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Circular fixator system and method

Abstract

A device includes a plurality of rings. Each ring has a first face, a second face, and at least one slot defined by first and second interior edges of the ring on opposing sides of the slot. The at least one slot penetrates from the first face to the second face. The first face of each ring has a first recess adjacent the slot on the first edge and a second recess adjacent the slot on the second edge. A plurality of posts join each one of the plurality of rings to an adjacent one of the plurality of rings.

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Background/Summary

(1) This application is a continuation of U.S. patent application Ser. No. 17/644,357, filed Dec. 15, 2021 (now U.S. Pat. No. 11,918,251), which is a continuation of U.S. patent application Ser. No. 16/822,265, filed Mar. 18, 2020 (now U.S. Pat. No. 11,234,737), which is a continuation of U.S. patent application Ser. No. 15/773,665, filed May 4, 2018 (now U.S. Pat. No. 10,624,674), which is a national phase entry under 35 U.S.C. § 371 of international patent application no. PCT/US2016/055747, filed Oct. 6, 2016 which claims the benefit of priority of U.S. Provisional Patent Application No. 62/254,489, filed Nov. 12, 2015, all of which are expressly incorporated herein by reference in their entireties.

FIELD
(1) This application pertains generally to medical devices, and more particularly to a circular fixator.
BACKGROUND
(2) For most standard triple arthrodesis procedures, a prebuilt frame including two tibial rings and a foot plate with an extension can be utilized. A Circular Fixator system can be used for open or closed fracture fixation, pseudoarthrosis or nonunions of long bones, limb lengthening by epiphyseal or metaphyseal distraction, correction of bony or soft tissue deformities, or correction of segmental or nonsegmental bony or soft tissue defects. Circular Fixators have been used on long bones including: the tibia, fibula, femur, humerus, radius and ulna.
(3) Prior to insertion of wires or pins, the circular fixator is positioned around the tibia and foot. The leg is eccentrically located in the frame to accommodate the posterior musculature, and the plantar aspect of the foot extends above or below the foot plate. To maintain the tibia and foot in position, folded up towels can be placed under the calf.
(4) The surgeon inserts wires through the bones, and secures the wires to the frame using bolts that are inserted into holes in the rings and foot plate of the frame.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
(1) FIG. **1**A is an isometric view of a circular fixator according to some embodiments.
(2) FIG. **1**B shows a patient's leg positioned in the circular fixator of FIG. **1**A.
(3) FIG. **1**C shows the patient's leg fixed in the circular fixator of FIG. **1**A.
(4) FIG. **2**A is a plan view of the circular fixator of FIG. **1**A.
(5) FIG. **2**B is a posterior side elevation view of the circular fixator of FIG. **1**A.
(6) FIG. **3** is a side elevation view of the circular fixator of FIG. **1**A.
(7) FIG. **4**A is an isometric view of a variation of the circular fixator of FIG. **1**A having recess pockets (without scallops).
(8) FIG. **4**B is a plan view of the device of FIG. **4**A.
(9) FIG. **5** is an isometric view of one of the fixation elements of FIG. **1**C.
(10) FIG. **6** is a side elevation view of the fixation element of FIG. **5**.
(11) FIG. **7** is an isometric view of an embodiment of the fixation element further including a post.

(12) FIG. **8** is a front elevation view of the fixation element of FIG. **7**.
(13) FIG. **9** is a cross sectional view taken along section line **9**-**9** of FIG. **8**.
(14) FIG. **10** is an enlarged detail of FIG. **9**.
(15) FIGS. **11**A and **11**B are isometric and plan views of a medial-lateral foot support shown in FIG. **1**A.
(16) FIGS. **12**A and **12**B are plan and side views of another embodiment of a medial-lateral foot support suitable for use with the circular fixator of FIG. **1**A.
(17) FIG. **13** is an isometric view of a mounting device for the foot support shown in FIG. **11**.
(18) FIG. **14** is an isometric view of a medial-lateral leg support shown in FIG. **1**A.
(19) FIG. **15** is an isometric view of an anterior leg positioner shown in FIG. **1**A.
(20) FIGS. **16**A and **16**B are left and right side elevation views of the leg positioner shown in FIG. **15**.
(21) FIGS. **17**-**19** are isometric, left side and anterior elevation views of the positioner body shown in FIG. **15**.
(22) FIGS. **20** and **21** are isometric and posterior elevation views of one of the support devices shown in FIG. **15**.
(23) FIG. **22** is an isometric view of a wire drill guide for inserting the wires shown in FIG. **1**C, with the tip extended.
(24) FIGS. **23**-**25** are front, side and top plan views of the wire drill guide shown in FIG. **22**.
(25) FIG. **26** is a cross sectional view taken along section line **26**-**26** of FIG. **25**.
(26) FIG. **27** is an exploded view of a second embodiment of the wire drill guide with combined tip and socket.
(27) FIG. **28** is a side elevation view of the wire drill guide of FIG. **27**.
(28) FIG. **29** is an exploded view of a third embodiment of the wire drill guide with combined barrel and socket.
(29) FIG. **30** is a side elevation view of the wire drill guide of FIG. **29**.
(30) FIG. **31** is an isometric view of the plug shown in FIG. **1**B.
(31) FIG. **32** is a cross sectional view of the plug of FIG. **31**.
(32) FIGS. **33** and **34** are isometric and plan views of a wrench used to tighten the fixation elements and pin of FIG. **1**C.
(33) FIGS. **35** and **36** are front and rear isometric views of a clip for securing a sponge to one of the wires or rods of FIG. **1**C.
(34) FIG. **37** is a front end view of the clip of FIG. **35**.
(35) FIG. **38** is a rear end view of the clip shown in FIG. **36**.
(36) FIG. **39** is a top plan view of the clip shown in FIG. **35**.
(37) FIG. **40** is a cross sectional view taken along section line **40**-**40** of FIG. **39**.
(38) FIG. **41** is a side elevation view of one embodiment of a rocker plate, according to some embodiments.
(39) FIG. **42** is a plan view of the rocker plate shown in FIG. **41**.
(40) FIG. **43** is a side view of the rocker plate shown in FIG. **41**.
(41) FIG. **44** is a side elevation view of a slider, according to some embodiments.
(42) FIG. **45** is a side view of the slider shown in FIG. **45**.
(43) FIG. **46** is a plan view of the rocker plate having a plurality of counterbores formed therein, according to some embodiments.
(44) FIG. **47** is a side elevation view of the rocker plate of FIG. **46** coupled to a circular fixator, according to some embodiments.

DETAILED DESCRIPTION

(45) This description of the exemplary embodiments is intended to be read in connection with the accompanying drawings, which are to be considered part of the entire written description. In the description, relative terms such as “lower,” “upper,” “horizontal,” “vertical,”, “above,” “below,”

“up,” “down,” “top” and “bottom” as well as derivative thereof (e.g., “horizontally,” “downwardly,” “upwardly,” etc.) should be construed to refer to the orientation as then described or as shown in the drawing under discussion. These relative terms are for convenience of description and do not require that the apparatus be constructed or operated in a particular orientation. Terms concerning attachments, coupling and the like, such as “connected” and “interconnected,” refer to a relationship wherein structures are secured or attached to one another either directly or indirectly through intervening structures, as well as both movable or rigid attachments or relationships, unless expressly described otherwise.

(46) The present disclosure provides circular fixators comprising rings with a plurality of slots for attachments of fixation devices. The fixation devices fix the wires that inserted into the patient's leg and/or foot, for example. The circular fixator can be used for other extremities with different variations of the structures as described herein. In some embodiments, the fixation devices include bolts with side slots, for receiving the wires. The fixation devices can be pre-assembled and pre-loaded onto the circular fixator (e.g., by a scrub technician) prior to the arrival of the surgeon in the operating room. After inserting the wire, the surgeon can quickly and easily slide the pre-loaded fixation device into position for capturing the wire in a side slot of the fixation device. In some embodiments, the rings have recesses. The recesses can include receptacles such as scallop-shaped recesses, curved recesses, V-shaped recesses, rectangular, semi-hexagonal, semi-octagonal, or recess pockets on both sides of the slots, and recesses adapted to receive the fixation devices, and prevent them from slipping in the tangential direction when the surgeon applies tension to the wires for compression or distraction of joints or fractures. In some embodiments, the fixation devices include washers adapted to fit in respective recesses. The fixation device is configured to fit in the receptacle. In some embodiments, at least one edge of the fixation device can be received by the receptacle, even though the shape of the fixation device is different from the shape of the receptacle. For example, a rectangular receptacle can receive a hexagonal fixation device, and two sides of the receptacle will engage two opposite sides of the hexagonal fixation device to prevent slippage.

(47) In some embodiments, one or more of the fixation devices include posts for providing an offset between the plane of the ring and the fixation bolt. In some embodiments, the posts have horizontal grooves and the washer has a ridge for engaging one of the grooves of the post, to prevent the bolt from slipping on the post. In some embodiments, the posts are adapted to fit in the recesses.

(48) In some embodiments, leg positioners are provided for supporting the leg and foot in a neutral position or other desired position during the procedure. In some embodiments, the leg positioners can be positioned and affixed to the circular fixator quickly and easily without using any tools, and the leg positioners have support elements, which can be quickly and easily adjusted without using tools for positioning the leg.

(49) FIG. **1**A is a an isometric view of a circular fixator **100** according to some embodiments of this disclosure. FIG. **1**B shows the circular fixator **100** of FIG. **1**A with a patient's foot drawn in phantom to show an exemplary use of the circular fixator for positioning the leg prior to and during the fixation procedure. FIG. **1**C shows the circulator fixator **100** with the patient's foot fixed by wires **412**, following the procedures. FIGS. **2**A, **2**B and **3** show plan, rear elevation and side elevation views of the circular fixator **100**.

(50) The circular fixator **100** is a device comprising a plurality of rings **102**, **130** and **142**. In some embodiments, one ring **102** of the plurality of rings is elongated. The elongated ring **102** has a proximal portion **102***a* and a distal portion **102***b*. The elongated ring **102** is configured so that the distal portion **102***b* can be rigidly attached to the first portion **102***a* in a first position parallel to or coplanar with the proximal portion **102***a*. As shown in phantom in FIG. **3** the distal portion **102***b* can be rigidly attached to the first portion **102***a* in a second position having a non-zero angle with respect to the proximal portion. In some embodiments, the non-zero angle is 90 degrees.

(51) In some embodiments, the plurality of rings include first and second circular rings **142**, **130** adapted to be positioned around a leg of a patient during fixation, and the first ring **142** is greater in diameter than the second ring **130** and **102**. This configuration permits the surgeon to maintain a constant distance. As a general rule of thumb, the clearance between the inner diameter of each ring and the nearest leg tissue is about two fingers' breadth (e.g., about 3.7 cm to about 4 cm), at different heights along the patient's leg. Similarly, if the fixator is adapted for use on another extremity, a similar clearance between the inner diameter of each ring and the nearest tissue is used. Because the patient's calf is greater in diameter further from the ankle, the top ring **142** is correspondingly greater in inner diameter than the middle ring **130**. Because the ring **130** is smaller, it reduces the moment arm for pins or wires. For example in one embodiment, the top ring **142** has an inner diameter of about 18 cm, and the middle ring **130** has an inner diameter of about 16 cm. This is just one example, and any combination of ring sizes can be used to accommodate the geometry of any given patient's calf.
(52) Each ring **102**, **130** and **142** has a first (e.g., top) face, a second (e.g., bottom) face, and at least one slot. For example, ring **102** has slots **104**, **110**, **116**, **122**; ring **130** has four slots, including slots **132**, **138**; and ring **142** has slots **144**, **150**, **154**, and **160**. Each slot is defined by first and second interior edges of its respective ring **102**, **130** and **142** on opposing sides of the slot. Each slot (e.g., **104**) penetrates from the first face of the ring (e.g., **102**) to the second face. The first (e.g., top) face of each ring (e.g., **102**) has a first scallop-shaped recess (e.g., **106***a*) adjacent the slot **104** on the first edge and a second scallop-shaped recess (e.g., **106***b*) adjacent the slot **104** on the second edge. The slot **104** terminates at an opening **108***a*, **108***b* at each respective end of the slot. The openings **108***a*, **108***b* have a dimension that is substantially greater than a width of the slot **106**. Similarly, in the example of FIG. **1**, slot **110** has scallop-shaped recesses **112***a*, **112***b* and end openings **114***a*, **114***b*; slot **116** has recesses **118***a*, **118***b* and end openings **120***a*, **120***b*; slot **122** has recesses **124***a*, **124***b* and end openings **126***a*, **126***b*; slot **132** has recesses **134***a*, **134***b* and end openings **136***a*, **136***b*; slot **138** has recesses **140***a*, **140***b* and end openings **141***a*, **141***b*; slot **144** has recesses **146***a*, **146***b* and end openings **148***a*, **148***b*; slot **150** has recesses **151***a*, **151***b* and end openings **152***a*, **152***b*; and slot **160** has recesses **162***a*, **162***b* and end openings **164***a*, **164***b*.
(53) In other embodiments, instead of a scallop-shaped recess **134***a*, **134***b*, **146***a*, **146***b*, one or more of the rings include recess pockets, as described below with reference to FIGS. **4**A and **4**B. In some embodiments the circular fixator includes at least one ring **102** having scallop shaped recesses **106***a*, **106***b*, **112***a*, **112***b*, **118***a*, **118***b*, and at least one ring having recess pockets, as described below in the discussion of FIG. **4**A.
(54) FIGS. **4**A and **4**B show a variation of the circular fixator **700**. In some embodiments, the circular fixator **700** includes the same bottom ring **102** as described above, with scalloped recesses on each side of each slot. The scallops provide additional protection against slippage of the fixation device, for example when tensioning a wire to compress or distract a joint. In some embodiments, the middle ring **702** has slots **712** with recesses **714***a*, **714***b* (without scallops) on each side of the slots **712**. Similarly, the top ring **704** has slots **716** with recesses **718***a*, **718***b* (without scallops) on each side of the slots **712**. In many procedures, the surgeon does not require compression or distraction of the foot or leg at the levels of the middle ring **702** or the top ring **704**. These rings **702**, **704** stabilize the leg. The rings **130**, **142** with scallops can be used at the upper levels of the leg as described above with reference to FIGS. **1-3**.
(55) However, if the upper and middle ring are only used for stabilization, the rings **702**, **704** without the scallops may permit the fixation device **300** to move toward the wire more quickly without any chance of becoming caught in a scallop. Additionally, the recesses **714***a*, **714***b*, **718***a*, **718***b* without scallops allow the surgeon to fix the fixation device **300** anywhere along the length of the slots, and the surgeon is not limited to any discrete set of fixed locations.
(56) When the wire is run perpendicular to the slots **712**, **716**, there is little chance that the fixation device **300** can slip in the slot. If the wires are to be run perpendicular or nearly perpendicular to

the slots, the surgeon may prefer that the rings **702**, **704** (without scallops) are used for ease of use. On the other hand, the greater the angle between the wires and the slots, the greater the benefit of the scallops, for preventing slippage.

(57) In other embodiments (not shown), all three rings **102**, **702**, **704** can be provided without scallops.

(58) The reference numerals of other features of the circular fixator of FIGS. **4**A and **4**B which are the same as the corresponding items shown in FIG. **1**A are omitted for ease of understanding, and their descriptions are not repeated.

(59) The device further includes a plurality of posts **270** joining each one of the plurality of rings **130**, **142** to an adjacent one of the plurality of rings. In some embodiments, the center ring **130** is connected to the top ring **142** by fixed posts **270**, and the center ring **130** is connected to the bottom ring **102** by a plurality of calibrated struts **260**. The calibrated struts permit accurate and even adjustments to the distance between the bottom ring **102** and the center ring **130** (e.g., for compression/distraction of the foot or height adjustments to the desired height). In some embodiments, all of the posts **270** are of the same fixed type (as shown in FIG. **4**A). In some embodiments, as shown in FIG. **1**A, one or more of the posts **270** can be replaced by suitably configured plates **271**, threaded rods, spacers, or struts. For example, the places **271** can each have a respective vertical slot **272**. Each slot **272** has openings **273** at the top and bottom of the slot. The slots **272** can have the same width as the slots **112***a*, **112***b*, and the openings **273** can have the same size as the openings **114***a*, **114***b*. The slots **272** of the plates **271** can receive fixations elements **330**, and the openings **273** can receive plugs **170**, for pre-loading the fixation elements **330**, in the manner described below. In other embodiments, any combination of posts **270**, plates **271**, rods, spacers and/or struts can be used.

(60) In some embodiments, each scallop-shaped recess (e.g., **112***a*, **112***b*) comprises a plurality of curved arcs, and each curved arc subtends an angle in a range from about 10 degrees to 170 degrees. In some embodiments, the subtended angle is in a range from 30 degrees to 150 degrees. In some embodiments, the subtended angle is in a range from 30 degrees to 150 degrees. In some embodiments, the subtended angle is in a range from 60 degrees to about 120 degrees. In some embodiments, each scallop-shaped recess comprises a plurality of circular arcs, each circular arc subtending an angle of about 90 degrees. The arcs subtend an angle that is sufficiently large to resist slipping of any fixation device **330** (FIG. **5**, described below) relative to the slot, particularly if any force component is applied to the fixation device **330** parallel to the direction of the slot (e.g., **110**). In some embodiments, the rings **102**, **130**, **142** comprise a metal, such as aluminum or titanium.

(61) In some embodiments, at least one of the fixation devices **300** comprises a bolt **330**, a nut **334** and a washer **340**. The bolt **330** has head **332** and a threaded portion **331** sized to fit through the slot (e.g., **112***a*, **112***b*). The bolt **330** includes a side slot **348** in a side surface of the threaded portion **331**, for receiving a wire (FIG. **1**C) The washer **340** is shaped to fit a respective one of the curved arcs on the scallop-shaped recess **114***a*, **114***b* on each side of the slot **110** of the ring **102**. In some embodiments, the washer **340** has a textured gripping surface **346** for securely positioning the wire. The washer **340** has two curved edges **343** adapted for fitting the curved arcs of the scallop shaped recesses. The remaining two edges of the washer can be flat. The gripping surface can have ridges, barbs, splines, slots, a knurled surface, or the like. In some embodiments, the opening (e.g., **114***a*, **114***b*) at each end of each slot (e.g., **112***a*, **112***b*) is adapted to receive a nut **334** of a fixation device **330** through the opening. In some embodiments, the slot (e.g., **112***a*, **112***b*) is adapted to receive a threaded portion **331** of the fixation device **330** through the slot, but the slot has a width that is smaller than a dimension of the nut **334**. Thus, once the nut **334** is affixed to the threaded portion **331**, the fixation device **330** can be inserted into the openings (e.g., **114***a*, **114***b*) but cannot fall out of the slots. The fixation devices can be pre-assembled, and the pre-assembled fixation devices can pre-loaded onto the slots prior to surgery. The openings (e.g., **114***a*, **114***b*) can be then

be plugged to prevent release of the fixation devices **330**.
(62) Some embodiments further comprise at least one post **302** (FIG. **7**) having a threaded body portion **314** adapted to fit through the slot (e.g., **110**) of the ring **102**. The post **302** has a longitudinal slot **307** (add to drawing) through the post (and parallel to the longitudinal axis of the post) for receiving the bolt **330** of the fixation device **300**. The post **302** has a mounting surface **303** for engaging a respective one of the curved arcs on the scallop-shaped recess (e.g., **112***a*) on each side of the slot (**110**). In some embodiments, the mounting surface **303** of the post **302** has two curved (e.g., circular) arc edges **310**, adapted to be received in one of the curved arcs on the scallop-shaped recess. In some embodiments, the mounting surface **303** of the post **302** has two flat edges **312**, which can be gripped in the jaws of a wrench or other suitable tool. The post **302** allows the surgeon to position the bolt **330** of a fixation device **300** at a height that is offset from the rings **102**, **130**, **142**.
(63) As shown in FIG. **7**, the post **302** has a plurality of grooves **306** on at least one side face of the post, oriented perpendicular to the length (longitudinal axis) of the post. In some embodiments the opposite side surface **304** of the post **302** is flat, as shown in FIG. **8**. In other embodiments, both side faces of the post have grooves **306**. The washer **340** includes a ridge **342** adapted to engage one of the grooves **306**. This prevents the bolt **330** from slipping relative to the post **302**, particular when a component of the force applied to the bolt **330** is parallel to the direction of the slot **307** of the post **302**. In some embodiments, the washer **340** is of the same type described above, and the ridge **342** is included on the face of the washer opposite the textured gripping surface **346**.
(64) In some embodiments, the surgeon can also insert rods **350** into the bone using the circulator fixator **100**. A pin cube **351** (FIG. **1**C) can be mounted in the slot (e.g., **154**, FIG. **1**C) for fixing the pin **350** (also referred to as a rod).
(65) In some embodiments, the surgeon tightens the bolts **330** using a ratcheting wrench **600** (FIGS. **33** and **34**) having an open socket that can slide over a threaded rod to tighten or loosen a bolt or nut. The wrench has a ratchet mechanism. In some embodiments, the ratchet mechanism includes a switch pin biased against a gear **610** by a spring to act as a pawl, to allow rotation in one direction. The wrench body **601** has an open end **605**, and the rotating socket **602** has an open end **603**. To place the wrench in position on the rod, the open end **603** of the socket is aligned with the open end **605** of the wrench body, as shown in FIGS. **33** and **34**. This wrench configuration is particularly useful for tightening or loosening threaded rod, bolts and nuts.
(66) In other embodiments (not shown), the switch pin is omitted. The direction of rotation of the wrench is fixed for applying torque only when rotated in one direction. A spring-biased piston with a beveled piston surface acts as a pawl that engages the gear **610** of the hexagonal socket **602** to allow one-way rotation of the hexagonal socket. The wrench **600** is oriented with one side facing upwards to apply torque for tightening bolts **330**, and with the other side facing upwards to apply torque for loosening the bolts. In some embodiments, indicia are placed on the wrench, so the user can quickly determine which side of the wrench should face upwards for any given tightening or loosening step.
(67) In some embodiments, as shown in FIGS. **31** and **32**, the device further comprises a plurality of detachable plugs **170**. Each plug **170** has a shape and size adapted to be detachably retained in a respective one of the openings (e.g., **114***a*), for retaining the bolt **330** in the slot **110** prior to tightening the nut **334** and bolt **330**. Each plug **170** has a compressible tubular end **176** and a ridge **180** for retaining the plug within a respective one of the openings **114***a*. The scrub technician can quickly and easily insert one of these plugs in each opening **114***a*, **114***b* of a slot **110** for retaining pre-assembled, pre-loaded fixation devices **330**, posts **300**, or pin cubes on the circular fixator.
(68) In some embodiments, the plug **170** includes a gripping portion **172**, which may include a gripping surface **174**, such as a contoured portion. The plug **170** further includes a plug portion **176**, which is shaped to fit the openings (e.g., **114***a*, **114***b*) at the end of each slot. For a circular opening (e.g., **114***a*), the plug portion **176** is generally shaped as a circular cylinder. The plug

portion **176** further includes a plurality of slots **178** oriented in the longitudinal direction. For example, the plug portion **176** may have four slots evenly spaced about the circumference of the plug portion **176**. The plug portion **176** further includes a ridge **180** for retaining the plug **170** in the opening **114***a*. The ridge is greater in diameter than the opening **114***a*. The slots **178** permit the members of the plug portion **176** to be squeezed together for insertion into, or removal from, the openings. The plug is made of a plastic materials such as acrylonitrile-butadiene-styrene (ABS).

(69) In some embodiments, a plurality of leg positioners hold the patient's leg in a neutral position while the surgeon inserts wires and/or rods in the leg. The leg positioners generally include at least one Y-shaped member (or round or curved member) having a concave or angled portion for supporting a limb of a patient, and a mounting device for attaching the positioner to one of the plurality of rings without a tool.

(70) FIGS. **1** and **11**A-**11**B show an example of a medial-lateral leg positioner **230**, in which the Y-shaped member **230** includes a support arm **231** having a slot **235** through the arm. An angled support member **233** is attached to the arm **231**. The leg positioner **230** can be attached to or detached from the ring **102** without using any tool.

(71) FIGS. **12**A and **12**B show another example of a medial-lateral leg positioner **261**, having a support arm **262** and a support member **263**. The support member **263** is asymmetrical, and includes an extended cup-shaped member **265** configured to extend under and support the foot. The extended member **265** can be curved or angled. In some embodiments, the extended member **265** ends in a substantially flat portion **267**. The other portion **264** of the support member **263** can be flat or curved, and can be similar to the member **233** in FIG. **11**A. The support arm **262** has a slot **2266** through the arm. The leg positioner **230** can be attached to or detached from the ring **102** without using any tool.

(72) In some embodiments, the leg positioner **230** is attached to the ring **102** by a mounting device **257** (FIG. **13**) comprising a threaded member **256** adapted to fit through the slot (e.g., **110**) of one of the plurality of rings **102** and through the slot **235** of the support arm **231** simultaneously, for attaching the arm **231** to the ring **102**. The threaded member **256** has a head **254** at one end. The head **254** has a width W**1** smaller than a width of the slots **110** of the rings, and a length L**1** greater than the width of the slots **110** of the ring **102**. The length is selected so that the head can engage one of the curved arcs of the scallop-shaped recesses **112***a*, **112***b* on each side of a slot **110** of one of the plurality of rings **102**.

(73) In some embodiments, the mounting device **257** further includes a threaded knob **252** configured so that it can optionally be received in one of the curved arcs of the scallop-shaped recess **112***a* of the one of the plurality of rings **102** (although the knob **252** can be located in other positions. The threaded knob **252** is configured for receiving the threaded member **256** of the mounting device **257**. The threaded knob **252** has a size that is greater than a width of the slots **110** of the rings, but smaller than the dimension of the openings **114***a*, **114***b*. Thus, the mounting device can be pre-assembled to the Y-shaped member **230**, and the knob can then be passed through the opening **114***a*, **114***b* to install the leg positioner **230** on the ring **102**. Alternatively, the pre-assembled mounting device **257** can be installed on the ring by orienting the head **254** parallel to the slot **110**, and passing the head **254** through the slot **110**.

(74) FIG. **14** shows another leg positioner **250** suitable for attachment to the top ring **142**, in which the Y-shaped member **250** includes a support arm **251** having a slot **255** through the arm. An angled support member **253** is attached to the arm **251**. The leg positioner **250** can be attached to the ring **142** using the same type of mounting device **257** described above (and shown in FIG. **13**), and for brevity, a description of the mounting device is not repeated. The threaded member **256** of mounting device **257** is adapted to fit through the slot (e.g., **110**) of one of the plurality of rings **102** and through the slot **255** of the support arm **251** simultaneously, for attaching the arm **251** to the ring **130** or **142**.

(75) These are just two examples of the leg positioner. In other embodiments, the support member

233 and/or **253** can have a different angle. In other embodiments, the support member **233** and/or **253** can have a concave curved shape.
(76) FIGS. **15-21** show another type of leg positioner **200** suitable for supporting two different portions of the leg at two different heights simultaneously. FIGS. **15**, **16**A and **16**B are isometric, right side, and left side elevation views, respectively, of the leg positioner assembly **200**. FIGS. **17-19** are isometric, side elevation and front elevation views of the body **201** of the assembly **200**. FIGS. **20** and **21** are isometric and rear elevation views of the top leg positioner **212** of FIG. **15**.
(77) Leg positioner **200** includes a plurality of independently positionable support devices **204**, **206** for supporting a limb of a patient. Support device **204** has a respective arm **207** and a respective concave or angled portion **208** attached to the arm **207**, for supporting the heel. Support device **206** has a respective arm **207** and a respective concave or angled portion **212** attached to the arm **207**, for supporting the calf. The positions of the support devices **204**, **206** can be switched by the surgeon or technician, if desired.
(78) Leg positioner **200** includes a body **201** having a plurality of openings **203** for slidably receiving respective ones of the plurality of support devices **204**, **206** through the openings **203**. In some embodiments, the support devices **204**, **206** are of the same type as each other. In some embodiments, the support devices **204**, **206** are of different types from each other (i.e., include different concave or angled portions). In other embodiments, the support devices **204**, **206** are of different sizes and/or different types.
(79) In some embodiments, the concave or angled portion **212** of at least one of the support devices **206** has a plurality of slots **214***a*, **214***b* for receiving a retaining strap (not shown) therethrough. For example, the technician or surgeon can optionally run a Velcro strap through the slots **214***a*, **214***b* and wrap the strap around the patient's leg.
(80) The leg positioner **200** also includes a respective retaining device **209**, **215** proximate each respective openings **203**, for retaining a respective one of the support devices **204**, **206** in a continuously selectable position.
(81) The leg positioner **200** further includes a mounting device **218** for detachably mounting the leg positioner to an edge of one of the plurality of rings. For example, as shown in FIG. **1**A, the leg positioner **200** can be attached to the bottom ring **102**.
(82) As best seen in FIGS. **17-19**, the body **201** has a first opening **203**. The first opening **203** includes a passage **203***p* (FIG. **19**) penetrating completely through the body **201** from a first face **201***a* of the body **201** to a second face **201***b* opposite the first face, and a relatively narrow slot **205** extending from the passage **203***p* to a side edge **201***e* of the body. The slot **205** has a height H**2** that is less than a height H**1** of the first opening **203**.
(83) As shown in FIGS. **15**, **16**A, **20** and **21**, each support device (also referred to as a leg positioning element) **204** (**206**) comprises an arm **207** adapted to slidably fit in the first opening **203** for sliding along a first direction X normal to the first face **201***a*. A support **208** (**212**) is adapted to support a first portion of a limb of a patient. A neck portion **207***n* connects the support **208** (**212**) to an end of the arm **207**. The neck portion **207***n* is adapted to slidably fit in the slot **205**, to permit removal of the leg positioning element **204** (**206**) from the body **201** through the slot **205** in a second direction Y parallel to the first face **201***a*. When the support device **204**, **206** is advanced in the X direction, so the retaining members **221** engage the arm **207**, the support device **204**, **206** is constrained from moving in the Y direction.
(84) Referring now to FIG. **16**B, the body **201** has a first and second retaining members **221** defining the slot **205** therebetween. The retaining members **221** have a depth **221***d* in the first direction (X) that is less than a depth **201***d* of the body **201** in the first direction. The length of the neck portion **207***n* is greater than the depth **221***d* of the retaining members **221**, and is sufficiently long so that the end of the arm **207** can be backed out (in the −X direction) until the neck **207***n* is aligned between the retaining members **221**, and can be moved in the Y direction through the retaining members **221**. In some embodiments, the neck portion **207***n* has a length LN (FIG. **20**)

that is less than the depth **201***d* of the body **201** in the first direction X. FIG. **16**B shows the positioner **200** with both support devices **204**, **206** in the fully retracted position (wherein the concave or angled portions **208**, **212** abut the first face **201***a* of the body **201**. In this position, the neck portions **207***n* are positioned between the retaining members **221**, to permit the support devices **204**, **206** to be removed from the body by sliding the support devices in the Y direction, through the slot **205** between the retaining members **221**. Conversely, when the arms **207** are extended so the concave or angled portions **208**, **212** do not abut the first face **201***a* of the body **201**, the arms **207** can slide in the X direction, but cannot move in the Y direction.

(85) In some embodiments, when the surgeon completes insertion of wires and/or pins, the leg positioner assembly **200** can be removed easily by fully retracting each of the support devices **204**, **206**, and sliding the support devices in the Y direction relative to the body **201** of the leg positioner assembly **200** (or sliding the body **201** relative to the support devices **204**, **206**). Thus, the leg positioner assembly **200** can be removed without disturbing the position of the leg relative to the frame **100**.

(86) The leg positioner **200** further includes a first locking device **209** (**215**) for locking the arm **207** in a fixed position relative to the body **201** without using a tool. For example, as shown in FIG. **15**, the locking device **209** (**215**) can be a screw including an enlarged head for gripping and advancing the screw without a tool.

(87) Some embodiments further comprise a mounting device **218** for mounting the body to the circular fixator **100** without using a tool. For example, body **201** has two jaws **216**, **217** spaced sufficiently far apart to receive an edge of one of the rings **102**, and a screw **218** which penetrates the bottom jaw **216**.

(88) FIGS. **23**-**26** show a wire drill guide **400** for inserting wires **412** to fix the patient's leg to the frame **100**. The drill guide **400** is adapted for use with both smooth wire (not shown) and olive wire **412** (having an olive structure **413**). FIG. **22** is an isometric view, and FIG. **24** is a side elevation view. FIG. **23** is a front elevation view of the wire insertion tip **406** shown in FIGS. **22** and **24**. FIG. **25** is a top plan view, and FIG. **26** is a cross-sectional view taken along section line **26**-**26** of FIG. **25**. FIG. **26** includes the ring **102** of circular fixator **100** and a wire **412** having an olive structure **413** for reference. The ring **102**, wire **412** and olive structure **413** are not part of the drill guide **400** but are included in FIG. **26** for ease of understanding the use of the wire drill guide **400**.

(89) The drill guide **400** includes a barrel **401**, through which the wire **412** can be run. The barrel **401** is generally in the form of a hollow, half-cylindrical shell, with flat edges **401***b* on the bottom thereof. A handle **402** is provided at the rear end of the drill guide **400**. The front end of the barrel **401** has a rearward extending finger **404**. With the flat edges **401***b* of the barrel resting on the top or bottom surface of one of the rings **102**, **130**, **142**, the rearward extending finger **404** wraps around under the inner edge of the ring (e.g., **102**), to provide stability while the surgeon inserts the wire **412**. For example, in FIG. **26**, a cross-section of the ring **102** is shown in phantom. By positioning the drill guide **400** relative to the inner edge of the ring **102** as shown, the drill guide **400** is stably directed radially inward toward the patient's leg.

(90) As shown in FIG. **26**, the barrel **401** has a proximal guide portion **410** with an inlet opening **409** therein at the rear of the barrel. The opening **409** of the proximal guide portion **410** is larger in diameter than the olive structure **413**. The passage **410** and inlet **409** are larger than the olive **413** of a standard olive wire **412**, permitting the olive to be inserted through the inlet **409**. The barrel **401** also includes an outlet passage **411** which is larger in diameter than the olive **413**.

(91) The drill guide **400** further comprises a tip **405** having a central longitudinal passage **407**. The passage **407** is greater in diameter than the wire **412** (e.g., K-wire), but smaller in diameter than the olive **413**. (Although an example is described herein using olive wire, the same drill guide **400** can also be used with smooth wire.) The tip **405** has a slot **406** extending in the radial direction from the passage **407** all the way to the exterior surface of the tip, as best seen in FIGS. **22** and **24**. Thus, if an olive wire **412** is inserted through the barrel **401** and the outlet passage **411**, and advanced

until the olive **413** is within or near the tip **405**, the tip **405** of the drill guide **400** can be removed by passing the slot **406** of the tip over the front portion **412***f* of the wire **412**. The remaining portions of the drill guide **400** can then be backed off over the olive **413**, and the rear portion of the wire **412** (distal from the patient) is fixed to the frame **100** by the fixation element **330**. The drill guide can be made of 630 stainless steel, for example.

(92) The method of using the drill guide **400** for inserting at least one wire **412** includes placing a drill guide **400** on a ring **102** of the circular fixator **100**, so as to direct the at least one wire **412** towards a bone of the patient, where the drill guide **400** has a longitudinal opening **407** adapted to pass the at least one wire **412** therethrough (but not large enough to pass the olive **413** therethrough). The surgeon or technician holds the handle **402** to position the drill guide **400**. The surgeon drives the at least one wire **412** through the longitudinal opening **407** and through the bone.

(93) In some embodiments, the drill guide **400** has a flat surface **401***b* and a finger **404** for wrapping around a proximal edge of the ring **102**, and the step of placing the drill guide **400** includes positioning the drill guide so that the flat surface **401***b* engages a top or bottom face of the ring **102**. The barrel is sized to be long enough (or angled) to permit the surgeon to slide the drill guide **400** forward until the tip **405** contacts the bone for precise drilling.

(94) In other embodiments of the method, the surgeon can position the drill guide **400** under the ring **102**, so that the flat surface engages a bottom face of the ring, and the finger **404** wraps around the top surface of the ring.

(95) In some embodiments, the drill guide **400** has a proximal guide portion **410** with an opening **409** therein, the opening of the proximal guide portion larger in diameter than the olive structure **413**. The step of driving the at least one wire **412** further comprises passing the olive structure **413** through the opening **409** of the proximal guide portion **410**.

(96) In some embodiments, the drill guide **400** has a removable tip **405** with a slot **406** therein and a front opening **407** for feeding the wire **412** therethrough. The wire **412** has an olive structure **413** larger than the front opening **407**. The step of driving the at least one wire **412** includes driving the wire **412** until the olive structure **413** is within or near the tip **405**, and removing the tip **405** of the drill guide **400** by passing the slot **407** of the tip over the wire **412**.

(97) In some embodiments, a socket **414** (collar) receives the front end of the barrel **401** and the rear end of the tip **405**. In some embodiments the socket **414** has slots to provide sufficient compliance that the socket **414** can snugly receive the front end **416** of the barrel and the rear end of the tip **405**. In some embodiments, the length of the front end **416** and the length of the socket **416** are selected to provide allow the socket **414** to slide part of the length of socket forward to extend the length of the drill guide (in the position shown in FIG. **22**). Alternatively, the drill guide can be included in a kit having a plurality of sockets **414** of different lengths.

(98) FIGS. **27** and **28** are isometric and side cross sectional views of another embodiment of the drill guide **400-2**, in which the barrel **401** and socket **415** are integrally combined in one unitary piece. The remaining elements of drill guide **400-2** are the same as for the drill guide **400**, as indicated by like reference numerals, and descriptions of these elements are not repeated for brevity. The operation and use of the drill guide **400-2** is the same as described above with reference to FIGS. **23-26**, and the description is not repeated, for brevity.

(99) FIGS. **29** and **30** are isometric and side cross sectional views of another embodiment of the drill guide **400-3**, in which the tip **425** and socket **427** are integrally combined in one unitary piece. The tip **425** includes a central passage **427** having a front opening, and a radial slot **426** connecting the central passage **427** to the outer surface of the tip **425**. The socket receptacle **428** receives the front end **416** of the drill guide barrel **401**. The remaining elements of drill guide **400-2** are the same as for the drill guide **400**, as indicated by like reference numerals, and descriptions of these elements are not repeated for brevity. The operation and use of the drill guide **400-3** is the same as described above with reference to FIGS. **23-26**, and the description is not repeated, for brevity.

(100) FIGS. **35-40** show a sponge clip which can be used during any of the fixation procedures described herein (e.g., Charcot fixation procedure). The clip comprises a body **500** having a longitudinal axis **520** (shown in FIG. **40**, and coinciding with section line **40-40** in FIG. **39**). The body **500** has a tubular sidewall **511** integrally attached at a perimeter of the body. The body **500** has a slot **501** extending parallel to the longitudinal axis **520**. The slot **501** penetrates the tubular sidewall **504** and extends part way through the body **500**.
(101) The body **500** has first and second longitudinal tubular gripping surfaces **503** and **504** within the slot **501**. The second longitudinal tubular gripping surface **504** has an inner diameter that is different from an inner diameter of the first longitudinal tubular gripping surface **503**. The slot **501** extends through each of the first and second longitudinal tubular gripping surfaces **503**, **504**. The gripping surface **503** is sized to grip a wire **412** (e.g., smooth 1.8 mm or 2 mm K-wire or olive wire), and the gripping surface **504** is sized to grip a standard (4 mm, 5 mm or 6 mm) half pin **350** (shown in FIG. **1**C) of the type surgically inserted during the procedure. (Pins **350** can be inserted in the anterior side of the tibia or in the calcaneus, but wires **412** are used elsewhere. Wires can also be used in the tibia and/or calcaneus.) By inserting the wire **412** or pin **350** into the slot **501** and placing the gripping surface **503** around the wire **412** (or the griping surface **504** around the pin), the clip is quickly attached to the pin **350** or wire **412** without any tools. The clip can be positioned close to the insertion site of the wire or pin, to retain a sponge or other absorbent material against the wound site.
(102) The body has first and second end surfaces **510**, **511**. The first end surface **510** is perpendicular to the longitudinal axis **520**, and the second end surface **511** is oriented at an oblique angle relative to the longitudinal axis **520**. The clip **500** can be attached to a wire **412** or pin **350** perpendicular to the bone, with the first end surface **510** facing toward the wound site, and the second end surface **511** facing away from the wound site. In this orientation, the first end surface **510** is parallel to the surface of the bone and holding a sponge against the wound site. Alternatively, the clip **500** can be attached to a wire **412** or pin **350** at an oblique angle with respect to the bone, with the second end surface **511** facing toward the wound site, and the first end surface **510** facing away from the wound site. In this orientation, the second end surface **511** is parallel to the surface of the bone and holding a sponge against the wound site. Thus, by selecting which end of the clip **500** to place closer to the wound site, the surgeon can maximize the area of the clip which engages the sponge (or other dressing) with the longitudinal slot **501** of the clip **500** aligned with the wire **412** or pin.
(103) In some embodiments, the clip **500** has a counterbore **505** in the first end surface **510**, to relieve pressure on the wound site. In some embodiments, the clip **500** has a counterbore **518** in the second end surface **511**. The counterbores **505**, **518** can assist in retaining the sponge or other dressing. In some embodiments, one or both of the counterbores **505**, **518** has reinforcing ribs **517**.
(104) In some embodiments, the first longitudinal tubular gripping surface **503** is at or near the longitudinal axis **520**, and the second longitudinal tubular gripping surface **504** is near a periphery of the body. In some embodiments, the second longitudinal tubular gripping surface **504** has a dimension G**2** perpendicular to the longitudinal axis **520** which is larger than a dimension G**1** of the first longitudinal tubular gripping surface **503** perpendicular to the longitudinal axis **520**.
(105) In some embodiments, the clip has a flat surface **513** opposite the opening of the longitudinal slot **501**, to permit the surgeon or technician to push the clip onto the wire **412** or pin. The flat surface can have a key **515** to provide flexibility to open and close the clip, and to retain the clip on the pin. The remainder of the body has a round perimeter for ease of removal.
(106) In some embodiments, the clip is formed from a single piece of a plastic, such as acrylonitrile-butadiene-styrene (ABS).
(107) In some embodiments, a method for using the above-described apparatus for positioning a leg of a patient comprises pre-loading respective fixation devices **330**, **302** in a plurality of slots (e.g., **110**) of a circular fixator **100**. Each fixation device **330** has a threaded bolt with a side slot

307 in a side edge thereof. The circular fixator **100** includes at least one ring e.g., **102**, having the plurality of slots (e.g., **110**) extending therethrough. The ring **102** has a scallop shaped recess **112***a*, **112***b* or recess pocket with a plurality of curved arcs on each of two respective interior edges that define the slot **110** therebetween. The fixation device **330** further includes a washer **340** having peripheral edges **343** adapted to fit in a respective curved arcs of the respective recess **112***a*, **112***b* of each of the edges. Alternatively, if the user wants to put the fixation device **330** in between scallops, the user can turn the washer **340** sideways, to clear the scallops.

(108) Each threaded bolt **330** has a respective head **332** and a respective nut **334**, and at least one slot (e.g., **110**) of the circular fixator **100** has an opening **114***a*, **114***b* at each end thereof. The openings **114***a*, **114***b* have a size larger than a size of the head **332**. The pre-loading step includes: inserting the head **332** or nut **334** of one of the fixation devices **330** though one of the openings **114***a*, **114***b*, so that the ring **102** is between the head and the nut; and inserting a plug **170** in each of the openings **114***a*, **114***b* after inserting the head **332** or nut **334**, to prevent the fixation device **330** from falling out of the ring **102**.

(109) In some embodiments, at least one leg positioner **200** is attached a to an posterior end of the circular fixator without using a tool before the position step. In some embodiments, the leg positioner **200** includes a plurality of adjustable supports **204**, **206**, the method further comprises independently adjusting the position of each support **204**, **206** without using a tool, to accommodate the leg thereon.

(110) Some embodiments include attaching leg positioners **230**, **250** to the circular fixator **100** on medial and lateral sides of a foot of the patient without using tools, so as to support the foot in a neutral or other desired position, before inserting the at least one wire **412**. In some embodiments, each of the additional leg positioners **230**, **250** includes a mounting device **257** having a threaded member **256**. The step of attaching additional leg positioners comprises: placing the mounting device **257** so that the threaded member **256** of the mounting device extends through the slot (e.g., **138**) of the ring **130** and a slot **235** (**255**) in an arm **231** (**251**) of the leg positioner **230** (**250**), and the head **254** of the mounting device **257** engages respective recesses (e.g., **140***a*, **140***b*) in the ring **130** on opposite sides of the slot **138** of the ring **130**; and securing the mounting device **257** and the leg positioner **230**, **250** to the ring **130** with a nut **252**.

(111) The circular fixator **100** is positioned around the leg. In some embodiments, the circular fixator **100** has first and second circular rings **142**, **130** adapted to be positioned around the leg of the patient. The first ring **142** is greater in diameter than the second ring **130**, and the positioning step includes: positioning the first ring **130** around a first portion of the leg, and positioning the second ring **142** around a second portion of the leg. The first portion of the leg has an anterior-to-posterior dimension that is greater than an anterior-to-posterior dimension of the second portion of the leg.

(112) At least one wire **412** is inserted through leg after the pre-loading. The surgeon positions the wire drill guide **400** with the finger **404** engaging the ring (e.g., **102**) of the circular fixator **100**) near the insertion site, and directs the tip **405** inward toward the bone. The tip **405** can be extended to contact the bone. The surgeon inserts the wire **412**. When the olive structure **413** reaches the passage **411**, the tip **405** is removed, and the drill guide **400** can be backed away from the insertion site.

(113) Each pre-loaded fixation device is slid until the side slot **348** thereof engages the at least one wire **412**. To permit this step, the pre-loading includes placing the threaded bolt **330** of one of the fixation devices through the slot **110** of the circular fixator ring **102** with a nut **334** attached to the bolt, so that the nut is sufficiently loose to permit the sliding. The sliding step includes moving the one of the fixation devices **330** until the peripheral edges **343** of the corresponding washer **340** of the fixation device are received in respective curved arcs of the respective recess **112***a*, **112***b* of each of the edges.

(114) In some embodiments, at least one of the fixation devices **330** includes a post **302** having a

longitudinal slot **307** therethrough and a threaded member **314**, and the pre-loading includes: placing the threaded bolt **330** of one of the fixation devices through a slot **307** in the post **302** of that fixation device, placing respective nuts **316** on the threaded member **314** of the post **302** and the threaded bolt **330**, and placing the fixation device **330** in the ring **102**, so that the threaded member **314** of the post extends through the slot **110** of the ring **102**, with the nut **316** on the threaded member **314** of the post **302** sufficiently loose to permit the sliding. The ring **102** has a scallop shaped recess **112***a*, **112***b* with a plurality of curved arcs on each of two respective interior edges that define the slot of the ring therebetween, the post **302** has a mounting surface **303** configured to fit in a respective one of the curved arcs of the scallop-shaped recess **112***a*, **112***b* on each respective side of the slot **110** in the ring **102**, and the step of sliding includes sliding the threaded member **314** of the post **302** within the slot **110** until the side slot **348** of the threaded bolt **330** engages the wire **412** and the mounting surface **303** of the post **302** is received by a pair of the curved arcs of the scallop shaped recess **112***a*, **112***b*.

(115) In some embodiments, the post **302** has a plurality of grooves **306** on a side face thereof, and the fixation device further comprises a washer **340** having a ridge **342**; the method further comprises: inserting the threaded bolt **330** through the washer **340**, wherein the step of placing the threaded bolt **330** through the slot **307** in the post **302** includes engaging one of the grooves **306** with the ridge **342**.

(116) The fixation devices **330**, **350** are secured by tightening, so as to secure the engaged wire **412** to the circular fixator. In some embodiments, the securing includes tightening a head **332** or a nut **334** of at least one of the fixation devices **330** using a ratcheting wrench **600** having a socket member **602** with an open end **603** in the socket member to fix the fixation device **330**; and passing the wire **412** or pin **350** through the open end **603** of the socket **602** after the tightening to remove the wrench.

(117) Once the wires **412** and/or pins **350** are inserted, the leg positioners **200**, **230**, **250** are removed. The side leg positioners **230**, **250** are removed by loosening the corresponding nuts **252** from the mounting devices **257**, and releasing the positioners **230**, **250**. The removal of the leg positioner assembly **200** includes retracting each support device **204**, **206** until the corresponding neck portion **207***n* of the corresponding arm **207** is aligned in between the retaining members **221**; and sliding the support members **204**, **206** out through the passage **205** between the retaining members in a direction perpendicular to the direction of the retraction (and parallel to the front face **201***a* of the body **201** of the leg positioner assembly **200**. Once the support members **204**, **206** are removed, the body **201** of the leg positioner assembly **200** can be removed by unscrewing the knob **218**.

(118) In some embodiments, following insertion of at least one wire **412** or pin **350**, a first sponge or other dressing (not shown) is held at a first wound site of the patient using a first clip **500** having a longitudinal slot **501** in a side surface of the first clip **500** for receiving and gripping the wire **412** or pin **350** to position the sponge.

(119) The first clip **500** has a flat surface **510** at a first end thereof for engaging the sponge with a longitudinal axis **520** of the first clip **500** approximately normal to a tissue of the patient at the first wound site. The first clip **500** has an angled surface **511** at a second end opposite the first end, and the method further comprises: holding a second sponge (not shown) at a second wound site of the patient using a second clip **500** for receiving and gripping a second wire **412** to position the second sponge. The second clip **500** is identical to the first clip. The angled surface **511** of the second clip engages the second sponge with a longitudinal axis **520** of the second clip at oblique angle relative to a tissue of the patient at the second wound site.

(120) In some embodiments, the first clip has first and second tubular gripping surfaces **503**, **504** within the longitudinal slot. The at least one wire **412** is gripped by the first tubular gripping surface **503**. The second tubular gripping surface **504** has a different size from the first tubular griping surface **503**. The second wound site has a half pin **350** or a second wire **412** inserted

therein, the half pin **350** or second wire **412** has a different diameter from the at least one wire, and the half pin **350** or second wire is gripped by the second tubular gripping surface **504** of the second clip.

(121) In some embodiments, a rocker plate can be coupled to the ring **102** to support the circular fixator **100**, **700**. FIGS. **41-43** illustrate one embodiment of a rocker plate **800** configured to couple to the ring **102** of a circular fixator **100**, **700** as described herein. The rocker plate **800** includes a frame **802** having a closed end **806***a* and an open end **806***b*. In some embodiments, the frame **802** has an elongated, semi-circular (or horseshoe) design, although it will be appreciated that the frame **802** can have any suitable shape. Although a single frame rocker plate **800** is illustrated, it will be appreciated that the rocker plate **800** can comprise one or more unconnected frame components, such as, for example, a first frame component and a second frame component. The rocker plate **800** is configured to fit multiple sizes of circular fixators **100**, **700**.

(122) In some embodiments, the frame **802** defines one or more slots **804**, **810** extending from a top surface into the frame **802**. For example, the frame **802** illustrated in FIGS. **41-43** has a first slot **804** and a second slot **810**. In some embodiments, the slots **804**, **810** are T-slots having an upper portion **812** having a first width and a lower portion **814** having a second width greater than the first width. Although embodiments are illustrated herein including T-slots, it will be appreciated that the slots **804**, **810** can include any suitable shape configured to allow movement of a slider **820** within the slot **804**, **810**. In some embodiments, the slots **804**, **810** are sized and configured to allow movement of the slider **820** within the slot but prevent rotation of the slider **820**.

(123) In some embodiments, the slots **804**, **810** are sized and configured to receive a plurality of sliders **820** therein. The slots **804**, **810** are coupled to an opening **808***a*, **808***b* at each end of the frame **802**. The openings **808***a*, **808***b* are sized and configured such that the plurality of sliders **820** can be inserted into the T-slots **804**, **810** through the openings **808***a*, **808***b*. FIG. **44** illustrates one embodiment of a slider **820**. Each of the sliders **820** includes a slider portion **822** coupled to a support portion **824** by a first elongate shaft **826**. The slider portion **822** has a diameter less than or equal to the second width of the lower portion **814** of the T-slots **804**, **810** but greater than the first width of the upper portion **812**. In some embodiments, the slider portion **822** comprises a disc (slider plate) sized and configured to slide within the lower portion **814** of the T-slot. The first elongate shaft **826** has a diameter less than the diameter of the upper portion **812**, and extends from the slider portion **822** through the upper portion **812** and above the top surface of the frame **802** when the slider **820** is inserted into the slot **804**, **810**. The slider **820** can be slideably moved within the T-slots **804**, **810** to position the rocker plate **800** and/or the sliders **820** with respect to a bottom ring **102** of a circular fixator **100**, **700**.

(124) In some embodiments, the first elongate shaft **826** includes a plurality of threads sized and configured to receive a nut **828**. The nut **828** can be tightened to fix the slider **820** in place with respect to the rocker plate **800**. In some embodiments, the T-slot **804**, **810** allows the slider **820** and/or the rocker plate **800** to be positioned with respect to the circular fixator **100**, **700**. In some embodiments, one or more spacers (not shown) can be positioned between the nut **828** and the frame **802** and/or the nut **828** and the support portion **824**. The spacers can increase a spacing between the rocker plate **800** and a circular fixator **100**, **700** coupled thereto.

(125) The support portion **824** is sized and configured to interface with and support the bottom ring **102** of the circular fixator **100**, **700**. A second elongate shaft **830** extends from a proximal end of the support portion **824**. The second elongate shaft **830** is sized and configured to extend through a slot **104**, **110** formed in the lower ring **102** of the circular fixator **100**, **700**. In some embodiments, the second elongate shaft **830** includes a plurality of threads. The plurality of threads are configured to receive a nut thereon (not shown) to couple the rocker plate **800** to the circular fixator **100**, **700**.

(126) In some embodiments, a sole **840** is coupled to a bottom edge of the rocker plate **800**. The sole **840** comprises a molded and/or machined cover that extends from a bottom surface of the rocker plate **800** at least partially over each of the side walls of the rocker plate **800**. The sole **840**

can comprise any suitable material, such as, for example, a plastic material, a rubber material, a composite material, and/or any other suitable material. The sole **840** can include an overmolded and/or a machined sole attached to the frame **802**. The sole **840** does not extend over the openings **808***a*, **808***b* or the slots **804**, **810** and does not interfere with movement of the sliders **820** within the T-slots **804**, **810**. In some embodiments, the sole **840** includes a non-slip surface.

(127) FIG. **46** illustrates one embodiment of a rocker plate **900** having a plurality of scallop-shaped recesses **852***a*, **852***b* formed thereon. The plurality of scallop-shaped recesses **852***a*, **852***b* are formed about the periphery of the T-slots **804**, **810**. The scallop-shaped recesses **852**, **852***b* are similar to the scallop-shaped recesses **106***a*, **106***b* formed in the ring **102** and prevent slipping of the slider **820** relative to the T-slots **804**, **810**. The scallop-shaped recesses **852***a*, **852***b* prevent movement or slippage of the rocker plate **800** with respect to the lower ring **102**.

(128) FIG. **47** illustrates one embodiment of the rocker plate **900** coupled to an embodiment of the circular fixator **100**. The rocker plate **900** includes a plurality of sliders **820** inserted into the T-slots **804**, **810** formed therein. The bottom ring **102** of the circular fixator **100** is supported at a predetermined spacing by the support portion **824** of each of the sliders **820**. The predetermined spacing can be adjusted to accommodate patients with varying foot sizes. The second elongated shaft **830** of each of the sliders **820** extends through the slots **104**, **110** formed in the ring **102**. A nut **854** is threadably coupled over a proximal end of the elongate shaft **830** to maintain the circular fixator **100** and the rocker plate **900** in a fixed position.

(129) In some embodiments, a securing bar **960** is coupled to a proximal end of the rocker plate **900**. The securing bar **960** maintains the first and second ends of the rocker plate **900** at a fixed spacing and prevents the first and second ends of the rocker plate **900** from twisting or expanding during an operation. In some embodiments, the securing bar **960** is positioned to prevent the sliders **820** from sliding out of the T-slots **804**, **810** formed in the frame **802**. For example, as shown in FIG. **47**, in some embodiments, the securing bar **960** effectively covers the openings **808***a*, **808***b* formed in the slots **804**, **810**, preventing the sliders **820** from sliding out of the T-slots **804**, **810**. In some embodiments, a pin (not shown) is inserted into the openings **808***a*, **808***b* to prevent the sliders **820** from sliding out of the slots **804**, **810**.

(130) Although the subject matter has been described in terms of exemplary embodiments, it is not limited thereto. Rather, the appended claims should be construed broadly, to include other variants and embodiments, which may be made by those skilled in the art

Claims

1. A rocker plate assembly, comprising: a body including a first side member having a first end, a second side member having a second end, and a connecting portion attached to the first side member opposite the first end and attached to the second side member opposite the second end, wherein the first and second side members each define at least one T-slot extending from a top surface of the body into the body and further wherein the top surface of the body includes a plurality of scallop-shaped recesses adjacent each side of each of the T-slots, and a plurality of sliders slidably retained in the at least one T-slot of the first and second side members and configured to couple the body of the rocker plate assembly to a circular fixator.

2. The rocker plate assembly of claim 1, wherein at least one of the plurality of sliders comprises: a slider plate received by a bottom of the at least one T-slot of the first and second side members, a first shaft attached to the slider plate and slidable and rotatable within a top portion of the at least one T-slot of the first and second side members, and a support portion attached to the first shaft.

3. The rocker plate assembly of claim 2, wherein the at least one of the plurality of sliders further comprises: a second shaft attached to the support portion, the second shaft offset from the first shaft.

4. The rocker plate assembly of claim 1, further comprising a sole having a bottom edge, a first

sidewall, and a second sidewall, wherein the sole is coupled to a bottom surface of the body, and wherein the first and second sidewalls extend at least partially over sidewalls of the body.
5. The rocker plate assembly of claim 4, wherein a portion of the sole includes a non-slip surface.
6. The rocker plate assembly of claim 1, further comprising a securing member attached to the first and second ends of the body, the securing member covering openings of the at least one T-slot of the first and second side members, so as to prevent a slider from disengaging the at least one T-slot of the first and second side members.
7. A rocker plate assembly, comprising: a curved body having a top surface defining a plurality of scallop-shaped recesses and including: a first side member having a first end, a second side member having a second end, and a curved connecting portion integrally attached to the first side member opposite the first end and attached to the second side member opposite the second end, wherein the first and second side members each have at least one T-shaped slot extending from the top surface and between the plurality of scallop-shaped recesses; and a plurality of sliders, each having: a slider plate slidably retained in a respective bottom of a respective one of the T-shaped slots of the first and second side members, a threaded first shaft slidably retained in a respective top of the respective one of the T-shaped slots of the first and second side members, a support portion attached to the threaded first shaft, and a second shaft attached to the support portion, the second shaft offset from the threaded first shaft.
8. The rocker plate assembly of claim 7, further comprising a sole having a bottom edge, a first sidewall, and a second sidewall, wherein the sole is coupled to a bottom surface of the curved body, and wherein the first and second sidewalls extend at least partially over sidewalls of the curved body.
9. The rocker plate assembly of claim 7, comprising a first nut threadably received on the first shaft for gripping a respective one of the side members between the first nut and the slider plate.
10. The rocker plate assembly of claim 7, wherein the second shaft is threaded, the assembly further comprising a second nut threadably received on the second shaft for gripping a ring of a circular fixator between the second nut and the support portion.
11. The rocker plate assembly of claim 7, further comprising a securing member attached to the first and second ends of the curved body, the securing member covering openings of the at least one T-shaped slot of the first and second side members, so as to prevent the sliders from disengaging from the assembly.
12. A fixation system, comprising: a plurality of rings, each ring having a first face, a second face, and at least one slot penetrating from the first face to the second face; a plurality of members joining each one of the plurality of rings to an adjacent one of the plurality of rings; a rocker plate including a curved body having a top surface defining a plurality of scallop-shaped recesses and including: a first side member having a first end, a second side member having a second end, and a curved connecting portion integrally attached to the first side member opposite the first end and attached to the second side member opposite the second end, wherein the first and second side members each have at least one T-shaped slot extending from the top surface and between the plurality of scallop-shaped recesses; and a plurality of sliders slidably retained in the at least one T-shaped slot of the first and second side members, each slider having a first shaft received by a respective one of the at least one T-shaped slot of the first or second side members and a second shaft received by one of the at least one slot of a bottom one of the plurality of rings, wherein the second shaft is offset from the first shaft.
13. The fixation system of claim 12, wherein each of the plurality of sliders further comprises a support portion, the first shaft attached adjacent a first end of the support portion, and the second shaft attached adjacent a second end of the support portion.
14. The fixation system of claim 13, wherein each of the plurality of sliders further comprises a disc and a nut, each disc is received in a bottom of the at least one T-shaped slot of a respective one of the first or second side member, and the first and second side members are gripped between the

disc and nut of each respective slider.
15. The fixation system of claim 13, further comprising a securing member attached to the first and second ends of the rocker plate curved body, the securing member covering openings of the at least one T-shaped slot of the first and second side members, so as to prevent the plurality of sliders from sliding out of the at least one T-shaped slot of the first and second side members.
16. The fixation system of claim 12, further comprising a sole having a bottom edge, a first sidewall, and a second sidewall, wherein the sole is coupled to a bottom surface of the curved body, and wherein the first and second sidewalls extend at least partially over sidewalls of the curved body.
17. The fixation system of claim 16, wherein a portion of the sole includes a non-slip surface.
18. The fixation system of claim 12, wherein the first shaft is threaded, the rocker assembly further comprising a first nut threadably received on the first shaft for gripping a respective one of the side members between the first nut and a respective one of the plurality of sliders.
19. The fixation system of claim 12, wherein the second shaft is threaded, the rocker assembly further comprising a second nut threadably received on the second shaft for gripping a ring of a circular fixator between the second nut and the support portion.
20. The fixation system of claim 12, further comprising a member attached to the first and second ends of the body, the member covering openings of the at least one T-shaped slot of the first and second side members, so as to retain the sliders.