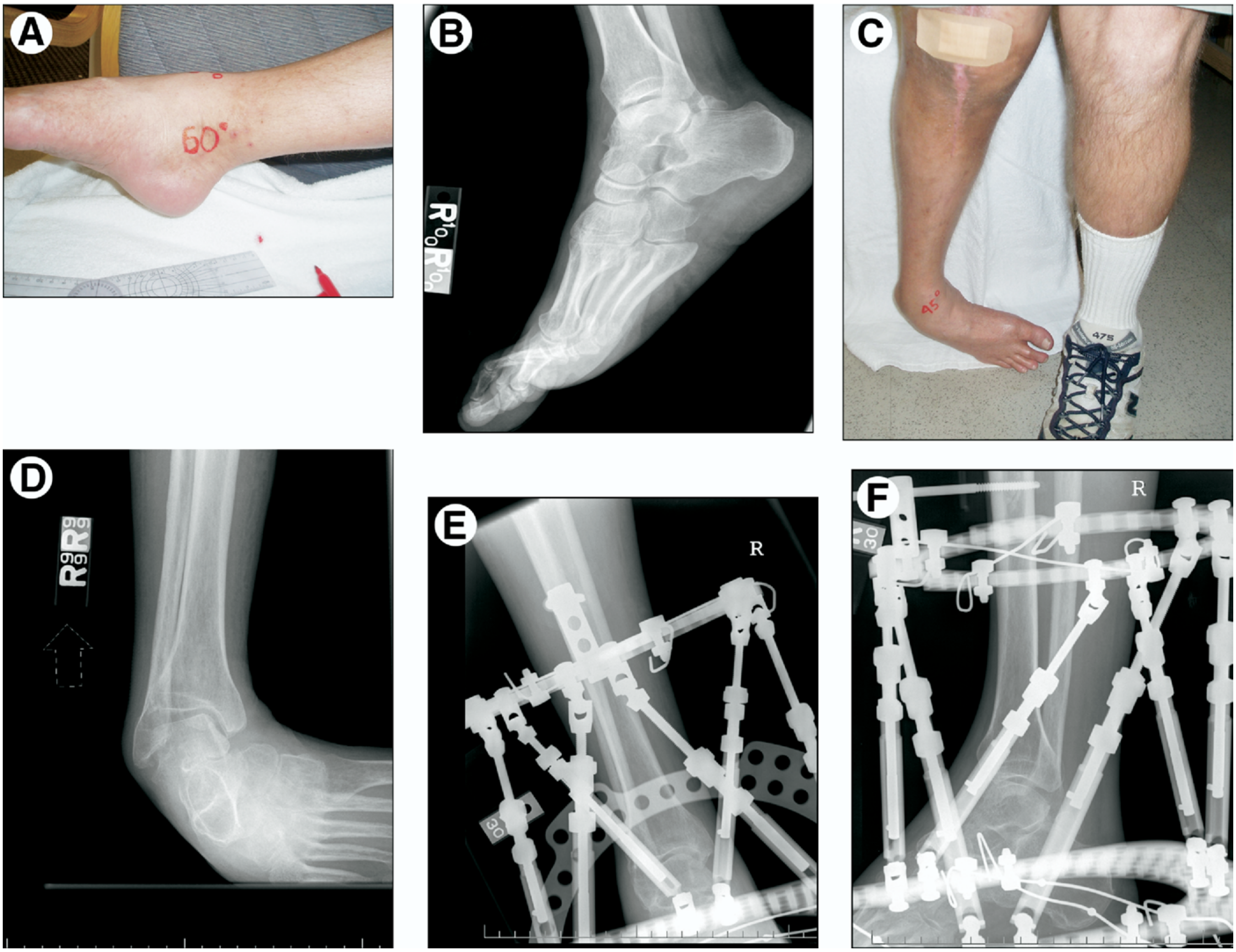

Figure 1 (A-D) AP and lateral clinical pictures and radiographs of a 35-year-old man with fixed equinovarus deformity secondary to iatrogenic peroneal palsy after a total knee replacement. (E and F) Radiographs after treatment using TSF. (Color version of figure is available online.)

entation of the cockpit. Another example of its use is in robotics for the Rutger's ankle,[8] which is a forced feedback device based on the Stewart platform used for developing strength, flexibility, and proprioception to ankles for posttraumatic healing or prevention of repeat injuries. Currently, researchers are developing a protocol for telerehabilitation of the ankle.[8]

Orthopaedic application of the Stewart platform was introduced in 1994 by Charles Taylor, MD, in Memphis, Tennessee.[9] By combining software analysis to an external hexapod allowed for accurate correction of angular deformity. Currently, with the development of foot-specific frames and software, severe foot and ankle deformity can be addressed by this treatment modality.[4]

Indications of TSF

The indications of the TSF for the foot and ankle are numerous but should be reserved for severe deformities that are not braceable. Some deformities are not amenable to acute correction secondary to patient's current medical status, past surgical history, active infection, or poor skin quality. The TSF can be used for fracture reduction and stabilization. Primary ring position is not critical to the mounting of the external fixator. Reduction does not have to be performed during the operation and can be done during an appropriate interval to provide optimal care of the soft tissues.[7] Traditionally, olive wires are used for direct reduction of fracture fragments, but the TSF allows reduction of the fracture with respect to a stationary reference fragment.[1]

Equinus or equinovarus deformity can be a complex deformity involving ankle joint contracture and subluxation which can be a congenital abnormality, or acquired after spastic neuromuscular disorders, neuropathic fractures and dislocations, posttraumatic ischemic contractures, peroneal palsy, burn injuries, or iatrogenic after limb-lengthening procedures. When equinus deformity has not improved after the use of physical therapy modalities and splinting, operative treatment frequently involves lengthening of the Achilles tendon[10] with or without a posterior capsule release. An open