The Evolution of Limb Deformity

What Has Changed over the Last Ten Years?

Jessica L. Wilczek, DPM*, Guido A. LaPorta, DPM, MS

KEYWORDS

• Deformity • Limb • Correction • Planning • External fixation

KEY POINTS

- Evaluation of deformity on standard radiographs fosters the notion that lower extremity deformity is 2-dimensional.
- The extremity is, however, a 3-dimensional structure and deformity usually occurs in 3 planes.
- The initial step in accurate correction involves the ability to assess this 3-dimensional deformity.
- All bone deformities can be characterized by 6 parameters, 3 angulations, and 3 translations.
- The complexity of these deformities may make acute correction difficult and in some cases impossible.

INTRODUCTION

Traditional revisional, reconstructive, and deformity correction surgery of the foot, ankle, and distal tibia is usually accomplished by acute correction followed by internal fixation. Certain clinical situations, such as segmental osseous defects, osteomyelitis, Charcot foot and ankle, multiplane deformities, and soft tissue loss may be more amenable to external fixation. External fixation can be used for acute or gradual correction either by traditional Ilizarov methods or computer hexapod–assisted devices such as the Taylor spatial frame (TSF). Regardless of the strategy, the surgeon must be knowledgeable about deformity planning, osteotomy principles, and the tension-stress effect[1,2] on bone and soft tissue. This article presents the fundamental concepts necessary to successfully apply the TSF for foot and ankle deformity.

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Department of Graduate Medical Education and Podiatric Surgery, Our Lady of Lourdes Memorial Hospital, 169 Riverside Drive, Binghamton, NY 13905, USA
* Corresponding author.
E-mail address: jessicawdpmlourdes@gmail.com

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TAYLOR SPATIAL FRAME

The TSF represents an elegant advancement to the Ilizarov external fixation system. Designed by J. Charles and Harold S. Taylor in 1994 and used in clinical practice since 1996, the TSF, in its basic form, is represented by 2 rings (or ring segments) connected by 6 telescopic struts with special connecting bolts. The struts are free to rotate at their connection points to the proximal and distal rings. Adjusting the length of the struts will reposition 1 ring with respect to the other. The TSF applies the concept of the Stewart[3] platform and Chasles[4] theorem to correct both 1 and 2 level deformities. The Stewart platform,[5] which serves as the basis for flight simulation, uses 6 struts and can move an object in space in any direction by adjusting the length of the struts. Correction of length, angulation, translation, or rotation, either sequentially or simultaneously, can be accomplished with the same basic construct. The number of struts coincides with the number of correction axes and provides appropriate stability to the construct. Each strut of the TSF is axially loaded without bending forces. The orientation of the struts is triangular rather than circular, resembling a very stable octahedron (crystalline structure of diamonds). The TSF has 1.1 times the axial stiffness, 2 times the bending stiffness, and 2.3 times the torsional stiffness when compared with a traditional Ilizarov-type circular frame.[6]

The TSF can be prebuilt to mimic a particular deformity (chronic method) or the rings may be individually applied, as perpendicular as possible, to its respective osseous segment with telescopic struts applied as a final step (rings first method). The authors have generally used the rings first method for most foot and ankle deformities. Specialized constructs, available since 2004, have been designed for foot deformities. The workhorse constructs for most foot deformities are the butt frame and miter frame. A lobe frame is also available but rarely used because of stability concerns.

SYSTEM COMPONENTS

The components of the TSF provide the same versatility and flexibility as the original Ilizarov system. The use of these components will not be discussed in detail here. One important feature is the presence of tabs on the rings, ring segments, and foot plates that serve as attachments for the adjustable struts. One of these tabs is designated the master tab and has a specific position and importance. During frame assembly, the following principles must be adhered to. First, the master tab is always located on the proximal ring regardless of which ring is chosen as the reference ring. When using a proximal reference, the master tab references the position of the entire construct. Therefore, second, the master tab should always be located directly anterior. If it is not directly anterior, a rotary frame offset, representing the amount of internal or external rotation of the master tab, must be entered in the software. It should be noted that most foot constructs have a 180° rotary frame offset because the master tab is located directly posterior to the leg or plantar to the foot as opposed to anterior. Third, the master tab serves as the connection for struts 1 and 2. Fourth, looking at the construct from the proximal to the distal ring, the struts are arranged from 1 through 6 in a counterclockwise direction regardless of which extremity the frame is applied to. Fifth, when using a distal reference, the tab located between struts 1 and 2 on the distal ring is used as the anterior reference. This tab is referred to as the anti–master tab and should be located directly anterior to the distal fragment. Should it not be directly anterior, a rotary frame offset representing the amount of internal or external rotation of the anti–master tab must be entered in the software.