Intraoperative Use of External Fixator Attachments for Reduction of Lower Extremity Fractures and Dislocations

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Abstract

The mainstay of complex open lower extremity fractures and dislocations is the temporizing external fixator. We propose the use of external fixator attachments that allow for the reduction of fractures and dislocations intraoperatively. By using external fixator carbon fiber rods, the surgeon is able to create a capital "T" (sweet T) shaped attachment and connect this to a Schanz pin. Simultaneously, the external fixator carbon fiber rods can be configured into the shape of a capital Greek letter pi (Cherry II) and applied to an external fixator pin. When both of these configurations are used, multi-directional forces can be applied across the fracture fragments with the added benefit of using extrinsic hand muscle power for force generation and manipulation of fracture fragments to facilitate reduction.

External fixation has a long history both for initial open or closed management of fractures and for definitive management.[1] After the introduction of internal fixation constructs using nails or plates, external fixation largely transitioned from a means of definitive management to a temporizing measure taken before definitive internal fixation.

The Delta Frame external fixator (DePuy Synthes), which is used for significantly swollen ankle and pilon fractures, features anteromedially placed tibial shaft pins and a transcalcaneal pin. For distal tibia fractures that are not amenable to urgent internal fixation because of the degree of swelling or soft-tissue injury, it provides ligamentotaxis and traction for reduction of fracture fragments and stabilization.[2]

Numerous other external fixator configurations, such as knee-spanning or tibia-spanning external fixators, can be used for similar purposes. These stabilization methods are all minimally invasive and thus cause little trauma to the zone of injury[3] and give soft-tissue injuries time to heal before definitive internal fixation.

Several different external fixator configurations can be used for a variety of fracture patterns and locations, but we propose using the external fixator as a starting point and adding proximal and distal attachments. These attachments have the potential to create more reduction force, and they provide more control of proximal and distal fracture fragments, continue to be minimally invasive, offer extrinsic grip power, are easily assembled and disassembled for intraoperative fracture reduction, and reduce the surgeon's radiation exposure.

Take-Home Points

- External fixator attachments are fast and easy to assemble with existing external fixator equipment.
- They allow for multi-directional force application and use of extrinsic power grip.
- They limit radiation exposure and provides unobstructed line of sight to zone of injury.
- The attachments can then be removed once reduction is achieved.

Materials and Methods

Our institution employs an external fixator system that is often used for high-energy lower extremity pathology. This system facilitates assembly of a Sweet T–Cherry II configuration. For periarticular ankle injuries, a Delta Frame

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external fixator is applied as described in the AO (Arbeitsgemeinschaft für Osteosynthesefragen) surgical reference. Two diaphyseal Schanz pins are inserted into the tibia anterior to posterior based on the pin-placement guide and confirmed with fluoroscopy. These pins must be positioned close enough to the fracture site to provide stability, but not so close as to enter the zone of injury. A Denham pin is placed in the calcaneus medial to lateral. Care is taken to avoid the posterior tibial neurovascular bundle. Then, with use of pin-carbon fiber rod connectors, rods are attached so the Schanz pins connect with the Denham pin. In Sweet T–Cherry II assembly, a different rod configuration is used; rods are attached to the proximal-most Schanz pin and the Denham pin. In Sweet T assembly, a rod-rod connector is used to attach 2 carbon fiber rods to each other. These rods are orthogonally connected in a T shape. A pin-rod connector is then used to attach the assembled apparatus to the proximal-most Schanz pin. **Figure 1** shows the assembled Sweet T.

Next, in Cherry II assembly, 2 carbon fiber rods are attached to and locked to the Denham pin, one medial and the other lateral in an orientation orthogonal to the Denham pin extending distally. The Cherry II apparatus is completed with a third rod and is placed parallel to the Denham pin and orthogonal to the first 2 rods. **Figure 2** shows the assembled Cherry II, and **Figure 3** shows the fully assembled Sweet T–Cherry II external fixator configuration. After the fully assembled external fixator is fitted with the Sweet T and Cherry II attachments, the attachments are used to manually reduce the fracture, the reduction is confirmed with fluoroscopy, and the external fixator connectors are locked to maintain the reduction.

For knee-spanning external fixators, 2 Sweet T assemblies can be attached to the 2 Schanz pins. Furthermore, if 2 transverse pins are used for tibial external fixation, 2 Cherry II attachments can be used for multidirectional traction. An added benefit is extrinsic grip power, vs the intrinsic grip power provided with use of only the Schanz and Denham pins.

Results

The fully assembled apparatus provides a firm, well-fixed configuration for applying traction in multiple directions. Axial traction can be applied, as can anterior or posterior translation forces,

Figure 1. Assembled Sweet T attached to the proximal-most Schanz pin.

Figure 2. Assembled Cherry II attached to the calcaneal Denham pin.

Figure 3. Completely assembled Sweet T and Cherry II fracture reduction system.

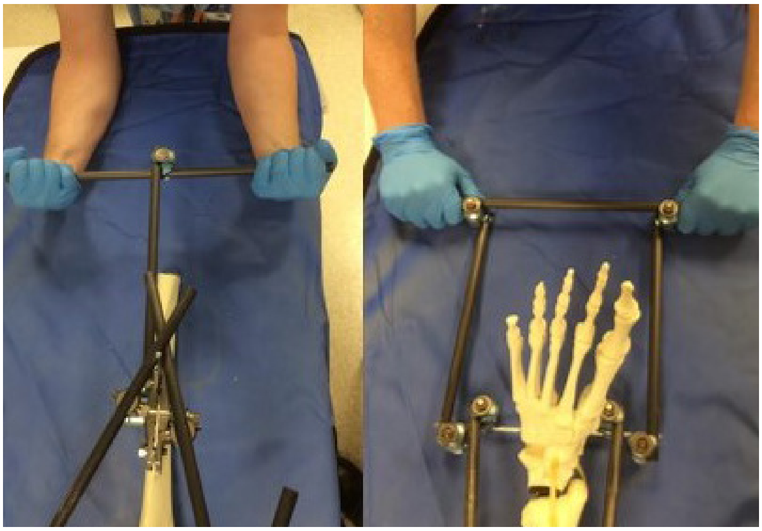

Figure 4. Use of extrinsic power grip with Sweet T and Cherry II external fixator attachments.

which may be helpful in fracture reduction and joint dislocation. For difficult-to-reduce fractures or dislocations, the surgeon can apply multidirectional traction distally while the assistant applies countertraction proximally. Fracture reduction is confirmed with fluoroscopy, and the external fixator is locked in position to maintain reduction. After reduction is confirmed, Sweet T and Cherry II are easily removed. The end result is a reduced fracture or dislocation that has the typical appearance of the temporizing external fixator.

Discussion

The Sweet T–Cherry II configuration is assembled quickly and can aid the orthopedic surgeon and assistant in managing trauma cases involving difficult-to-reduce fractures. The principle is the same as in any other traction-countertraction model, though the materials required for assembly are already available to the surgeon, and additional equipment is not required. Furthermore, the large size of the attachments has the potential to offer more points of manipulation by the surgeon and assistant, when compared with Schanz and Denham pins alone. The configuration allows full extrinsic grip power as well (**Figure 4**), whereas only intrinsic hand power is allowed with traction applied through Schanz and Denham pins alone. In addition, one operator applying proximally directed traction and the other applying distally directed traction may generate more force than that obtained with the standard external fixator configuration and may reduce fractures that would otherwise be irreducible by closed means.

These attachments also have the potential to reduce surgeon and assistant radiation exposure. By positioning Sweet T and Cherry II proximally and distally, with the fluoroscopy machine over the zone of injury, the operators of the attachments increase their distance from the source of radiation. This strategic positioning decreases radiation exposure and reduces direct and scatter energy from the fluoroscopy machine and the patient.[4] In addition, with the operators of the attachments farther from the zone of injury, the surgeon has a clear and direct view of the procedure, which may otherwise be obstructed with use of tensioning devices or conventional external fixator configurations. Sweet T and Cherry II attachments theoretically could be used for any configuration that uses proximal and distal fixation points. There is also the added benefit that these attachments are not restricted to applying traction axially but can also translate fracture fragments anteriorly, posteriorly, medially, or laterally, which has the potential to aid in reducing fractures and dislocations with varying degrees of translation, not only shortening. Although these attachments have mechanical counterparts, such as femoral distractors and other tensioning devices, the counterparts may take longer to assemble, apply, and activate. Sweet T and Cherry II attachments are included in the external fixator equipment and may generate more force and control while achieving reduction and stabilization similar to those achieved with other traction or tensioning devices. In addition, other tensioning devices may be cumbersome and unwieldy relative to Sweet T and Cherry II. For these attachments, research is needed on forces generated, time of assembly, and ease of use.

Conclusion

The Sweet T and Cherry II external fixator attachments have the potential to aid in managing difficult-to-reduce complex fractures and dislocations. These attachments are quickly assembled and may generate more force than does reduction with Schanz and Denham pins alone. The shape of these attachments may also provide a more comfortable and easier-to-manipulate base for application of traction in multiple directions. An added benefit is extrinsic grip power. Use of these attachments also has the potential to reduce operator radiation exposure and may provide an unobstructed view of the operative field, as the attachment operators are farther from the zone of injury. In addition, the materials used to assemble these attachments are included in almost all external fixation sets. More research comparing standard external fixator configurations with external fixator configurations using Sweet T and Cherry II attachments is needed.

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This paper will be judged for the Resident Writer's Award.