Treatment Strategies and Frame Configurations in the Management of Foot and Ankle Deformities

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KEYWORDS

• Circular external fixation • Hexapod frame configurations • Foot and ankle • Hexapod assemblies • Classification • Ring fixation • Deformity correction

KEY POINTS

- Despite the widespread use of hexapod circular external fixation for fracture reduction and bone deformity correction, there is no common nomenclature/classification of frame assemblies.
- We propose a unique approach to making the decision on whether to use a hexapod or Ilizarov-type fixator based on the correction, complexity, and ability to achieve the correction acutely.
- Various hexapod frame configurations for foot and ankle deformity correction were combined into a classification based on correction levels, fixation blocks, and direction of the strut attachments.
- This classification allows the combination of foot and ankle frame assemblies into a few standard hexapod configurations irrespective of which external fixator is used.
- Using the proposed nomenclature, this classification can be further expanded to include nonhexapod frames.

INTRODUCTION

G. Ilizarov laid the basis for a revolutionary way to treat foot and ankle deformities using various external fixation assemblies. His method has increased in popularity and evolved significantly over the last decades. The success of the method is based on

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an extremely flexible approach to the external stabilization of tibia and foot bones. The Ilizarov system is very versatile and allows for an almost infinite number of frame configurations, using a lot of components to permit an accurate solution of every foot pathology.[1,2] Unfortunately, this versatility has its negative side—for each particular foot pathology, the surgeon has to build these assemblies from scratch, often using a great number of different components.[1,3] Because of this limitation, newer advances in the circular external fixator technology, namely hexapod fixators, have developed.

These fixators provide the ability to accurately adjust the bone fragment position in all 3 axes by adjusting just the length of 6 interconnecting struts. The 6 struts that connect the rings are arranged in a specific configuration creating a parallel kinematic system or Stewart-Gough platform.[4,5] Parallel in this description means that correction of the position can be performed simultaneously (parallel) in all directions. Therefore, these fixators provide accurate simultaneous 3-dimensional adjustments of fragment position across a variety of clinical indications, including fracture management, deformity correction, limb lengthening, and joint arthrodesis. The ability to simultaneously correct complex deformities make hexapod frames especially attractive to manage foot and ankle deformities, where it is very rare that there is only 1 level of 1-plane deformity.[5–8] Severe deformities like recalcitrant clubfoot, neurologic foot, collapsed Charcot foot, and posttraumatic sequelae are examples of these complex foot and ankle problems that can be managed using hexapod external fixators.[8–10]

Despite the obvious advantages of the hexapod fixators, there are certain difficulties in building and adjusting these frames. Foot deformity correction is especially challenging, because these complex multiplanar deformities often require multiple levels of correction in quite a limited space. Despite the ease of hexapod strut adjustment, frame design and construction can be complex. Very often, because of severe deformity, the frame configuration is altered, and the fixator may be even too small to fit 6 struts.

All of these limitations result in difficulties in communication between surgeons and complicate the learning of these techniques. First attempts to standardize the nomenclature and description of the hexapod frames for foot and ankle were attempted by Taylor.[6,7] In an attempt to describe these quite elaborate constructs he brought some carpentry terms into the external fixation (miter or butt constructs) and even more colloquial frame names like Tennessee torpedo.[5,11]

Takata and colleagues[12] presented foot hexapod assemblies classification based on the frame position relative to the foot, orientation of the axis of the hexapod, and direction of the struts attachment to the reference ring. This classification seems quite ambiguous, because very similar assemblies were classified differently. Also, it is extremely difficult to use this classification with other hexapod systems.

Another level of difficulty is introduced with the necessity to use software to plan correction. The software requires the measurement and entry of 3 sets of parameters (deformity, mounting, and correction parameters). Using an algorithm, the software calculates when and how to adjust each of the 6 struts at each level of correction.[6,7] These instructions are then available to the patient as a prescription or adjustment schedule.

MODULAR CLASSIFICATION OF FOOT AND ANKLE DEFORMITY CORRECTION AND FRAMES ASSEMBLIES

The absence of common nomenclature brings the need to introduce a novel circular fixator design classification that encompasses all possible frame adaptations without the use of colloquial terms. There is also a need for a simple decision-making algorithm to decide when and why a hexapod frame can be more beneficial than a traditional Ilizarov-type fixator. Therefore, we propose a new modular approach to foot and