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APPARATUS AND METHODS FOR JOINING BONES

Abstract

Apparatus and methods are provided for using a plate to fuse bones together, including reducing or stabilizing a fracture or osteotomy. Legs of the plate are inserted into pre-drilled guide holes in one of the bones and one or more screws are inserted through apertures and into another of the bones to secure the plate to the bones. A plate insertion tool can be used to temporarily tension the legs prior to insertion into predrilled guide holes in a bone by bending or pivoting the legs away from the body. A tensioning tool can be used to tension the plate after the legs are inserted into the guide holes in the bone and during the insertion of one or more of the screws.

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Background/Summary

FIELD
[0001] Apparatus and methods for joining or fusing two bones together are described herein and, more specifically, apparatus and methods for attaching to the bones a plate having legs at one end portion and at least one opening for bone screws at an opposite end portion.
BACKGROUND
[0002] Screws are commonly used for joining or fusing two bones or bone pieces together. The screw or screws may cross a joint, fracture or osteotomy. For example, screws can be used to fuse metatarsal phalangeal (MTP) joints to relieve pain or correct deformity. By way of another example, screws can be used in a Lapidus procedure to fuse the joint between the first metatarsal bone and the medial cuneiform.
[0003] Instead of screws, fusions can be made using one or more plates. In one form, plates have legs at one end and screw holes at another end. A spreader tool can abut the legs to bend the legs from an acute angle to a large angle by pushing against an opening in the body of the plate. Disadvantageously, such a spreader tool can require specialized openings in the body for receiving part of the tool. Moreover, unnecessary openings in the body—beyond those necessary for receiving the screws—can weaken the body. Furthermore, the requirement that the spreader tool contacts the opposite ends of the plate can limit the designs of plates that can be used with such a tool.
[0004] The plate insertion tools and methods described herein can address these problems.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
[0005] FIG. **1** is a perspective view of a plate insertion tool having a handle rotatably mounted to a head, a pair of arms slidable relative to the head, and a pusher finger;
[0006] FIG. **2** is a side perspective view of an exemplary embodiment of a plate having a body portion with three apertures each for receiving a screw and a pair of legs at one end that are each connected to the body at an acute angle and spaced apart by a shoulder;
[0007] FIG. **3** is a front perspective view of the plate of FIG. **2**;
[0008] FIG. **4** is a front elevation view of the plate insertion tool of FIG. **1**;
[0009] FIG. **5** is a cross-section view of the plate insertion tool of FIG. **1**, taken along line V-V of FIG. **4**;
[0010] FIG. **6** is a top plan view of the plate insertion tool of FIG. **1**;
[0011] FIG. **7** is a bottom plan view of the plate insertion tool of FIG. **1**;
[0012] FIG. **8** is an exploded perspective view of the plate insertion tool of FIG. **1**;
[0013] FIG. **9** is a front elevation view of the arms of the plate insertion tool of FIG. **1**, showing the arms being slid together such that inwardly extending fingers at the ends of the arms are in a clamping position, with a spring disposed between actuators at the opposite ends of the arms from the inwardly extending fingers and biasing the actuators away from each other to slide the inwardly extending fingers toward each other;
[0014] FIG. **10** is a front elevation view of the arms of the plate insertion tool of FIG. **1**, showing the arms being slid away from each other such that the inwardly extending fingers at the ends of the arms are in an open position, with the spring disposed between actuators being compressed and the actuators being closer to each other as compared to in FIG. **9**;

[0015] FIG. **11** is a left side elevation view of the plate insertion tool of FIG. **1**, showing the pusher finger in a retracted position;
[0016] FIG. **12** is a left side elevation view of the plate insertion tool of FIG. **1**, showing the pusher finger in an extended position;
[0017] FIG. **13** is a perspective view of the plate insertion tool of FIG. **1** in combination with the plate of FIG. **2**, showing the actuators of the arms being pushed toward each other to slide the inwardly extending fingers away from each other to their open position such that the plate can be moved against the bottom of the head of the tool;
[0018] FIG. **14** is a perspective view of the plate insertion tool of FIG. **1** in combination with the plate of FIG. **2**, showing the actuators of the arms being moved away each by the biasing force of the spring to slide the inwardly extending fingers toward each other to their clamping position such that the plate is clamped against the bottom of the head of the tool by the inwardly extending fingers;
[0019] FIG. **15** is a side elevation view of the arrangement of the plate insertion tool and plate of FIG. **14**, showing the pusher finger in the retracted position;
[0020] FIG. **16** is a side elevation view of the arrangement of the plate insertion tool and plate similar to that of FIG. **15**, but showing the handle having been rotated to move the pusher finger to the extended position abutting the shoulder to pivot the pair of legs to an increased angle, generally perpendicular, as compared to the acute angle shown in FIG. **15**;
[0021] FIG. **17** is a side elevation view of the arrangement of the plate insertion tool and plate of FIG. **16**, with the legs starting to be inserted into pre-drilled guide holes in the first metatarsal;
[0022] FIG. **18** is a side elevation view of the arrangement of the plate insertion tool and plate of FIG. **16**, with the legs being further inserted into the pre-drilled guide holes in the first metatarsal as compared in FIG. **17**;
[0023] FIG. **19** is a perspective view of the arrangement of the plate insertion tool and plate shown in FIG. **18**;
[0024] FIG. **20** is a perspective view of a tensioning tool having a pair of handles having operative ends, with one of the ends being attached relative to one of the openings in the plate of FIG. **2** and another of the ends being anchored relative to a bone, showing the tensioning tool pulling the body of the plate in a direction generally away from the legs of the plate to tension the body prior to insertion of a first of the bone screws into a pre-drilled guide hole aligned with one of the screw holes of the plate;
[0025] FIG. **21** is another perspective view of the tensioning tool of FIG. **20**, showing the first of the bones screws threaded into the pre-drilled guide hole;
[0026] FIG. **22** is a perspective view of the plate of FIG. **2** fusing the first metatarsal and the first proximal phalanx, with the legs of the plate being inserted into the pre-drilled guide holes in the first metatarsal, the first of the bone screws attached to the body of the plate and inserted into pre-drilled guide hole in the first proximal phalanx, and showing predrilled guide holes for a second of the bone screws and the optional bridging screw;
[0027] FIG. **23** is a side elevation view of the plate attached to the bones using the legs of the plate, the two screws and the optional bridging screw to fuse the bones together.
[0028] FIG. **24**A is a perspective view and FIG. **24**B is a side elevation view of a second embodiment of a plate having a body portion with a pair of legs at one thereof and three offset screw holes at an opposite end portion, the pair of legs being at an acute angle relative to the body;
[0029] FIG. **25**A is a perspective view and FIG. **25**B is a side elevation view of a third embodiment of a plate having a body portion with a pair of legs at one thereof and three offset screw holes at an opposite end portion, the pair of legs being at an acute angle relative to the body, and an intermediate fourth screw hole in the body between the legs and the other three screw holes;
[0030] FIG. **26**A is a perspective view and FIG. **26**B is a side elevation view of a fourth embodiment of a plate having a pair of legs depending from a linear extension and arranged in-line

and three offset screw holes in a body at an opposite end of the extension from the legs, the pair of legs each being at an acute angle relative to the extension;

[0031] FIG. **27**A is a perspective view and FIG. **27**B is a side elevation view of a fifth embodiment of a plate having a pair of legs depending from a linear extension and arranged in-line and three offset screw holes in a body at an opposite end of the extension from the legs, the pair of legs each being at an acute angle relative to the extension, and an intermediate fourth screw hole in the body between the extension and the other three screw holes;

[0032] FIG. **28**A is a perspective view and FIG. **28**B is a side elevation view of a sixth embodiment of a plate having a body portion with a pair of legs at one thereof and two transverse screw holes in an inclined, flared end portion of the body, the pair of legs being at an acute angle relative to the body;

[0033] FIG. **29**A is a perspective view and FIG. **29**B is a side elevation view of a seventh embodiment of a plate having a body portion with a pair of legs at one thereof and two transverse screw holes in an inclined, flared end portion of the body, the pair of legs being at an acute angle relative to the body, and an intermediate third screw hole in the body between the legs and the inclined, flared end portion of the body;

[0034] FIG. **30**A is a perspective view and FIG. **30**B is a side elevation view of an eighth embodiment of a plate having a body portion with a pair of legs at one thereof and two transverse screw holes in a flared end portion of the body, the pair of legs being at an acute angle relative to the body;

[0035] FIG. **31**A is a perspective view and FIG. **31**B is a side elevation view of a ninth embodiment of a plate having a body portion with a pair of legs at one thereof and two transverse screw holes in a flared end portion of the body, the pair of legs being at an acute angle relative to the body, and an intermediate third screw hole in the body between the legs and the flared end portion of the body;

[0036] FIG. **32**A is a perspective view and FIG. **32**B is a side elevation view of a tenth embodiment of a plate having a pair of legs depending from a linear extension and arranged in-line and two in-line screw holes in a body at an opposite end of the extension from the legs, the pair of legs each being at an acute angle relative to the extension;

[0037] FIG. **33**A is a perspective view and FIG. **33**B is a side elevation view of an eleventh embodiment of a plate having a pair of legs depending from a linear extension and a screw hole at an opposite end of the extension from the legs, the pair of legs each being at an acute angle relative to the extension;

[0038] FIG. **34**A is a perspective view and FIG. **34**B is a side elevation view of a twelfth embodiment of a plate having a body portion with a pair of legs at one thereof and two in-line screw holes at an opposite end portion, the pair of legs being at an acute angle relative to the body;

[0039] FIG. **35**A is a perspective view and FIG. **35**B is a side elevation view of a thirteenth embodiment of a plate having a body portion with a pair of legs at one thereof and two in-line screw holes at an opposite end portion, the pair of legs being at an acute angle relative to the body, and an intermediate third screw hole in the body between the legs and the other two screw holes;

[0040] FIG. **36**A is a perspective view and FIG. **36**B is a side elevation view of a fourteenth embodiment of a plate having a pair of legs depending from a linear extension and arranged in-line and two in-line screw holes in a body at an opposite end of the extension from the legs, the pair of legs each being at an acute angle relative to the extension;

[0041] FIG. **37**A is a perspective view and FIG. **37**B is a side elevation view of a fifteenth embodiment of a plate having a pair of legs depending from a linear extension and arranged in-line and two in-line screw holes in a body at an opposite end of the extension from the legs, the pair of legs each being at an acute angle relative to the extension, and an intermediate third screw hole in the body between the extension and the other three screw holes;

[0042] FIG. **38**A is a perspective view and FIG. **38**B is a side elevation view of a sixteenth

embodiment of a plate having a body portion with a pair of legs at one thereof and two transverse screw holes in a flared end portion of the body, the pair of legs being at an acute angle relative to the body;

[0043] FIG. **39**A is a perspective view and FIG. **39**B is a side elevation view of a seventeenth embodiment of a plate having a body portion with a pair of legs at one thereof and two transverse screw holes in a flared end portion of the body, the pair of legs being at an acute angle relative to the body, and an intermediate third screw hole in the body between the legs and the flared end portion of the body;

[0044] FIG. **40**A is a perspective view and FIG. **40**B is a side elevation view of an eighteenth embodiment of a plate having a pair of legs depending from a linear extension and arranged in-line and two transverse screw holes in a body at an opposite end of the extension from the legs, the pair of legs each being at an acute angle relative to the extension;

[0045] FIG. **41**A is a perspective view and FIG. **41**B is a side elevation view of a nineteenth embodiment of a plate having a pair of legs depending from a linear extension and arranged in-line and two transverse screw holes in a body at an opposite end of the extension from the legs, the pair of legs each being at an acute angle relative to the extension, and an intermediate third screw hole in the body between the extension and the other two screw holes;

[0046] FIG. **42**A is a perspective view and FIG. **42**B is a side elevation view of a twentieth embodiment of a plate having a body portion with a pair of legs at one thereof and two offset screw holes in an inclined end portion of the body, the pair of legs being at an acute angle relative to the body;

[0047] FIG. **43**A is a perspective view and FIG. **43**B is a side elevation view of a twenty-first embodiment of a plate having a body portion with a pair of legs at one thereof and two offset screw holes in an inclined end portion of the body, the pair of legs being at an acute angle relative to the body, and an intermediate third screw hole in the body between the legs and the inclined end portion of the body;

[0048] FIG. **44**A is a perspective view and FIG. **44**B is a side elevation view of a twenty-second embodiment of a plate having a body portion with a pair of legs at one thereof and two in-line screw holes in an inclined end portion of the body, the pair of legs being at an acute angle relative to the body;

[0049] FIG. **45**A is a perspective view and FIG. **45**B is a side elevation view of a twenty-third embodiment of a plate having a body portion with a pair of legs at one thereof and two in-line screw holes in an inclined end portion of the body, the pair of legs being at an acute angle relative to the body, and an intermediate third screw hole in the body between the legs and the inclined end portion of the body;

[0050] FIG. **46**A is a perspective view and FIG. **46**B is a side elevation view of a twenty-fourth embodiment of a plate having a pair of legs depending from a linear extension and arranged in-line and two in-line screw holes in an inclined end portion of the body at an opposite end of the extension from the legs, the pair of legs each being at an acute angle relative to the extension; and

[0051] FIG. **47**A is a perspective view and FIG. **47**B is a side elevation view of a twenty-fifth embodiment of a plate having a pair of legs depending from a linear extension and arranged in-line and two in-line screw holes in an inclined end portion of the body at an opposite end of the extension from the legs, the pair of legs each being at an acute angle relative to the extension, and an intermediate third screw hole in the body between the extension and the other inclined end portion of the body.

DETAILED DESCRIPTION

[0052] A plate insertion tool is provided for use with a plate, such as a compression plate, having a body portion with one or more apertures each for receiving a screw and a pair of legs at one end that are each connected to the body at an acute angle and spaced apart by a shoulder, the plate insertion tool being usable to temporarily tension the legs prior to insertion into holes in a bone.

The plate insertion tool includes a pair of facing, inwardly extending fingers being movable between a clamping position for clamping therebetween, in use, the legs of the plate, and an open position where, in use, the inwardly extending fingers are spaced from the legs of the plate. The pair of inwardly extending fingers are closer to each other in the clamping position as compared to the open position. The plate insertion tool also includes a pushing finger movable between a retracted position and an extended position relative to the pair of inwardly extending fingers and positioned for engaging, in use, the shoulder of the plate such that when the pushing finger moves to the extended position the legs are temporality tensioned by bending the legs away from the body.

[0053] A system for joining bones together is also provided, where the system includes a plate having a body portion with one or more apertures each for receiving a bone screw and a pair of legs at one end that are each connected to the body at an acute angle and spaced apart by a shoulder. The system also includes the plate insertion tool.

[0054] A method of using the system is also provided, where the method includes drilling a pair of guide holes for receiving the legs of the compression plate; clamping the compression plate relative to the plate insertion tool by moving the pair of inwardly extending fingers from the open position to the clamping position; engaging the shoulder of the compression plate with the pusher finger; moving the pusher finger toward the extended position to temporality tension the legs by pivoting the legs away from the body of the compression plate to a greater angle relative to the body as compared to the acute angle; and inserting the legs of the compression plate into the guide holes when the legs are pivoted away from the body to the greater angle.

[0055] As described herein and illustrated in FIGS. **1-23** apparatus and methods are provided for using a plate to fuse bones together. Generally, the plate has a body portion with one or more apertures or screw holes each for receiving a screw and a pair of legs side-by-side at one end that are each connected to the body at an acute angle and spaced apart by a shoulder. The legs are inserted into pre-drilled guide holes in one of the bones and one or more screws are inserted through the apertures and into another of the bones to secure the plate to the bones. A plate insertion tool can be used to temporarily tension the legs prior to insertion into holes in a bone by bending or pivoting the legs away from the body, as will be described further herein. Advantageously, the plate insertion tool only needs to contact one end portion of the plate to tension the legs. Also advantageously, specific holes in the plate are not needed for the plate insertion tool to tension the legs.

[0056] Turning to details of a first exemplary embodiment of the plate **10**, shown in FIGS. **2** and **3**, the plate **10** has a body portion **12** with three apertures **14**, **16**, **18** each for receiving a screw **22**, **24**, **26** and a pair of legs **20** that are parallel and arranged side-by-side at one end thereof with a shoulder **28** therebetween. The legs **20** are each connected to the body **12** of the plate **10** at an acute angle, as shown in FIGS. **2** and **15**. The plate **10** can be a compression plate, e.g., made of a shape-memory material, such as nitinol. Thus, when the legs **20** are pivoted away from the body **12** to a perpendicular or toward a perpendicular arrangement relative to the body **12** (e.g., increasing the angle of the legs relative to the body), such as shown in FIG. **16**, they have a bias to return to their original orientation. This bias can be used advantageously during and after insertion of the legs **20** into pre-drilled guide holes **32** in a bone **30** to tension the plate **10** and thereby compress adjacent bones **30**, **40** together, particularly when the pre-drilled guide holes **32** are generally perpendicular or at least at a greater angle than the acute angle of the original orientation. The plate insertion tool **100** is used to not only to pivot the legs **20** of the plate **10** rearwardly, but also to maintain that pivoted arrangement of the legs during insertion into the pre-drilled guide holes.

[0057] The plate **10** shown in FIGS. **2** and **3**, includes two screw holes in the body thereof at an end portion of the body opposite the legs. Those two screw holes are preferably, though not necessarily, configured with internal threads for engaging with external threads on the heads of the screws. The plate **10** also includes an intermediate or third screw hole in the body that is intermediate the legs and the other two screw holes. This intermediate screw hole, if present, can optionally be used for a

bridging screw that passes through one bone and at least partially into another.
[0058] The plate insertion tool includes a handle **110** that is rotatably mounted to a head **120**, as shown generally in FIGS. **1** and **5-7**. A pair of arms **130**, **132** are slidably secured to the head **120**, and can slide toward and away from each other. Ends of the arms **130**, **132** each include an inwardly extending finger **134**, **136**. The inwardly extending fingers **134**, **136** are arranged to face each other and are spaced from bottom surfaces **122** of the head. Movement of the arms **130**, **132** toward and away from each other likewise moves the fingers **134**, **136** toward each other, into a clamping position, and away from each other, into an open position. A pusher finger **140** is extensible relative to the handle **110** and the head **120** and is moveable from a retracted position, shown in FIG. **11**, to an extended position, shown in FIG. **12**.
[0059] When used with the plate **10** of FIGS. **2** and **3**, the pair of inwardly extending fingers **134**, **136** of the arms **130**, **132** are movable between a clamping position for clamping therebetween the legs **20** of the plate **10**, as shown in FIG. **14** and an open position where the inwardly extending fingers **134**, **136** are spaced from the legs **20** of the plate **10**, as shown in FIG. **13**. When the plate insertion tool **100** is clamping the plate **10**, as shown in FIG. **14**, the pusher finger **140** can move from its retracted position, shown in FIG. **15**, to the extended position, shown in FIG. **16**, relative to the pair of inwardly extending fingers and engage with and push the shoulder of the plate away from the legs to temporality tensioned the legs by bending the legs away from the body to an angle generally perpendicular relative to the adjacent portion of the body (or at least an increased angle relative to the body or, in other words, less acute of an angle).
[0060] When the plate **10** is clamped and the legs are temporarily tensioned, as shown in FIG. **16**, the legs of the plate can be inserted into a pair of predrilled guide holes in a bone, as shown in FIGS. **17** and **18**. The predrilled guide holes can be formed, for example, using a template to ensure the spacing. When the legs are nearly all the way inserted into the guide holes (the underlying inwardly extending fingers of the arms prevent complete insertion), the plate insertion tool can be disconnected from the plate to allow the legs to be inserted further into the guide holes. The plate insertion tool is disconnected from the plate by firstly moving the pusher finger to its retracted position and then secondly moving the arms away from each other to move the inwardly extending fingers from their clamping position to their open position, as shown in FIG. **19**.
[0061] After the legs of the plate have been inserted into the pre-drilled guide holes in one of the bones to be fused, the screws can then be inserted through the screw holes body of the plate and into the other of the bones to be fused. Optionally, the plate can be tensioned and then the screws inserted. By having the plate attached to the other of the bones under tension, compression or additional compression between the two adjacent bones can result, thereby improving the fusion of the two bones, which can take advantage of Wolff's Law. As used herein, the term fused can include reducing or stabilizing a fracture or osteotomy. Also as used herein, when bones or a pair of bones or adjacent bones are mentioned, that can include what was a single bone but is fractured or otherwise separated.
[0062] A tensioning tool **200** can be used for tensioning the plate **10** during insertion of at least one of the screws. The tensioning tool, an exemplary embodiment of which is shown in FIGS. **20** and **21**, can include a pair of arms **210**, **212** connected about a pivot **214**. One end of the arms on one side of the pivot include handle, and the opposite end of the arms on the other side of the pivot include operating ends **216**, **218**, details of which will be described further herein. Squeezing the handles together causes the operating ends **216**, **218** of the arms **210**, **212** to also move together.
[0063] A bone anchoring pin **230** can be inserted into a pre-drilled guide hole at a location spaced from the plate **10** and on an opposite side the plate **10** from the legs **20**, as shown in FIGS. **20** and **21**. A plate pin **232** can have an external thread on its tip such that it can be threadingly engaged with the internal threads of one of the two screw holes, preferably the rearward most screw hole, having internal threads, also as shown in FIGS. **20** and **21**. The operating ends of the arms **216**, **218** can be identical, and, as best shown in FIG. **21**, are configured for attachment relative to the bone

anchoring pin **230**-either directly or via a cannulated sleeve **234** disposed about the bone anchoring pin **230**, as shown in FIGS. **20** and **21**—and relative to the plate pin **232**—either directly or via a sleeve disposed about the plate pin **232**. The operating ends **216**, **218** are configured for attachment by having an annular ring **242** that can fit around the pins or sleeves. Optionally, the rings can be pivotably attached relative to adjacent portions of the arms to allow for the handles to be pivotably orientated relative to the operating ends for facilitating positioning and use of the handles during operation of the tensioning tool. The rings can, for example, each be attached to a support **236** terminating in a clevis **238** that is pivotably attached the adjacent portions **240** of the arms **210**, **212**. When the rings are mounted relative to the pins, squeezing the handles together causes the operating ends of the arms to move together, thereby pulling the plate away from the legs thereof and toward the anchoring pin, thereby tensioning the body of the plate. Optionally, the arms can be locked in the tensioning position, such as by fixing the pivot therebetween or blocking the arms from moving away from each other (such as by using a clamp).

[0064] When the plate is under tension, a guide hole **34**, such as shown in FIG. **20**, can be drilled in the bone underlying the other of the two internally threaded screw holes. A screw can then be threaded into the hole and the head of the screw threadingly engaging with the internal thread of the screw hole, as shown in FIG. **21**. Thus installed, the plate is tensioned between the installed screw and the legs. At this point, the tensioning tool **200** can be removed and guide holes for the other two screws can be made in the bones, as shown in FIG. **22**. Finally, the other two screws can be inserted through their respective holes, as shown in FIG. **23**, to finish the insertion of the plate. Advantageously, the tension in the body of the plate as well as the tension in the legs, which are biased to return from a generally perpendicular orientation to the original acute orientation, individually and together combine to contribute to improved compression of the bones that are being fused together. As mentioned above, the bridging screw is optional. The bridging screw can also be inserted prior to removal of the tensioning tool.

[0065] Turning now to details of the plate insertion tool **100**, the head **120** includes a rearward-facing annular extension **124** that has a circumferentially-extending groove **126**, as shown in FIGS. **5** and **8**. The handle **110** has a central threaded bore **128** along a central axis thereof and, at the end facing the head **120**, an annular recess **121** for receiving the annular extension **124** of the head **120**, as shown in FIG. **8**. A pair of transverse through-bores **123** intersect the recess **121** but are spaced from the central threaded bore **128**. The transverse through-bores **123** are positioned on the handle **110** such that, when the handle **110** is mounted on the annular extension **124** of the head **120**, they are aligned with the circumferentially extending groove **126** of the annular extension **124**. When pins **125** are inserted into the through bores **123**, the pins **125** allow for rotation of the handle **110** about the annular extension **124** of the head **126**, but engagement between the pins **125** and the circumferentially extending groove **126** restrict or prevent axial movement between the head **120** and the handle **110**. The handle **110** can include several openings **127** about a rearward portion of its circumference. A tool **129**, such as a rod or an end of a driver, can be inserted into one of the openings **127** to provide leverage for rotating the handle **110**. Similarly, the rearward end of the handle **110** can include a threaded opening **131** for attachment of a threaded end of a tool, such as a driver, that can used for leverage in rotating the handle **110**.

[0066] The pusher finger **140** is disposed at the end of a threaded shaft **142**. The head **120** includes a pair of depending legs **133** with a gap therebetween. The legs **133** have the generally planar bottom surfaces **138**, as shown in FIG. **4**. The pusher finger **140** is positioned between the legs **133** of the head **120** and beneath the generally planar bottom surfaces **138** of the legs **133**, as shown in FIG. **8**. The pusher finger **140** has a pair of planar sides **140** that can slide between matching generally planar, facing sides **145** of the legs **133**. The shaft **142** also extends between the legs **133**, and can slide between along an arcuate surface **147** that spans between the legs **133**. The shaft **142** extends rearwardly from the pusher finger **140** and through the annular extension **124** and into the threaded bore **128** of the handle **110**. Engagement between the planar sides of the pusher finger **144**

and the planar, facing sides **145** of the legs **133** prevents rotation of the shaft **142**. However, rotation of the handle **110**—which is axially fixed relative to the head **120**—forces the shaft **142**, and thus the pusher finger **142**, to slide forward or backward relative to the head **120**. In this manner, the handle **110** can be rotated to move the pusher finger **140** between its extended and retracted positions.

[0067] As mentioned above, each of the arms **130**, **132** of the plate insertion tool **100** includes an inwardly extending finger **134**, **136**. The arms **130**, **132** are identical, so like numbers will be used for like parts. The arms **130**, **132** each also include an actuator **160** at an opposite end thereof. The actuator **160** can be in the form of a disc or other shape that can be pushed by a surgeon or other user. The arms **130**, **132** each include a lower leg **162** that is generally perpendicular to the inwardly extending finger **134**, **136**, a transverse leg **164** that is generally perpendicular to the lower leg **162** (and thus generally parallel with the inwardly extending finger **134**, **136**), and, at an opposite end of the transverse leg **164** from the lower leg **162**, the actuator **160** (which can be generally upstanding, and generally perpendicular to the transverse leg), as shown in FIGS. **8**-**10**. Although the arms **130**, **132** are identical, they abut each other on different sides, as shown in FIGS. **9** and **10**.

[0068] The transverse legs of the arms each include an obround opening **166**. A pair of parallel, spaced arm pins **168** extend through the obround openings, as shown in FIGS. **9** and **10**. The pins are fixed to the head, as will be explained in further detail. The pins and the obround openings are shaped such that the arms can only slide toward or away from each other. The actuators include an inward side that includes a stud **170** for supporting a compression spring **172** between the studs, and thus, the actuators, when assembled. The spring biases the actuators away from each other, which in turn causes the inwardly extending fingers to be biased toward each other into the clamping position, which is shown in FIG. **9**. When the actuators are squeezed together against the biasing force of the spring, the arms are constrained by the fixed pins so that the opposite ends of the arms, with the inwardly extending fingers, slide away from each other into the open position, which is shown in FIG. **10**. Once the actuators are no longer squeezed together, the bias of the spring then moves the arms so that the inwardly extending fingers are in the clamping position.

[0069] The head includes a pair of upwardly extending flanges **180** with a gap therebetween, as shown in FIG. **8**. The transverse legs of the arms are partially disposed between the flanges. The flanges each include two apertures **182**, and the opposing apertures of the flanges are aligned to receive the arm pins. When the transverse legs are partially disposed in the gap between the flanges, the pins extend through the obround openings in the transverse legs. The transverse legs, and thus the arms, can slide relative to each other but engagement of the fixed pins and the obround openings limits the extent of sliding. An upper bracket **184**, shown in FIG. **8**, has a pair of depending flanges **186** with opposing apertures **188**. The upper bracket can engage with the head, with the flanges of the upper bracket disposed outwardly from the pair of upwardly extending flanges of the head. The apertures of the depending flange of the upper bracket can align with the aperture of the upwardly extending flanges of the head such that the same pins can be used to secure the flanges together, and thus the upper bracket to the head. The upper bracket can also include a through opening **189**, parallel to the depending flanges, for receiving a central part of the spring.

Alternative Plates

[0070] There are many different types of configurations of the plates that can be suitable for different fusion and other procedures. As mentioned above, the plates can be compression plates that are formed of a shape-memory material, such as nitinol. In addition to the first exemplary embodiment of a plate illustrated in FIGS. **2** and **3**, twenty-four alterative embodiments are illustrated in FIGS. **24**A-**47**B. The plates each have at least one screw hole at one end portion of a body and a pair of depending legs at another end of the body. The pair of legs are at an acute angle relative to the extension. In some embodiments, the legs are side by side with a shoulder

therebetween; in other embodiments, the legs are in-line and depend from a linear extension of the body. The plate insertion tool and/or the methods described herein can be used for tensioning the pair of legs.

[0071] Some plates have two screw holes and others three screw holes. Optionally, the screw holes can be configured with internal threads for engaging with external threads on the heads of the screws. The screw holes can be in-line, e.g., lying along a center-line of the body. The screw holes can alternatively be offset relative to each other. In yet another alternative, the screw holes can be arranged transverse, e.g., in a line transverse to a center-line of the body, in a T-shaped body, for example.

[0072] Some of the plates also have an intermediate screw hole. The intermediate screw hole, if present, can optionally be used for a bridging screw that passes through one bone and at least partially into another. The portion of the body surrounding the intermediate screw hole can include a contour that cooperates with a contour of the underside of the bridging screw to stabilize the head of the bridging screw against the body. Instead of a bridging screw, the other type of screw and screw hole can be used.

[0073] The geometry of the plates can be tailored for different indications. By way of non-limiting examples, the plates of FIGS. **24**A-**25**B and **38**A-**47**B can be used for arthrodesis of the first metatarsophalangeal joint (MTP) or 1st (Lapidus), 2nd, 3rd, 4th, and 5th tarsometatarsal (TMT) fusions, various fracture fixation, or Lisfranc fusion or stabilization.

[0074] The plates of FIGS. **26**A-**27**B and **34**A-**37**B can be used for arthrodesis of the first metatarsophalangeal joint (MTP) or 1st (Lapidus), 2nd, 3rd, 4th, and 5th tarsometatarsal (TMT) fusions or various fracture fixation. The plates of FIGS. **28**A-**31**B can be used for talo-navicular (TN) fusion, calcaneo-cubioid (CC) fusion, Lapidus fusion, or Navicular-cuneiform (NC) fusion. The plates of FIGS. **33**A-**34**B can be used for Akin osteotomy, 1st, 2nd, 3rd, 4th, and TMT fusions, intercuneiform fusions, Jones or avulsion fractures of the 5th metatarsal, or various fractures.

[0075] Turning now to more specific details of the various embodiments of the plates, FIGS. **24**A and **24**B show a second embodiment of a plate having a body portion with a pair of legs—arranged side by side—at one thereof and three offset screw holes at an opposite end portion, the pair of legs being at an acute angle relative to the body. Optionally, an intermediate fourth screw hole can be provided in the body between the legs and the other three screw holes, as depicted in the third embodiment of FIGS. **25**A and **25**B.

[0076] FIGS. **26**A and **26**B show a fourth embodiment of a plate having a pair of legs depending from a linear extension and arranged in-line and three offset screw holes in a body at an opposite end of the extension from the legs, the pair of legs each being at an acute angle relative to the extension. Optionally, an intermediate fourth screw hole can be provided in the body between the legs and the other three screw holes, as depicted in the fifth embodiment of FIGS. **27**A and **27**B.

[0077] FIGS. **28**A and **28**B show a sixth embodiment of a plate having a body portion with a pair of legs at one thereof and two transverse screw holes in an inclined, flared end portion of the body, the pair of legs being at an acute angle relative to the body. Optionally, an intermediate third screw hole can be provided in the body between the legs and the inclined, flared end portion of the body, as depicted in the seventh embodiment of FIGS. **29**A and **29**B.

[0078] FIGS. **30**A and **30**B show an eighth embodiment of a plate having a body portion with a pair of legs at one thereof and two transverse screw holes in a flared end portion of the body, the pair of legs being at an acute angle relative to the body. Optionally, an intermediate third screw hole can be formed in the body between the legs and the flared end portion of the body, as depicted in the ninth embodiment of FIGS. **31**A and **31**B.

[0079] FIGS. **32**A and **32**B show a tenth embodiment of a plate having a pair of legs depending from a linear extension and arranged in-line and two in-line screw holes in a body at an opposite end of the extension from the legs, the pair of legs each being at an acute angle relative to the extension.

[0080] FIGS. **33**A and **33**B show an eleventh embodiment of a plate having a pair of legs depending from a linear extension and a screw hole at an opposite end of the extension from the legs, the pair of legs each being at an acute angle relative to the extension.
[0081] FIGS. **35**A and **35**B show a twelfth embodiment of a plate having a body portion with a pair of legs at one thereof and two in-line screw holes at an opposite end portion, the pair of legs being at an acute angle relative to the body. Optionally, an intermediate third screw hole can be formed in the body between the legs and the other two screw holes, as depicted in the thirteenth embodiment of FIGS. **35**A and **35**B.
[0082] FIGS. **36**A and **36**B show a fourteenth embodiment of a plate having a pair of legs depending from a linear extension and arranged in-line and two in-line screw holes in a body at an opposite end of the extension from the legs, the pair of legs each being at an acute angle relative to the extension. Optionally, an intermediate third screw hole can be provided in the body between the extension and the other two screw holes, as in the fifteenth embodiment shown in FIGS. **37**A and **37**B.
[0083] FIGS. **38**A and **38**B show a sixteenth embodiment of a plate having a body portion with a pair of legs at one thereof and two transverse screw holes in a flared end portion of the body, the pair of legs being at an acute angle relative to the body. As shown in FIGS. **39**A and **39**B, optionally an intermediate third screw hole can be formed in the body between the legs and the flared end portion of the body.
[0084] FIGS. **40**A and **40**B show an eighteenth embodiment of a plate having a pair of legs depending from a linear extension and arranged in-line and two transverse screw holes in a body at an opposite end of the extension from the legs, the pair of legs each being at an acute angle relative to the extension. Optionally, an intermediate third screw hole can be formed in the body between the extension and the other two screw holes, as in the nineteenth embodiment shown in FIGS. **41**A and **41**B.
[0085] FIGS. **42**A and **42**B show a twentieth embodiment of a plate having a body portion with a pair of legs at one thereof and two offset screw holes in an inclined end portion of the body, the pair of legs being at an acute angle relative to the body. Optionally, an intermediate third screw hole can be formed in the body between the legs and the inclined end portion of the body, as in the twenty-first embodiment of a plate shown in FIGS. **43**A and **43**B.
[0086] FIGS. **44**A and **44**B show a twenty-second embodiment of a plate having a body portion with a pair of legs at one thereof and two in-line screw holes in an inclined end portion of the body, the pair of legs being at an acute angle relative to the body. Optionally, an intermediate third screw hole is provided in the body between the legs and the inclined end portion of the body, as in the twenty-third embodiment of the plate shown in FIGS. **45**A and **45**B.
[0087] FIGS. **46**A and **46**B show a twenty-fourth embodiment of a plate having a pair of legs depending from a linear extension and arranged in-line and two in-line screw holes in an inclined end portion of the body at an opposite end of the extension from the legs, the pair of legs each being at an acute angle relative to the extension. Optionally, an intermediate third screw hole is provided in the body between the extension and the other inclined end portion of the body, as in the twenty-fifth embodiment of a plate shown in FIGS. **47**A and **47**B.
[0088] All methods described herein can be performed in any suitable order unless otherwise indicated herein or otherwise clearly contradicted by context. The use of any and all examples, or language describing an example (e.g., “such as”) provided herein, is intended to illuminate the invention and does not pose a limitation on the scope of the invention. Any statement herein as to the nature or benefits of the invention or of the preferred embodiments is not intended to be limiting. This invention includes all modifications and equivalents of the subject matter recited herein as permitted by applicable law. Moreover, any combination of the above-described elements in all possible variations thereof is encompassed by the invention unless otherwise indicated herein or otherwise clearly contradicted by context. The description herein of any reference or patent,

even if identified as “prior,” is not intended to constitute a concession that such reference or patent is available as prior art against the present invention. No unclaimed language should be deemed to limit the invention in scope. Any statements or suggestions herein that certain features constitute a component of the claimed invention are not intended to be limiting unless reflected in the appended claims. Neither the marking of the patent number on any product nor the identification of the patent number in connection with any service should be deemed a representation that all embodiments described herein are incorporated into such product or service.

Claims

1. A plate insertion tool for use with a compression plate having a body portion with one or more apertures each for receiving a screw and a pair of legs at one end that are each connected to the body at an acute angle and spaced apart by a shoulder, the plate insertion tool being usable to temporarily tension the legs prior to insertion into holes in a bone, the plate insertion tool comprising: a pair of facing, inwardly extending fingers being slidingly movable between a clamping position for clamping therebetween, in use, the legs of the compression plate, and an open position where, in use, the inwardly extending fingers are spaced from the legs of the compression plate, the pair of inwardly extending fingers being closer to each other in the clamping position as compared to the open position, wherein the pair of inwardly extending fingers are biased toward the clamping position; and a pushing finger movable between a retracted position and an extended position relative to the pair of inwardly extending fingers and positioned for engaging, in use, the shoulder of the compression plate such that when the pushing finger moves to the extended position the legs are temporarily tensioned by bending the legs away from the body.
2. The plate insertion tool of claim 1, further comprising a rotatable handle, wherein the pusher finger is movable between the retracted position and the extended position relative to the handle upon rotation of the handle.
3. The plate insertion tool of claim 2, wherein the handle has an axis of rotation and wherein the pair of inwardly extending fingers are fixed in an axial direction relative to the axis of rotation of the handle.
4. The plate insertion tool of claim 3, wherein the pair of inwardly extending fingers are closer to the axis of rotation of the handle in the clamping position as compared to the open position.
5. The plate insertion tool of claim 4, further comprising: a head fixed in an axial direction relative to the handle, the head having a bottom surface for abutting, in use, a top surface of the body of the compression plate; and a first arm having one of the pair of inwardly extending fingers and a second arm having the other of the pair of inwardly extending fingers, the first and second arms being slidably mounted relative to the head for sliding relative to each other and the head between the clamping position and the open position, the pair of inwardly extending fingers being disposed adjacent to and spaced from the bottom surface of the head when in the clamping position.
6. The plate insertion tool of claim 5, wherein: the first arm has a first arm actuator at an end portion thereof opposite the one of the pair of inwardly extending fingers; the second arm has a second arm actuator at an end portion thereof opposite the other of the pair of inwardly extending fingers; the first arm actuator and the other of the pair of inwardly extending fingers being disposed on one side of the pusher finger and the second arm actuator and the other of the one of the pair of inwardly extending fingers being disposed on an opposite side of the pusher finger; and a spring disposed between the first arm actuator and the second arm actuator to push the first arm actuator and the second arm actuator away from each other, thereby biasing the pair of inwardly extending fingers toward the clamping position.
7. The plate insertion tool of claim 5, wherein the pusher finger is mounted relative to a threaded shaft passing through an opening in the head and into a threaded bore of the handle, the opening and the shaft being shaped to restrict rotation of the shaft and pusher finger, rotation of the handle

causing the threaded shaft to advance and retract relative to the head.

8. A system for joining bones together, the system comprising: a compression plate having a body portion with one or more apertures each for receiving a bone screw and a pair of legs at one end that are each connected to the body at an acute angle and spaced apart by a shoulder; and the plate insertion tool of claim 1.

9. A method of using the system of claim 8, the method comprising: drilling a pair of guide holes for receiving the legs of the compression plate; clamping the compression plate relative to the plate insertion tool by moving the pair of inwardly extending fingers from the open position to the clamping position; engaging the shoulder of the compression plate with the pusher finger; moving the pusher finger toward the extended position to temporality tension the legs by pivoting the legs away from the body of the compression plate to a greater angle relative to the body as compared to the acute angle; and inserting the legs of the compression plate into the guide holes when the legs are pivoted away from the body to the greater angle.

10. The method of claim 9, further comprising, after the step of inserting the legs of the compression plate into the guide holes when the legs are pivoted away from the body to the greater angle, inserting a bone screw through one of the one or more apertures of the body of the compression plate and into a pre-drilled guide hole.

11. The method of claim 10, further comprising, after the step of inserting a bone screw through one of the one or more apertures of the body of the compression plate and into a pre-drilled guide hole: disengaging the pusher finger from the shoulder of the compression plate by moving the pusher finger toward the retracted position; and unclamping the compression plate relative to the plate insertion tool by moving the pair of inwardly extending fingers toward the open position.

12. The method of claim 10, further comprising, after the step of inserting the legs of the compression plate into the guide holes when the legs are pivoted away from the body to the greater angle and before the step of inserting a bone screw through one of the one or more apertures of the body of the compression plate and into a pre-drilled guide hole, tensioning the body of the compression plate by pulling the body of compression plate in a direction generally away from the legs thereof.

13. The method of claim 12, wherein the system includes a tensioning tool having a pair of handles that can be squeezed toward each other to move operative ends of the handles toward each other, one of the operative ends having means for temporarily connecting to the compression plate and another of the operative ends have means for temporarily being fixed relative to the bone, the step of tensioning the body of the compression plate further comprising: temporarily connecting the one of the operative ends to the compression plate; temporarily fixing the another of the operative ends to the bone; squeezing the handles toward each other to pull the operative ends toward each other to pull the body of compression plate in a direction generally away from the legs thereof.

14. The method of claim 13, further comprising, after the step of inserting a bone screw through one of the one or more apertures of the body of the compression plate and into a pre-drilled guide hole: disengaging the pusher finger from the shoulder of the compression plate by moving the pusher finger toward the retracted position; and unclamping the compression plate relative to the plate insertion tool by moving the pair of inwardly extending fingers toward the open position.

15-18. (canceled)

19. The plate insertion tool of claim 1, further comprising a first arm having one of the pair of inwardly extending fingers and a second arm having the other of the pair of inwardly extending fingers, the first and second arms being slidable relative to each other between the clamping position and the open position.

20. The plate insertion tool of claim 19, further comprising a head having a pair of spaced arm pins, and wherein the arms each include an opening through which the arm pins extend such that the arms can only slide toward or away from each other.

21. The plate insertion tool of claim 20, further comprising a rotatable handle, wherein the pusher

finger is movable between the retracted position and the extended position relative to the handle upon rotation of the handle, wherein the head is fixed in an axial direction relative to the handle, the head having a bottom surface for abutting, in use, a top surface of the body of the compression plate, and wherein the pair of inwardly extending fingers being disposed adjacent to and spaced from the bottom surface of the head when in the clamping position.